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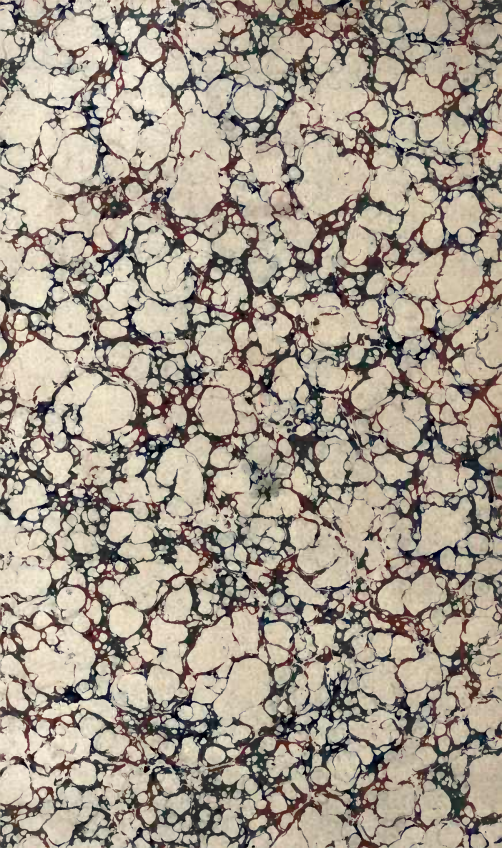
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EAGLE AND VULTURE

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THE  
NATURAL HISTORY  
OF  
BIRDS.

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BY ROBERT MUDIE,

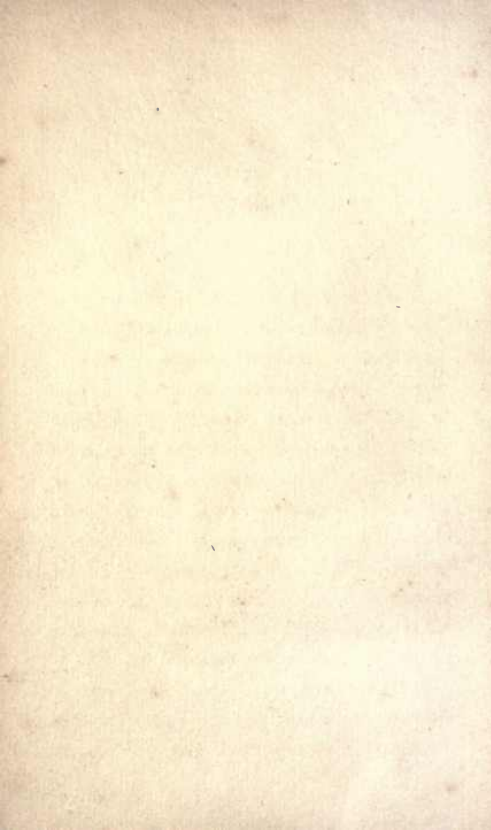
Author of "The Feathered Tribes of the British Islands," "Guide to the Observation of Nature," &c.



LONDON:  
ORR AND SMITH, PATERNOSTER ROW.

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MDCCCXXXIV.



## PREFACE.

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A PREFACE is not necessarily part of the book in front of which it is placed, any more than the bow or the salutation of a stranger upon entering a company is part of the conversation or the business for which he enters it; but each is a civility, the neglect of which is not courteous; and each, though but a mere demonstration of good manners, tends to make the parties open their minds to one another. Those who neglect the courtesy have the appearance of rudeness, and are in a sure road to the reality. This short preface is my salutation, hearty though homely: will the reader permit me to hope for the responsive feeling, "We shall be better acquainted?"

A general notion of the substance and order of the book may be obtained by glancing over the analysis of the contents. The titles of the chapters



are the great divisions ; the words in small capitals which stand out in the margins to catch the eye, are the subordinate divisions ; and the words which follow these are some of the points. Thus there are three steps of analysis, only the last one is necessarily imperfect, as inserting all the points would have been repeating the whole substance of the book.

The origin of the book, and the manner in which I have attempted to manage the execution of it, may be gleaned from the introduction. This introduction I, very respectfully but very earnestly, recommend to the attention of the reader, and more peculiarly to those readers who are interested in promoting the grand cause of knowledge, whether in themselves personally, or in others, especially in the young and the unexperienced. I do not ask a single reader to agree with me in any one point of detail, but I invite all to apply their closest observation and their most dispassionate thought to the subject ; and I am quite sure they will and they must agree with me, that the great body of the people may be much better educated in much less time than they have hitherto been.

Double the knowledge in half the time is not a tithe of the probability ; but if even this were accomplished, the time and the capacity gained would give more than double effect and enjoyment to every body.

All abuses of things naturally good derive their inveteracy from individuals gaining a profit at the public expense, and from these individuals being able to act with a degree of concert and combination, which a great and free people neither can, nor will exercise. Hence the difficulty of all reforms. There are, however, comparatively few obstacles to a reform in the mode of instruction. Here there is no "heavy body," to be started into motion, to be guided, and constantly tending to recoil. *The motive force is in the thing moved ;* and there is not (at least there should not be) a single clog on its energy : the natural desire for knowledge has only to be preserved alive, enticed by that which is pleasant, and kept in the way of that which is useful ; and all will learn, not only voluntarily, but in spite of opposition.

That such would be the case, if the young were not sickened with mechanical trifles in which there

is no occupation for the mind, and condemned to drudge at that in which they can see no usefulness and find no pleasure, is not only probable, but demonstrated in the cases of those who have been spared this weariness of the spirit, and also saved from those errors into which the unoccupied minds of the young are so prone to fall. To save from those errors, and at the same time to keep the natural desire alive and on the alert, there is no subject better fitted than natural history ; and if this little book shall be an assistant, however humble, in the accomplishment of this, the fondest wish of its Author will be gratified.

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THE  
NATURAL HISTORY OF BIRDS.

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Horned Owl.

INTRODUCTION.

SECT. I.—OBJECT AND ORIGIN OF THE WORK.

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THE object of this little volume is to render the study of that portion of nature of which it treats more inviting, more easy, and more instructive, especially to the young, and still more especially to those who devote the intervals of business or labour to that most delightful of all sports—self-improvement, but

who may not have the means of procuring, or time for studying, works of greater magnitude and more lofty pretensions.

In many cases, this simple announcement might be sufficient introduction; but this work will be found so very different, both in plan and execution, from any which has hitherto appeared on the subject, that some explanation appears to me to be necessary, both of the appearance of the volume, and of the style in which it appears. As long as there is only the old beaten track, there is no need of showing cause why it should be open, or of a finger-post to point out to where it leads; but it behoves the opener of a new path (if intended for a public one) to justify his act by the necessity of the case, to "prove the preamble," as the technical expression runs, and then to set up the finger-post, so that the people may, if so inclined, use the new path, and using it not be misled by it.

The chief reason, both for the appearance of the book and the novelty of the plan, is a firm conviction on my part, (founded, I think, upon observation sufficiently close, accurate, and long continued,) that very many, if not all, of our introductory works, not on this particular branch of knowledge only, but on every branch, go the wrong way to work, and by this means, instead of removing the difficulties which belong to the subject, encumber it with many others, which arise entirely from the mode of treating it.

This seems rather a sweeping assertion, and therefore, before I point out in what, to me at least, the mistake seems to consist, I must give some short account of the steps by which I arrived at this conclusion. But while I state what I feel to be the fact, and try to show how this feeling originated, I must not be understood as bringing censure against any

one, or as claiming merit to myself. It detracts nothing from the merit of the inventors of steam-engines that those of the early construction could not work, without the presence of a boy to open and shut the steam valves; and no great mechanical merit attaches to the little rogue who, in order to escape this monotonous labour and enjoy his pleasure, so tied the valves with strings that they were opened and shut by the engines themselves. Mine is the humble ambition of this boy; I would wish the machine of instruction to be made a little more self-acting, so that we may be spared the monotonous routine of technicalities, and be thereby left at liberty to use and enjoy that which we learn. When I say "technicalities," I allude to systems and supplemental notions which have no realities answering to them, and not to mere words. "Words," says the Malmsbury philosopher, "are the *money* of fools, but the *counters* of wise men;" and if the subject is rightly brought forward, the words are but a secondary consideration. What is called the technical word, and often on that account objected to, is very often the best; because the popular word has often many meanings, some of which are changing every day.

Having entered this caveat against being misunderstood, which is the more necessary that I must begin my proof with my own evidence, I shall now point out some of the steps which led me to the conclusion above stated:—In early life, my access to what are usually called elementary books was very limited; but my facilities for observing natural objects and phenomena, and some of the productions and operations of art, were correspondingly great. I found the acquiring of as much (boyish) knowledge of these, as, in so far, enabled me to under-



stand their natures, their relations to each other, and their uses to man, instead of being a repulsive and laborious task, a very fascinating and very easy amusement, so fascinating that I was never tired of it, and so easy that it hindered nothing else, and nobody heeded it. At this time, I sometimes found, or fancied, that those who had the books professing to explain the subjects, knew less of the subjects themselves than I did,—that (to take an instance from the subject of this volume,) he who was familiar with the goldfinch in the book, knew little of the goldfinch in the bush; and so of other matters.

Subsequently, when, in the course of events which are not worth mentioning, I came pretty largely and freely into contact with men of learning and talent, some of whom have graven their monuments and left us, and others still remain, discharging duties of the first importance, with great ability and much public approbation, I still found, that though there was one species of knowledge in which they were greatly superior to me, there was always, when the subject was not merely technical, that is, supplemental to the reality, another species in which I had the advantage of them; and that, when we came to consider the thing itself, and not the mere view which had been taken of it, my knowledge, though it often, indeed generally, went but awkwardly in mode and figure, went most directly to the point. This helped to convince me that how valuable soever their learning might be among the professedly learned, it was not exactly the best suited to the wants of a "working world."

I had a third means of obtaining evidence:—For about eighteen years, I had daily opportunities of observing the development of the mind at that very

important age, when the mere memory of the school-boy begins to give place to the speculation of the youth. Here, I found few instances in which there was not a desire, and a very ardent desire, to obtain knowledge, not only of all the subjects which formally belonged to the routine, but of all collateral ones, of the existence of which any glimpse could be obtained ; and in the cases which formed exceptions, I found that a very little retrospective analysis explained the cause. But, almost the moment that this youthful ardour impinged upon the book, its impetus was dissipated as that of a cannon shot is by a mound of loose earth ; so that, in the course of a very short time, that which had been gone to with so much desire, and begun with so much ardour, became a mere task, performed with reluctance and avoided by every means possible. Where however the subject as actually existing could be resorted to, there was no lack of ardour ; and where this was not practicable, the interpolation of something oral, and in ordinary language, as a *vinculum* or tie, to bind the book and the subject, was always a very tolerable substitute.

From this (and it was too general and too long-continued for being a mistake, and too completely free from a preconceived hypothesis or an ulterior object to be a prejudice,) it was very apparent to me that the fault was in the book ; for the ardour remained and required no excitement, when the subject could be seen in any other way than through that medium. I am well aware that this failure of the ordinary and formal means of knowledge is generally imputed to dulness, or unsteadiness and love of novelty, on the part of the learner. But, any one who chooses to attend practically to the subject, or

to consider what the motives are by which human actions are in general directed, will find that no imputation can be more groundless. The desire of knowledge is the first and the strongest of all our desires; and indeed all other desires are grounded upon a previous desire for knowledge. To suppose that we desire that which we do not know, is just as absurd as to suppose that we see what we do not see; and if there is nothing external answering to the desire, then the whole is more purely a mental matter, and consequently more exclusively a result of former knowledge than if it had a tangible object. Even when the infant evinces the first desire for nature's own cup, and before its little features have smiled on the parent by whom that cup is bestowed, or its little fingers have plied that elementary geometry and arithmetic, by means of which it learns to measure space and count time,—even then, the knowledge of hunger must come before the desire of food; for, if we venture to apply the ignorance-cloaking word *instinct* even here, we abandon mind at the very outset, and immortality is a dream.

If we are to charge the aversion for technical forms against those who turn away from them, we must begin at this early stage; because if we take a later one, we know not what may have taken place in the intermediate time. From all the investigation which I was able to make of the cases of indifference to knowledge to which allusion has been made, I always found cause enough in the previous treatment; and if this did not attach to neglect or improper conduct at home, it was invariably traceable to the system or the book. This is a subject which bears more intimately upon the intelligence, the virtue, and the happiness of mankind (which, by the way, are rather three

modes of expression than three subjects,) than almost any other that can be named. But a future opportunity may occur for explaining its nature; and the fact of its existence is all that is essential in the mean time.

For a considerable time, the conviction of this tendency that the books which are usually put into the hands of young persons, have to lull the desire for knowledge, remained with me as one of those subjects which we regret whenever we think about, but do not take steps for its removal. But, when another of those sets of revolutions (to which men more occupied in acquiring the knowledge of things than the things themselves, are subject) which have little interest for the public generally, and which therefore need not be mentioned, had led me to the writing of books—when I found that the public, and its grand organ the press, welcomed me with a degree of approbation which astonished me as much as the prophecy that I should become an author would have done twenty years previously—and more especially, when I found that the favour and commendation which I thus received were grounded upon that character of my writings, which was in accordance with this conviction, of the progress and proof of which I have given an outline;—when I was thus situated, and thus pleasantly schooled into more confidence in my conviction, I could hardly refrain from wishing to act further upon it.

The result was, a resolution to prepare a series of elementary books, upon all the more useful branches of knowledge, so framed that there should not be any task-work in them; and yet each explaining the broad principles of its subject in such a manner as to increase the quantity of knowledge, and at

the same time strengthen the desire of obtaining more. And here, again, I must meet any charge of vanity which may be brought against me by those who view plain matters in a learned light—who in fact consider the subject only in that point of view which, as I shall endeavour to show in a subsequent part of these works, is the erroneous one. Great learning is not required for the accomplishment of my object; for the excess of learning is the root of the evil. A moderate degree of information, accurate as far as it goes, connecting itself readily with all the other parts of knowledge, readily available to the practical purposes of life, and expressed in a clear and plain, but, at the same time, an inviting manner, are the requisites of a book of instruction for the people; a book, in short, which shall convey the requisite degree of knowledge, which may or should be read in the school, but which shall be read willingly, and sought after, out of the school, whether in the family or by the individual, is the book wanted, and the one which I shall labour to the utmost of my power to produce.

Such is the simple foundation of the elementary works which I had planned; and as, upon many of the subjects, I had had abundant practical experience of where the difficulty of the subject itself lies, and where the force of repulsion in the ordinary mode of treating it begins to act; and further, as I had taken note of these matters at the time, without any object to warp or bias my judgment, I saw no great difficulty in the execution. But still there was some difficulty in knowing how to begin, so as to obtain that hearing from the public, upon which the success and the usefulness of every thing addressed to the public must depend. This was a difficulty which

I did not see how to overcome. But circumstances often reveal to us that which direct inquiry cannot discover. Such has been the case in this instance; and the result has been the publication of this volume, which may be considered as the harbinger, and, in some respects, a specimen of others.

The circumstances are these: having undertaken to supply a very considerable number of articles for the third, or Natural History Division of the *BRITISH CYCLOPÆDIA*, now in the course of publication, the article "Bird" occurred in its order in the alphabet. I had got some credit for a descriptive work, on a portion of the same class of animals, "The Feathered Tribes of the British Islands;" and also for "A Guide to the Observation of Nature," containing more broad and general views, though described in a light and sketchy manner. The article "Bird" I felt to be one in which these qualities might be combined, and the combination made to bear more upon general science than either of the elements singly. Therefore I set about it with some research, no inconsiderable degree of study, and much and hearty good will. After I had made some progress in the composition, and began to see the length to which the article would extend, and the quantity of illustration which it would require, it occurred to me that a very little more would furnish a book which could be offered to the public on terms highly advantageous—such terms as might not again occur—at least with the same subject. I mentioned the notion to the Proprietors of the *Cyclopædia*; they at once adopted it; and the result is this volume of the *NATURAL HISTORY OF BIRDS*.

Of the matter it becomes me to say nothing, further than that, to the best of my knowledge, every

line in the book, which is not marked as a direct quotation, is original;—that many of the relations and analogies are such as I have never seen stated;—and I am not aware of any allusion to many of the collateral views which are opened up. But I am at liberty to mention the technical execution; and here I may say, and challenge contradiction, that this is the cheapest book that ever issued from the press. It is an original work; many of the illustrations are copied directly from nature; the others are all from authenticated originals; they are very numerous; and the whole are executed, and the book printed, in the very best style of the arts. Yet the price is not greater than that of mere compilations, of which both the text and the illustrations are borrowed from *any* source, and prepared and put together in any manner. Indeed, if this volume had had to bear the whole of its own expense, the prime cost per copy, even in anticipation of the largest sale that so expensive a book could have been expected to command, would have been more than double the amount at which it is, under the circumstances, offered to the public. This has been accomplished solely from the greater part of the matter being in types, and the greater number of the cuts available for other purposes. To throw away such an opportunity, I should have felt an injustice to myself, to the proprietors of the work, and to the public, more especially as it furthers that project, the execution of which I feel to be one of the best means which I can have of discharging that duty which every man owes to his country for having afforded him support and protection when incapable of helping himself, and also that debt of gratitude which I feel to be, in my particular case, peculiarly large and immediate.



It may seem that, in the preceding sentences, I have entered into details which are of minor interest to the public; but as I am endeavouring to win the reader's favour for a long acquaintance, it is right that we should fully understand each other at the commencement. Having said thus much, I shall now proceed, first, to notice what I conceive to be the leading defects of these existing works which profess to furnish elementary instruction in natural history, especially that of the feathered tribe; and, secondly, to give a very summary account of the plan and leading contents of the little volume.



Waxwing.



Hoopoe.

SECT. II.—ON THE STUDY OF NATURAL HISTORY,  
ESPECIALLY THAT OF BIRDS.

Every one knows that there are two ways of obtaining a knowledge of any natural production, or indeed of any subject, phenomenon, or event, soever that can occupy the attention of human beings. The first of these is direct personal observation—going directly to the subject, and examining it in as far as it is an object of the senses, and drawing from the facts, which are thus obtained, all those conclusions which are necessary either for connecting it with the knowledge which has been previously acquired, or for making it the medium of acquiring any future knowledge that may be desirable, and to which it may, in a natural manner, and by fair and legitimate inference, lead. Wherever this is practicable, it is far preferable to any other method, because it addresses itself immediately to the conviction, without any labour of weighing evidence, any reliance upon the testimony of others, or any trouble in deciding between truth and falsehood, or between certainty and probability.

From this superior quality of the information which it affords, and the ease and certainty with which that information is obtained, every one should endeavour to make the sphere of direct observation as wide as possible; and not only let slip no opportunity which may present itself without effort, but seek, by every justifiable means, every opportunity which does not directly interfere with and hinder the active duties of life. And it is worthy of remark, that, in this, the most important of all our employments, second only to the preservation of life, and the direct means of its preservation, our benignant Creator has not left us to the uncertainty of mere contingencies, but has implanted deeply in our nature the desire of observation; so that if we have not debased our natural powers, and destroyed our natural feelings by improper use, this desire constantly urges us on to the attainment of more knowledge. For this end, and obviously for this purpose, the fondest object of our wishes, satisfies us only for a time; and this time is short, not in proportion to the fickleness of our minds, as is sometimes alledged by those who would chain us down to an ignorant satisfaction with that which we already know, but to the very constitution of our nature, and to all that tends to the elevation of our character, whether intellectual or moral.

But the field of knowledge is so extensive, our means of personal observation, trammelled as the mind is by having to carry the body along with it, are so limited, and our lives are so short, in proportion to the extent of that which is to be learned, and which both nature and necessity impel us to learn, that our own direct personal observation can furnish

us with only a very limited portion of that which it is necessary for us to know. This is the case upon all subjects, but it is more especially the case in natural history, where, before we can rightly understand one part, we must have a knowledge of so many. The productions of nature depend so much on local causes, that those which can be seen even by the most active and adventurous traveller, amount only to a very small fraction of the whole. Hence we must, with reference to by far the greater majority of subjects, have recourse to information at second hand, and this may be regarded as the second general means of obtaining knowledge.

Now, on most subjects generally, and on many subjects exclusively, the best mode of obtaining this secondhand information, is through the medium of books; because these are accessible at all times; and therefore those persons, who are the most actively employed, may, if so inclined, acquire, by means of books, a great quantity—nay, almost any quantity of knowledge, and that during portions of time which are individually so short that, if not occupied in this manner, they are very apt to be utterly lost. There is another advantage which books possess, even over direct personal observation: we live at a point of the earth's surface, as it were, and our direct observation is limited to a small distance round that point, so that our observation is confined to a certain class of objects, dependent on locality and latitude in so far as they are natural; and these are very often not the ones that it is most desirable or most useful to know, and they themselves cannot be understood in a satisfactory manner without the knowledge not only of other things which lie without the sphere of

our observation in space, but which have preceded the present time, and are to be found nowhere but in the record of the book.

Thus, by means of books, any man who has access to the proper ones, and chooses, can combine the whole experience of the world up to the very day, and as far as observation, or knowledge by any other means has been carried, without moving from the same spot. There are many who have not the desire of roaming about to see what is going on, even in the brief period of their own lives, and there are many more who have not the means even if they had the desire. But to all these the book addresses itself with equal readiness and freedom; and if it be a book of truths, or of *science*, as we say, whether of facts, or of inferences, or of that happy combination of the two, imbued with that ardour of manner which says imperiously to him who once begins it, "You shall read onward to the end, and after this be more desirous of another," which constitutes what may be called a book of the first class, whatever may be its subject—the book speaks all languages. It is true that works which are more immediately descriptive of the place and the day, are confined in their locality, and ephemeral in their duration. They please a certain class of readers—that portion which, had they been precluded from the power of reading, would have spent their time in bandying about oral reports of local occurrences. These books cannot, from the very circumstances which give them their ephemeral and local character, be accurately rendered into any language save that in which they are originally written, or duly appreciated by any people save those of whose manners they more immediately treat.

These last mentioned works are pleasant withal

for their time and in their sphere; but they cannot be said to form part of that mighty tide of mental embodiment which has been collecting its rills and its feeders from every generation since the eyes of man were first opened on the sun, and which, in these latter times, and more especially since the press dashed away the chief obstacles to its course, rolls onward like some giant river, the streams whereof not only encompass the earth and the sea, but diffuse themselves through the atmosphere and cause fertility to abound at every spot. It is this which is the grand mental heritage to man in all nations and in every succeeding age. It was this which the eagle eye of Bacon saw with a prophetic glance at its future mightiness, though in his day it was but as a brook to the ocean compared with what it is now—and the future promise increases much faster than the present reality,—it was this which made him leave to the world that aphorism which is more redolent of matter, and more mighty in expression in its three simple words, than many books, and good books too, are in thrice the same number of volumes—“**KNOWLEDGE IS POWER.**”

So fully and so forcibly is the demonstration of this grandest of all elementary truths coming upon the world, that every other power is feeling, and virtually and often in words, confessing its superiority—bowing before it as **THE GOVERNOR** sent of Heaven, in place of which they only held temporary sway during its nonage, to restrain the wrongs and the waywardness of ignorance; but that, now that it has come of age, they deliver up to it the universal sceptre—a sceptre of peace and of prosperity—“Peace on earth and good will to all the children of men.”

This mighty power cannot be wielded, or, to follow

the metaphor, this flood cannot be fathomed, in all its depth, by any individual of the human race; but still it is a river of which all can drink; and there is no human being, be the circumstances of life what they may, to whom the draught is not both necessary and refreshing. Books are, as it were, the pitchers in which this water of the river of knowledge is fetched for the people; and though the water itself is always good, the pitcher may be naught, or its contents may be foul, from being taken up in the *shallows* where the mud is easily stirred. This, it is to be feared, is the case with very many of those books which profess to render the acquiring of knowledge popular and easy; and in none more so than in the introductions to the different branches of Natural History.

Natural history, though, when considered in its largest extent, it is the quarry from which the materials of all the sciences, as well as those of the arts, are brought, is yet a science wholly of observation. We may place the plant or the animal in peculiar circumstances, and watch the results; but still these differ in kind from those which we obtain when we make experiments on dead matter. Therefore, as the science is wholly one of observation, all the information which is offered to the public upon it, should be as much as possible in accordance with the mode in which knowledge occurs to us by observation.

This is necessary not merely to secure the possession of the knowledge itself, but to secure that enjoyment of what we know, which constitutes the real value and use of knowledge. The knowledge of the plants, the animals, the succession of the seasons, and of all the other appearances of nature, would avail us little, if

it did not bring along with it a more hearty love of nature, and a more ready perception of the practical use of all that nature presents to us. Merely abstract knowledge is of small value here: that which is most desirable, and most easily acquired, and which should, on these accounts, always be presented (and the more rudimental the book is, the necessity is always the more imperious,) is knowledge which, so to speak, should not merely inform the head, but which should tend fully as much to make the heart more kind and the hand more ready.

This is to be obtained only by making the book which treats of natural subjects come as near as possible to the actual observation of nature; and it is because this is not attended to, that the ordinary books which are accessible by or given to the young and the ignorant, not only fail in imparting that knowledge which is professed to be communicated, but rob the parties of the desire of obtaining it, and thus in reality defeat the very object which they profess to serve. This species of deception is, unfortunately not confined to natural history, but runs pretty largely through all the departments of knowledge; although it is probably worse in the case of natural history, than in that of any of the more abstract sciences which depend less upon observation; yet it is mischievous in every case, as withdrawing the attention from the reality and the practical enjoyment and use.

To investigate the causes of this would be foreign to the purpose of this introduction. It may, in part, arise from carrying the method of *induction*,—that of arriving at the general subject from the particulars, of which the excess is very disheartening to the student in even the most abstract sciences,—into na-



ture, where the original method—that of observation, is quite the reverse. But it also, in part, and very probably in greater part, arises from ignorance on the part of those by whom the books, professing to be simple and elementary, are compiled. By this means, the compilation, instead of being “an easy introduction” to the subject, or to the larger works from which it is taken, as it generally sets forth in the rubric, is not an introduction to the subject at all, and it is as much more difficult than the originals as it is shorter. With compilations upon scientific subjects, it cannot well be otherwise; for a scientific book must be very loosely written if the systematic part of it admits of abridgment, as the chief object and use of system is in itself abridgment, in which things are made (or understood) to throw light upon each other by their juxta-position, and thus shorten, as much as possible, the labour of detail. Thus far, therefore, the professed abridgment is only another name for mutilation, as the detached parts are much harder to be understood—and very generally not at all understandable for any useful purpose, for want of the connexion of the rest. Thus, the compiler, in order to produce a book, which shall be read, even as a matter of task and compulsion, must content himself with the parts which contain the illustrations—the “picture-work” of the book, as it were, and leave out all the more substantial parts, which give these illustrations their value.

This is remarkably the case with all the little books on natural history, which get into circulation chiefly on account of the figures which they contain, just as other elementary books often obtain circulation because they point out something to be done which shall occupy the time of the student, and which often

occupies it with very irksome labour to no useful purpose. The pictures might, in many instances, do just as well without the letter-press, as this only tells in words that which the figure, if an accurate one, tells at once. If there is any thing more than this, it is chiefly of an anecdotal nature; and, in the collection of these anecdotes effect is more generally studied than truth, and thus the little knowledge which is acquired is not accurate.

But even though this were not the case,—though the descriptions were minute and true down to every single feather of a bird,—still they are not of the kind which is wanted. They are all results—the *endings* of investigations, while we want the *beginning*, and the *mode of proceeding*. An instance taken from common life will perhaps illustrate this:—A man residing in London, wishes to go to Birmingham, but is ignorant of the direction in which it lies, and knows not one step of the way. This is precisely the situation of every person at entering upon the study of natural history, or of any other branch of knowledge. Well, would you present the man with the plan, the history, and the model of Birmingham, as the most likely means of getting him thither? Assuredly not; for the plan, the model, and the description, though true and minute to every smoking furnace in that town of fires, would not enable him to know Birmingham when he saw it, half so well as a rough general sketch of its appearance from that part of the London road at which it becomes visible; and as for finding the way, the most meagre map of the country across which the road lies, that ever was inserted in a road-book, would be far more valuable than all the plans and models of Birmingham, that even its vast constellation of artists could produce.

This case is too apposite for requiring any formal application: That which we desire is a beginning and a way for the ignorant, and we are presented with the end, which has been arrived at by those who are learned on the subject, and by them only. This seems so palpably absurd when stated, that if it formed only the rare exception and not the very general rule, it would not be tolerated for a day; but unfortunately it is not the only absurdity which people cling to and cherish, from the mere fact of its being handed down from antiquity, and the exposure of which they are apt to regard as something which will injure society in a manner they know not how, instead of what it is in reality—a little bit more gained from the dominion of Old Dulness.

In natural history, and more especially in the natural history of birds, which, from the fleetness of their aerial motions, carry the mind more readily and directly over the general map of the earth, than any other class of the earth's productions, this inversion of the order of nature—this substitution of the end for the beginning, is peculiarly hurtful; and it must be the cause why people, even well informed otherwise, know so very little about the nature and habits of those species which are before their eyes every day, and which appear to come for the express purpose of being observed and studied. Take, as a familiar instance, the common redbreast, and ask your next neighbour when and where it builds its nest, what are the number and colour of its eggs, how long the incubation lasts, how the young are fed, and on what; and the chances are many to one that you do not get direct answers, and if you do, they are the second-hand answers of some one who has written a description of the bird, which, if original at all, has

most probably been obtained from observations in a climate differing from yours, and therefore is not quite accurate, as the description of your redbreast. Carry your interrogations a little farther: Ask what is the geographical distribution of the bird; what circumstances tend to increase or to decrease its numbers; what are its uses in the general economy of nature, or its particular use or injury to man as a cultivator of the earth; and you will find the answers still more difficult to be obtained, as well as more unsatisfactory in the few cases where you can obtain them.

Now, we can account for this general want of information upon a subject which is not only so open to observation but so inviting, only in the books of instruction to which the great body of the people have access, not being of that kind which leads to personal observation or harmonises with it. The natural subject always presents us with the general view, not only of the creature itself as a whole, but so intimately connected with all the circumstances of place and time, that if we do not take notice of them, the mere details of the creature are not worth studying, and they are accordingly not studied by the people generally, but left to those who have a professional or a personal object in the study; and then the accomplishment of that object is not always the most certain guide to the truth. He who observes the bird, often does so as a mere ornithologist, and so misses the greatest part both of the use and the pleasure.

Every production of nature, when rightly studied, becomes, in after time, an index to that part of nature in connexion with which it is found; and a bird, as being one of the most remarkable of those productions, is more easily suggested to the mind than any

other, and more readily brings along with it all the relations of its locality, and all the phenomena of the time when it is observed. On this account, he who knows all the birds of the British islands, in their connexions and relations, can, whenever he is so minded, live mentally in all the varied scenes of the British islands, and, therefore, enjoy all the pleasure of them, be his bodily locality where it may. He may be on the bleak moor where there is not a shrub, in the close lane of the city where even the sky is barely seen, in the solitude of a prison-house, or laid on a bed of sickness, deprived of the use of sight, and with all his senses dull and indifferent to present objects. But still, if his former study has been true to nature, nature will not desert him in the hour of affliction, or even at the moment of dissolution. Even then, the eagle and the ptarmigan shall fetch him to the mountain, and he shall climb, with bounding heart and sinewed limbs, and the healthful breeze shall play around him, and he shall look down upon a hundred valleys, scan all their inhabitants, and taste all their freshness, till the grief of the body become clean forgotten in the enjoyment of the mind. Or, if other scenes please him more, the warbler shall lead him to the groves and bowery glades of the forest, and the green leaves shall play in the scented breeze, and the flowers shall blow, and the song of nature shall be sweet and varied, and he shall anew be "the happy boy" even in the extremity of decrepitude. Or the sea-bird shall conduct him to the cliff, against whose caverned base the waves of ten thousand seas have thundered in vain; and he shall look upon the majesty of the waters; and the ship shall appear, and he shall mentally get on board, girdle the world, and visit every scene and every tribe of men under the sun.

All this, and much more, may be done by any one who has studied the birds, even of one little nook of earth, so in their connexions that they may be (which they never fail to be when rightly studied,) an artificial memory; and in proportion as this species of knowledge extends to the tribes of other lands, the enjoyment—the real and substantial value—for, **THERE IS NO VALUE BUT IN ENJOYMENT**, extends and multiplies in a progression far more rapid than even the knowledge; so that he who has studied the whole in all their connexions, may, literally and without any figure, be said to have won the whole world for his heritage. And it is a heritage secured under the charter of the Almighty, of which the possession cannot be taken away by all the power and all the arts of man; neither can the possessor himself squander it, as external possessions are often squandered. In life, we are constantly hearing of cases in which those, who but a few years before had wealth sufficient for enriching a parish, sink down to the level of the mendicant in the streets.

But no man who has once acquired knowledge can despoil himself of that. The mental perception is as immortal as the mind itself; and the attempt to extinguish the one, were as vain as that to annihilate the other. **ONCE KNOWN, ALWAYS KNOWN**, is an aphorism to which there is no exception. When a man says that he has lost, or forgotten, the knowledge of any thing, be it what it may, he merely tells us in other words that he never had it. In this way we often hear people complaining that they have forgotten what they learned at school; but that is a mistake, they have forgotten only those subjects which they were occupied about, but did not learn; and in all these cases the cause of the failure is the want of the relations or connexions, by means of

which only the subject can be bound in the volume of thought, so that it shall never fail in returning to suggestion when it is required. The bird, for instance, which is known only as so many coloured feathers, and naked skin, and horning bill and claws, thus or thus formed, has no connexion with nature, and is not a subject of science of any sort; and, therefore, unless we constantly trace over the written words, or con them by rote, and thus have that spurious and useless memory which we have of other things of which substantially we are ignorant, there is nothing whereby it can be suggested to the mind. But, if we know the live bird in its bush, we have the bush, and the soil where it grows, and the season at which it buds and blossoms, and the caterpillar that feeds on its leaves; and the fields and farm-houses which are around, with all their reared animals and their cultivated plants; and the bird stands frontispiece to a volume on rural economy, any one part of which readily suggests all the rest. Then if the bush is by the margin of the brook, now murmuring over an opposing stone, now settling in a little glassy pool, and anon trundling down a little run among pebbles, with its minnows and its may-flies, the chance is that it will steal our thoughts to its gentle tide, and we will pass the mill-pond with its geese, the church tower with its ivies and its owls, and onward to the river, nor quit the course, till the rolling water has carried us fairly round the globe, and the little bird of the bush has become the key to nature's universal museum.

Thus, if in our study of nature, we take that order in which the objects of nature present themselves to our observation, that is, first, the general view, and then proceed to the details by analysis, success be-



comes as certain as failure is when we invert the order of nature. This method of proceeding, makes the acquiring of knowledge and the business of active life go hand and hand, and mightily assist each other; or rather it shows us that they are parts of the same succession of mental employment, which ought never to be separated. The error of the opposite system furnishes its own reproof, and should suggest its own correction, from the cases of those learned persons who, when they are unexpectedly turned back upon the road of formal and technical learning, are so inefficient and even helpless among the active part of mankind.

And this is exactly what might be expected from those who are accustomed to begin with the details, and arrive at the general conclusion, which is to be the rule of action, only after a patient study and induction of these. The event of life, like the production of nature, presents itself as a whole, and in its connexion; and if we are so to take advantage of it as to turn it to any useful purpose, we must be ready to act at once; for the opportunity, having arrived, will not wait till we have prepared ourselves for it.

Thus, every subject which can present itself, in reality, for our consideration, whether the result of that consideration is to be knowledge only as the means of future action, or is to be action according to knowledge at the time, presents itself as a whole and in a connexion; and the operation which it calls for on our part is *analysis*—a following out of the details, virtually or really, and an observation of the relations and connexions. This power and readiness at analysing is the only thing which can be considered as education; and, therefore, whether the means be by tutor, by book, or by personal observation, we must first view the subject as whole, and then work out the de-



tails. Natural history is one of the best fields in which to acquire this habit of ready analysis, because it has attractions which more abstract or more artificial studies do not possess ; and one of the most inviting departments of natural history, and therefore, one of the best for beginners, is the study of birds ; but to be studied successfully, they must be studied in their structure, their actions, their localities, and relations, and not as so many portions of mere matter of which size, shape, and colour, form the whole story.



Starling



Hen-Harrier.

SECT. III.—PREFATORY NOTICE OF THE FOLLOWING  
CHAPTERS.

This work is not, strictly speaking, a specimen of that simple analytical method of treating a scientific subject, which, as I have mentioned, best adapts it for the purposes of popular instruction ; because the nature of the larger work in which it in substance appears, prevented its being made expressly a school-book. Besides, the subject of birds, though one of the most inviting that can engage the attention of persons at any age, and one which has peculiar claims for the young, demands, when treated scientifically, however lightly, more preparatory knowledge than those at school can be supposed to possess, at least till an advanced period of their studies. No doubt the subject can, in great part, be understood with very little preparatory knowledge ; and in order that it may be as extensively useful as possible, I have endeavoured, in every instance, to take the simplest views of all those matters which come within the scope of the volume, and to express them in the plainest language. But still the beauty of the subject cannot be fully appreciated, or reverence for those

wonderful displays of Creative Wisdom which birds, more strikingly than any other creatures, evince, duly felt, without some knowledge of the principles of mechanics, of geography, of the seasonal changes on the earth and in the atmosphere, and of various other collateral subjects.

But these, instead of being objections to the treating of ornithology in a manner rather more scientific than is done in the usual books, are the very strongest arguments in its favour. If the mind has been rightly trained, so that the desire for knowledge has not been blunted, if the subject is interesting, and if the manner of treating it is not repulsive, then, the more forcibly that it brings before the reader the fact, that there is not only still more knowledge to be sought after, but that the obtaining of this additional knowledge is absolutely necessary to the full and perfect enjoyment of that which is already known, the greater is its value, because it is calculated to effect the greater good.

This is, in fact, at once the usefulness and the charm of every book; and there is no volume which the reader closes with regret that it should extend no further, but which produces this effect chiefly by hinting to him that there are other matters of which he is still ignorant, and which it would be very delightful to know. Indeed, this is the grand merit of instruction, whether it is attempted by books or by any other means. For the mind is a wonderful thing in its working: it heeds none of those mechanical obstacles which impede, or those lengths of distance which fatigue, the body on its marches. If the desire of knowledge can once be excited up to the necessary ardour, the mind will find the means of informing itself; so true is the saying, that "where there is a will, there is a way."

This is to be accomplished or approximated, not by the enumeration of details, but by dashing onward with the great principles, and throwing a glance now here, now there, to connect the immediate subjects with all the necessary collateral ones, as we career along. Who, when the gallant ship is sweeping by, with so much velocity that the landsman who gazes from the shore feels his head turn giddy, and nature around him to reel again as if aroused by the spirit-stirring sight, would stoop down to count the pebbles on the beach? Who, when the falcon is on the chace, or the eagle on the stoop, would pause to count the feathers in a wing, or the spots on a feather? And much more, when the mind is on its nobler movements, bounding and beaming onward, "from mortal to immortal ken," in the glorious course of thought, more fleet than any ship that ever stemmed the main, or any wing that ever cleft the air, who would stop it for mere details? The attempt were vain as that to charm down the sun from the firmament, or fetter the careering earth with a cobweb.

The details are for an after time—for letting the mind easily down on its pillow, after the contest is over, and the prize won. They are for reference, and belong to the humbler department of (what is called) memory; but the book of instruction ought to be of more spirit-stirring character—it should enkindle the fire which it is to guide—arouse the mind which it is to illuminate.

Books on natural history, which are addressed to the unlearned part of the public, and to the young especially, consist in general of nothing but details; and thus, though they have much in them to be remembered—or to speak more in accordance with the fact, to be forgotten, they have nothing to be

learned, and nothing to stimulate the desire of learning.

In this little volume, I have taken the opposite course. I have always begun with that which is broad and general, such as we find it in nature; but in a few instances I have carried the analysis down to the details, in order to show how easily the reader can do the same for himself in all other cases. His hope would have been fainter had I made the whole details with only a few generalisations; and if there had been details only, hope of improvement there would have been none.

From the first chapter to the fifth, both inclusive, there will be found, a general account of birds, as distinguished from the other classes of vertebrated animals. In these, their structures and the nature of their more important functions, whether vital or active, are treated in a light and sketchy manner, though, it is hoped, to a sufficient extent for enabling common readers to understand them more readily and better, than if I had gone minutely and technically into the details. In this part of the book, there will also be found Cuvier's structural classification of birds, with a running commentary; with a view of showing how the study of animals may be abridged by a good natural arrangement; but at the same time, how many difficulties there are in the way of such an arrangement, especially in the case of birds. In this part of the work, as written accounts even of a single specimen of each division would have destroyed the unity and continuity of my plan, I have added figures, generally of very typical species, and all represented with the utmost fidelity. Throughout the work, I have followed a similar method: when it appeared to me that the reader would feel inclined to know the details, I have given a repre-

sentation of a species, generally a British one, by which the reader may know his bird ; and then, the pleasant as well as the profitable way, is to go into wild nature, and find out its conduct and character there.

In the remaining three chapters, I have entered somewhat at large into the three great systems of the bill, the feet, and the wings. In all these, there will be found illustrations of the most typical specimens, which have been, for the most part, carefully drawn from nature, and in many instances from the living bird, so that their accuracy may be depended on ; and here, also, I have inserted a portrait of an entire bird, whenever I thought it would serve either as an illustration, or as an incentive to further enquiry.

Of the execution I cannot judge ; but the public have already given me credit in this respect, and I would not willingly deserve to fall off in their good opinion. I think that the chief merit is in the plan ; and this, after all, to use a homely expression, consists in its being apparently—no plan at all.

ROBERT MUDIE.

*Grove Cottage, Chelsea,  
Nov. 10, 1834.*

## CHAPTER I.

### DISTINCTIONS OF BIRDS FROM OTHER VERTEBRATED ANIMALS.

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**BIRD** (*Avis*, literally "that which flies," or in the plural *aves*, birds). A class of warm-blooded animals, and the second into which the vertebrated animals are arranged by most of the systematic naturalists.

Birds are a well-marked and easily distinguished class, even by their external characters; so that, though they differ much from each other in their appearances and habits, there is not the least danger of confounding them with any of the other classes. They are all produced from eggs, which are very generally, but not universally, hatched by the heat of the parent, which incubates, or sits upon them, warming them with the heat of the breast, which appears to increase for the purpose, and becomes one of the natural inducements for the bird to sit; and in many cases the breast of the female becomes denuded of great part of its usual covering, by which means the heat is more freely and immediately communicated to the eggs, the natural covering being a bad conductor of heat.

Though birds are not the only animals which are produced from eggs, and though the eggs of some species of reptiles resemble those of some birds both in size and in colour, yet the egg of a bird is very easily distinguished from that of any other animal. The shell is harder, containing more salts of lime and less gelatinous matter than that of the eggs of reptiles, and it is more granular in its surface; it is also more brittle, though from its shape it is strong in proportion to the quantity of matter in it. Farther, the egg of a bird cannot be dented without a fracture of the shell, while that of almost every other oviparous animal may. The contents of the bird's egg are also chemically different from those of that of the reptile; indicating even in the rudimental state a higher degree of organisation, and along with it, as is always the case, greater energy and activity in the powers of life. The egg of the bird is much more albuminous, so that it "boils hard," while that of the reptile consists more of gelatine. The flesh of the animals have much the same difference of quality. The muscular parts of birds are more dry and rigid than those of even the mammalia; and some of them are so hard and tough, as not to be eatable. The tendons and even the membranes have the same proportional firmness of structure; so that the flesh of an eagle is much firmer than the flesh of a lion. Even the bones of birds partake of that firmness which is traceable in the egg. All those which are elongated and cylindrical are hollow; but there is no marrow in the tubes, and no part of them is cellular with merely a crust of solid bone on the outside, as is the case in many of the bones of the mammalia. They are all remarkably firm in their texture; and the shape of the bone



is always such as to give the greatest possible degree both of strength and of stiffness with the least possible quantity of materials.

The distinctive characters which are traceable in the covering and contents of the egg, are found in an especially conspicuous manner in the covering of the bird. All birds are covered with feathers ; and they are the only animals which, properly speaking, are so. These feathers are of two sorts,—feathers for clothing, to protect the animal from the vicissitudes of the weather, and feathers for flight. Both of these are beautifully modified so as to suit the different habits of the several species, and adapt them to the climates and the elements in which they find their food.

Some other animals, as for instance the lepidopterous insects—the butterflies and the moths—have a coat of feathers, or rather of fringed or feathery scales ; but these have few or none of the characters of true feathers, and in no case, except that of birds, are feathers the instruments of flight. But still we can, in the imperfect feathers of the lepidoptera, discover one of the uses of feathers in birds better than we can perhaps do in the feathers of birds themselves, as in them it is conjoined with other uses. The study of one animal often assists us in acquiring a knowledge of another, especially when the one contains a single part of that which is a compound organ in another ; because by this means we get an analysis of the living animal, which is far more satisfactory than any that we could obtain by the dissection of a dead one ; for we can, in the one case, actually see the part of the organ in action, whereas in the other we can only infer or guess at the way in which it acts.

Now, every one must have noticed, that bees, flies, and all insects which have membranous or naked wings, must keep those wings constantly in rapid motion while they fly. The motion is often so rapid that the wings cannot be seen, any further than by a sort of tremulous motion in the air ; and the action of the wings produces all that humming and buzzing among flying insects, which makes the summer air so lively ; for insects do not breathe by the mouth, and have no organ of voice of any description. The action of those naked wings upon the air must be very considerable ; because when a common blue-bottle fly (*musca vomitoria*) alights on the window, and marches along one of the dusty bars of the frame, winnowing the air with its wings, in a vain attempt to escape through the glass, it stirs the dust more in proportion than a coach and six driving rapidly along a dry road on a hot summer's day. Insects with wings of this description cannot *hover*, or lean on the air with still and expanded wing.

But the lepidoptera, especially the butterflies, do hover about, and rest on the air, and wheel in various directions, with very little apparent motion of the wings ; and when they do move them, it is done much more slowly than the motion of the naked wing, in proportion to the rate of progressive motion. These lepidopterous wings also move in silence, or when they are brought into such rapid action as to produce a sort of noise, it is a low and muffled rustle, and does not ring out, so that the largest butterfly or moth gets along much more silently than the guat. We may add, as a farther instance of the same kind, that the bats when they fly, are always obliged to winnow the air with their flying membranes, something in the same way as naked winged insects do,

though the flight of bats, unless when they are agitated, is comparatively noiseless. So also those reptiles which fly by means of membranous appendages, are obliged to flutter these very much in proportion to the rate of their progressive motion.

Now the difference of action in these two textures of wings in the other classes of animals, shows us the advantages which birds derive from their feathery covering and feathery organs of flight. These feathers, even to the minutest fibre on the plumes or webs, are tubular, consisting of only a thin film of solid matter, filled with air within, though strengthened by partitions of cellular substance, more or less close together, according to the strain which the feathers have to bear. From the mode in which the feathers, and all their parts, are laid upon the bird, it presents a smooth surface upwards and forwards, so that the animal can move in either of these directions, with very little resistance from the friction of the air. When it moves in either of them, the resistance of friction does not increase so rapidly as the rate of motion; because the pressure smooths the feathers, and causes the air to take less hold on them. This property, which arises in part from the texture of the upper surface of the feathers, but chiefly from the way in which they are formed and placed, is of equal service to birds when they must perch, or otherwise remain at rest so as to abide the blast, as when they fly exposed to it. Perching or flying, when a bird is in the wind it always faces the current; and thus offers the least resistance both by its form and its feathers.

When, however, the feathers are taken in the opposite directions, they offer as much increase of resistance as they offer diminution when they are

taken above or in front. The wings are always more or less hollow on the under sides, and they take hold of the air by millions of fibres ; so that a bird with its flying feathers on the stretch, would fall much more slowly than one would suppose from the difference between its specific gravity and that of the air.

The resistance which all the feathers on the body of the bird offer to motion backwards is still greater ; and it increases with the force which tends to move the animal in that direction. The instant that it begins to be driven backwards so that a current against its body is produced, the points of the feathers rise, and take the wind with so many fibres that the resistance is very similar to that made by a scaly fish, when one attempts to draw one of these by the tail ; and every one who has angled, and accidentally caught even a common trout in that way, knows that an ounce weight is as difficult to land when so hooked as a pound weight is when hooked by the head. But the feathers of birds rise much more in proportion than the free edges of the scales upon any fish ; and they are every way as well formed for " holding on " in the air, as those are for holding on in the water. Thus the bird may be said to resist motion backwards in the air, by throwing out the point of each feather like the " fluke " of an anchor.

And all this curious complexity of structure is necessary for enabling the bird to perform those motions which, in the case of an " air-bird," or one which is much on the wing, and on it in all weathers, is absolutely necessary. We are so much in the habit of seeing birds fly, and they fly with such apparent ease, that we are apt to overlook the many mechanical difficulties that have to be overcome by their organisation. But when attempts have been made by men

to construct flying apparatus, or even to accomplish the apparently much simpler object of directing a balloon, which floats buoyantly without any effort, because it is filled with gas specifically lighter than the atmosphere, the attempters, notwithstanding all their mechanical skill, and even their mechanical science, have found that they would require to go a long time to school before they could accomplish even the most apparently simple of those objects. A flying apparatus, to be moved by the human arms, is, like the kindred fancy of a perpetual motion, a physical impossibility, and the attempt to construct one is one of those absurdities into which men are apt to fall in the infancy of knowledge, when they have vanity enough to lead them wrong, but want the requisite knowledge for keeping them right. Even if the arms could be trimmed to perfect wings, bearing the same proportion to the weight of the human body as those of the bird of most powerful flight have to its weight, there are not in the human body any muscles by which such wings could receive any thing like a flying motion. Then, if that difficulty could be got the better of (which it evidently could not), the spine would bend, the body cant over, and tumble to the ground on whatever part happened to be the heaviest. Or, if this again could be got the better of, man is not adapted for breathing on the wing, and thus the circulation would stop, and there would be an end of the flyer in the very beginning of his flight. In short, it may be said without fear of contradiction that no addition to the human body could make man a flier.

If the study of the structure of birds had no other effect than the preventing of such fancies as these—fancies which, like the other absurdity mentioned, still sometimes occupy time in which the schemer

might do something not altogether useless—it would be worthy of our attention. The author of this sketch remembers, long ago, a case in which a young man, in a small country town, had got so much of the formal or colloquial part of science, that he was looked upon as a prodigy, and, among other things, a very Archimedes in mechanics. Earth could not set bounds to his ambition, and he would needs fly : so, after months of labour, he produced a pair of wings, and, mounting the top of a high barn at his father's farm-yard, spread them for flight, and shot boldly into the air ; but no shot pigeon, or even pig of lead, was ever more true to the perpendicular ; for the wings barely saved him from a very dangerous fall. The consequence of this attempt at flight was not only the loss of all the high reputation which the party had previously enjoyed, but so overwhelming a burden of ridicule that it broke his spirit, and he became literally good for nothing while he lived.

The cases of all who attempt flying by mechanical contrivances may not be quite so disastrous as this one, but they must be all equally unsuccessful. Nor does it appear that the guiding of a balloon, in any other direction than that in which the current of the air happens to drive it, can be more successful. There is no fulcrum from which a purchase can be obtained but the air itself ; and the air presses equally in all directions when still, and in the direction of the wind with a force proportional to its velocity when it blows.

Still the bird, when it flies, overcomes mechanical resistances, and, according to the general law of matter, it must overcome them by mechanical means. The bird, too, is very simple in its form, and certainly

not more complicated in its organisation than the slowest-paced of the mammalia. But the bird, when its habit is to be much on the wing, is all-over adapted for flight, and the system of its mechanics, if we could fully comprehend it, would certainly be the most curious, and far from the least instructive, in the whole of the animal kingdom.

The buoyancy, as well as the upward motion, is not very difficult to understand, because the wing, from its general form, and the structure of the feathers, rises with much less effort than it descends. Thus the constant tendency of the powerfully-winged bird is to mount upwards, and on this account the firmest bird, that which with the same volume of body and extent of wings, has the greatest specific gravity, is the best flyer, flies more steadily, and apparently with less effort. This must, of course, have a limit; because, leaving the incapacity of breathing out of the question, no bird could fly in a vacuum, and thus there must be a certain density of air which is the best adapted for the flight of any given species of bird. This appears, even in the case of heavy birds, to be considerably less than the density of the mean level of the earth's surface. Eagles are heavy birds, even for their powerful wings, and yet they are high fliers, even when their abodes are at great elevations in the mountains. All birds which take long flights fly high, whatever may be their other habits. Wild geese, herons, all birds indiscriminately "take the sky" when they set out upon long journeys. In some this may be in part done to avoid enemies or obstacles, but the habit is too general for being accounted for upon any principle save that the high flight is the less fatiguing. Even rooks may be observed to adjust the height of their daily excursions from the

rookeries, to the distance at which the pasture upon which they are to feed lies; and the swallow tribe wheel about far more rapidly and gracefully when they hawk high before rain, than when they skim the surfaces of the pools in fine weather. If we may judge from their appearance when we see them on the wing (the only means we have of judging), it appears that birds, when they are not in search of any thing upon the ground near them, mount up till they come to that density of atmosphere which is best suited to their weight and wings, and then continue onwards. There may be another reason: those upper regions to which the birds ascend on their long flights are in a great measure exempted from the momentary gusts and squalls which war upon the surface under them.

This buoyancy, arising from the structure of the wings, is a very beautiful portion of the mechanics of birds, but it is one which man would find it very difficult to imitate. The general form of the wing, the characters of the feathers, the articulations of all the joints, the relative power of the muscles, and even the general form and action of the whole body, are concerned in it. They are all living too—all exerting their peculiar animal actions, in unbidden harmony, with each other; for even the feathers are alive, and the skin in which they are inserted can communicate an individual motion to each. Thus the process is one which we cannot analyse so as to bring it within the scope of our very limited notions of mechanics, though there is no doubt that both the compound motion, and all the individual motions, of which it is made up, are in strict accordance with mechanical principles.

The most singular part of the whole process of



flying is, however, the ease with which the bird makes the air a fulcrum, from which to leap, in that same element, and that not only by repeated jerks or efforts, which are characteristic of many of the smaller birds, which thus leap from perch to perch, or from thicket to thicket, but in the case of steady onward flight, in which a few movements of the wings will sometimes send the bird onward for many yards without any other apparent movement ; and such appears to be the impulse thus given, that the bird will sometimes turn, and almost double back upon its former course, by merely altering the inclination of the body and wings, and without any new stroke or effort on the part of these. The spring of the tiger, or the bound of the antelope, though taken from the solid earth as a fulcrum, and effected by what we consider as the most powerful muscular action among the mammalia, is a mere fraction in point of distance compared with some of these gliding rushes of birds in the air ; and it is worthy of remark, that birds cannot take these motions when they rise directly from the ground, or from their perch, but must have a certain quantity of fluttering, or hurried wing motion, to bring them up to their power.

We know that when any thing is projected forwards the resistance from which it is projected must be equal to the projectile force ; for no mechanical force can act in one particular direction only, unless by means of resistance in the opposite direction. Consequently, when a bird gives itself an impulse in the air, in which mere gravitation to the earth can bear no part, for that cannot bear a part, unless the direction is downwards, its body must strike the air backwards with a force equal to that which impels it forwards ; and, if the body of the bird had not a

means of resisting the reaction backwards, it might move its wings both long and vigorously without advancing a single inch. That the bird derives the greater part of that hold on the air, which enables it to take as effective a leap from that element as it could from a solid substance, and even more so, directly by the action of the wings, is true; but there is no doubt that it receives considerable assistance from the general muscular action. When birds are on long and smooth flight, they also acquire a momentum in proportion to their velocity, and the difference between their specific gravity and that of the air. In consequence of this momentum, they continue their progressive motion with much less effort; and the superiority of this momentum, in a rarer atmosphere, may be an additional reason why they fly high upon their long journeys. But there are many birds which proceed by a succession of jerks or leaps, in the pauses of which they are almost or altogether at rest, and these birds can acquire but little momentum, but must renew their whole impulse at every jerk. These are, for the most part, birds of low flight; and it is probable that the greater resistance of the denser atmosphere is as advantageous to them as the rarity of the upper strata is to those species which fly with a momentum. Birds of smooth flight also, however, often shoot onward with great rapidity, after having hovered so long over the same spot, as that all the momentum which they acquired in arriving at that spot must be exhausted; and they must take the whole of their new velocities from the resistance of the air.

The flight of those birds which proceed by jerks affords a good illustration of the fact which has been stated, of there being a buoyant or upward tendency

in the mere motion of the wings in flying. They do not proceed upon a level, but by a series of flat vertical parabolas, each as long as one of the jerks; and the motion is upward while the strength of the jerk lasts, and downward as it weakens. The tail feathers of such birds are also frequently flitted out horizontally, so that the tail may either resist too great an upward motion from the jerk, or act as a parachute against the downward motion.

The head and neck also come into action, both in altering the lateral course of the bird, and in shifting its centre of gravity, with reference to the central line of action in the wings; and the last alteration has no inconsiderable influence in its ascents and its descents. Indeed, a bird when flying is so much in action in all its parts, that it is impossible to point out the specific action of each. Thus we cannot explain the rationale of flight in any thing like a satisfactory manner, and therefore though the operation is not only possible, but performed habitually and with ease, the precise mode in which it is done still remains one of the wonders of nature.

We have made these general observations on the operation of flying and the organs of flight, not only because flying is peculiarly the motion of birds, and the one from which they are named, but also to show how much there is to be learned from the operations of nature, which we all have daily opportunities of observing, and yet upon which comparatively few of us ever bestow a single thought. But it is not from this species of motion alone that we can obtain any thing like a knowledge of birds, neither can we found wholly or chiefly upon it that classification which is calculated to assist us in our inquiries.

The general definition of a bird, at least as depend-

ent on its external appearance, is so simple and so well understood, that the repetition of it would be superfluous. It is a vertebrated animal ; and, be the species what it might, no one could mistake it for one of the mammalia, for a reptile, or for a fish. There have been some mistakes the other way, though they have been but few : in the infancy of natural science bats were considered as a sort of birds : and some of the moderns, who have not had opportunities of studying the physiology of the animal, have made a sort of bird of the ornithorhynchus.

These mistakes show, what we find to be the fact when we make the attempt, that the natural, or even the satisfactory classification of birds according to an artificial system, is no easy matter. The bats were called birds on account of their flying membranes, and the ornithorhynchus because of its mandibles, which are something (but not very) like those of a duck's bill, while both animals had all the essential characters of true mammalia, though mammalia of peculiar form and habits. Thus it appears that neither the bill nor the flight of birds can be taken as the ground of a classification ; as little can the feet ; and the digestive organs merely point out the general kind of food, and not how or where it is obtained.

The feeding of birds cannot be made so good a means of general distinction as that of the mammalia, because many birds are so very miscellaneous in what they eat that no one article can be considered as their characteristic or leading food. And when we take the three leading characters : the bill and digestive organs as the system of nourishment, the wings as the organs of motion in the air, and the feet as organs of motion, we find that not even any two of them vary

according to the same law, so that we cannot form a classification, even upon the relations which they bear to each other.

Thus, while birds are remarkably well defined as a class, while they are among the most interesting of all nature's productions, and while in their individual habits in wild nature, they are more accessible to our observation than, perhaps, any other animals, they are perfect puzzles when we attempt to systematise them; indeed the best that we can do is to go to wild nature, and study them individually in forest, field, or flood.

Their double motion, that of the feet and that of the wings, which is so modified that it becomes the four motions of walking, flying, swimming, and diving, is the chief cause of the perplexity. Some birds, as the common swift, have very little motion, save the aerial one; others, such as the ostrich, have none but the terrestrial one; some again, as the penguins, have very little more than the aquatic ones; and some, such as the pochard ducks, have all the four. Those which have the same kinds of motions have the one or the other predominating in an endless variety of degrees; and the character of the bill, according to the motions which we observe from other species, sometimes agrees more with the one system of motion, and sometimes with the other. All these perplexing circumstances increase the interest of the study of birds, at the same time that they increase the difficulty; and therefore, though none of the systems are quite consistent—that is, though no single character can be carried through the class—there has been no want of systems, or of ability in the formation of them. We have no desire to add another to the number, as the labour would be but of little value,

and in this work out of place; so we shall chiefly follow that of Cuvier, though with some slight variations. The necessity which Cuvier, who had studied the structure of animals intimately, and endeavoured to arrange them according to it, found himself under of sometimes using the bills, sometimes the feet, and sometimes the wings, as the leading characters of his subdivisions, shows very forcibly the difficulty which attends this class of animals.

But before any system can be made intelligible to those who do not already understand the subject, we must give some explanation of the structures and functions on which the systematic arrangement is founded; and this will be rendered more easy of consultation by marking it off into portions under separate titles.



## CHAPTER II.

### GENERAL STRUCTURE AND FUNCTIONS OF BIRDS.

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#### THE HEAD.

THE head of birds is in general small in proportion to the whole animal ; and the jaws are produced and terminate in horny mandibles, which are placed horizontally, forming the bill ; which, excepting in those species that kill prey, is the chief or the sole instrument in feeding. The bill varies much, both in the form and in the consistency of the mandibles. In some it serves as a pair of strong pincers for tearing flesh ; in others it is a spear for transfixing ; in others again it is adapted for hewing into timber ; or it is fitted for boring into the ground or for dabbling in the sludge at the bottom of shallow waters, in which cases it is understood to have a sentient covering, so that it can both find and seize the food. Sometimes it is borne open as the bird flies, and catches insects as in a net ; in other cases it catches by snapping. In some it is fitted for breaking the hard shells of fruits ; in others for cleaving pulpy ones, or raising the scales of cones so as to get at the seeds. The modes of using it are indeed exceedingly varied ; for birds are almost universal feeders, both in regard of substance and of situation ; and wherever a bird's food is to be found, there is generally a bird to eat it, and the bill of that bird is always very well adapted for taking it. But the office of the bill ends with the

prehension of the food, or the dividing of it into such portions as can pass the gullet (which is generally capable of considerable distension) into the stomach; and there is no mastication, or chewing by the mouth, of birds, and no apparatus for the performing of such an office.

The organs of smell, sight, and hearing, are placed in the head; the nostrils at the base of the bill, in the substance of it, or even near its extremity, according to the habit; and they are variously defended by feathers, hairs, scales, and valvular membranes.

The eyes of birds are placed in the sides of the head, generally speaking better adapted for seeing under them or laterally than above them or directly in front. But the position varies with the habit: birds which prey only in clear light and under them have the eyes far apart, and shaded; while those which prey in the twilight have them turned more to the front. The eye is better fortified than in the mammalia; the anterior part of the ball has a circle of bone; and there is a nictitating membrane, or third eyelid, which, when not used, is protected from the action of the weather by a lodgment in the inner canthus of the eye. It is thus more soft and moist than an exposed eyelid, and it works over the whole eye in a direction crosswise to the usual opening. The cornea of the eye is very convex, and beautifully clear; but the crystalline lens is rather flat. The eyes of birds are in many instances much more exposed to the action of the weather than the eyes of most other vertebrated animals, and they appear to be the organs of sense upon which birds have their chief dependence; and, true to the general law of nature, that the supply is always proportionate to the want, they are furnished and fortified in an extraordinary manner.



The ears of birds, within the bones of the head, are well formed ; but, with the exception of nocturnal feeders, which are, of course, much guided by the ear, they have little or no external concha. The nocturnal ones (the owls especially) have external ears ; but the openings of the ears of all birds are concealed by feathers, generally of a more downy character than those on the neighbouring parts. These protect the ear from the violent action of the air when the bird is in rapid flight, and also preserve a uniform temperature in that delicate organ.

#### THE NECK.

The neck of birds does not, like that of the mammalia, consist of the same number of vertebræ in all the species, but varies much according to the habit of the bird. In some it is very long, and in others moderate, but in all it is susceptible of much motion, and of motion in all directions ; so that, generally speaking, the point of the bill commands the whole space within reach of the extended neck, and also all parts of the body of the bird. The vertebræ are also articulated in such a manner as that the greatest and most rapid flexures of the neck do not in the least disturb the spinal cord or the circulation in the blood-vessels. Neither does it, generally speaking, interrupt the breathing by the windpipe ; though, as will be explained in another section of this article, the breathing of birds is not wholly performed through that organ.

As the bill of very many birds has to perform the functions both of a mouth and hand, it becomes necessary that the neck should be, in some respects, an arm ; and it is a very convenient and efficient one. The extent to which it can bend, not only without

injury to the bird, but with perfect ease, is proved by the fact, that most birds repose either with the neck doubled back upon the shoulders, and forward again on itself, or with the head placed under the wing. Many of the long-necked birds carry a fold of their necks upon their shoulders while they are in ordinary flight, though they stretch them out in case of alarm. The rapidity of motion, both in long necks and in those of moderate length, is exemplified in the strokes of the heron and the bittern, and in those of the woodpecker, which follow each other so fast, that the eye cannot see them, or the ear count their sounds. The rotatory motion of the joints of the neck is seen in the wryneck, which can turn the head quite round, till the chin and point of the bill are in the same line with the middle of the back.

The head and neck of birds, taken together, may, in the average of the class, be considered as the working apparatus, in the finding of food, the constructing of nests, and, generally speaking, in all mechanical operations. Their forms are of course as varied as the habits and haunts of the owners, being, in all cases, the best adapted to them; and therefore they do not admit of general description, though they are good characters of tribes and species, as indicating how and where the food is obtained. Independently altogether of their uses, in enabling us to obtain a rational knowledge of birds, they are valuable subjects of contemplation, as perfect models of mechanical arrangement, and most striking proofs of purpose, and the perfect accomplishment of purpose, in creation, which, labour as we may, will always present us much beyond our power of imitating, and may well command our admiration. And here we cannot help pausing to remark (for though the remark would occur to the

reflective reader, we are unwilling that he should rob us of the pleasure of making it : as enough remains for him, and what we state may lead the unaccustomed to reflection)—how superior the models which we find in nature, are to those of human contrivance. We study the latter ; we soon find out all their principles ; and there, in so far as we are concerned, instruction, and with that mental pleasure, ends, so that, be it the steam engine, the chronometer, or any other *chef d'œuvre* of science and art combined, the mental improvement and pleasure are soon at an end ; and we have nothing but the cold consideration of money value, and utility, which, however necessary to our bodily existence and comfort, is always blight and mildew to the mind when uppermost there. Or, if we carry our observation further, we find faults and imperfections which we cannot remedy, and these spoil our enjoyment.

But when nature is the model, we find no fault or imperfection, and we never can exhaust the information which it affords. The Macedonian conqueror is said to have wept when the world was won ; but if he had followed out the path of his tutor the Stagyrte, so far as to study the mechanism of the head and neck of a bird, he would have found, in that single specimen, a world of wisdom which he never could have conquered. There is not a projection or a hollow in all their curiously-shaped bones, or a tube, or membrane, or a fibre, in all the soft parts with which they are invested, but has its use, and is more beautifully adapted to that use, and fashioned with more perfect economy, than the most finished production of human skill. The motions which the point of the human finger can perform are almost infinite to our arithmetic, but they are nothing compared to

those of the point of the bill in some birds ; and when we consider that, by the aid of its other mechanism, and without any apparatus but what God has given it in its own structure, it will strike prey under the birch in Lapland, and again perform the same feat under the palm by the bank of the Niger, before the same spot of earth has thrice seen the sun, it is passing wonderful, and should, even under the worst of the little casualties of life, make us grateful to God for giving us such things for our contemplation.

#### THE BODY, OR TRUNK.

The body of birds, that is, the dorsal and the lumbar portion of the spine, upon which the body or trunk may be said to be articulated, has no specific action to perform in what may be termed the working motions. Hence, though it is composed of vertebræ, and by that means less liable to fracture than if it were a single bone of the same substance, the vertebræ admit of little motion, most of them are soldered together, and some of the junctions in time become ossified. It is the same with the sternum or principal bone on the under part. That is very large, and consists of five bones, which are closely united from the first, and ultimately soldered into one. One of these occupies the centre, two the sides anteriorly, and two posteriorly, the latter being forked at their posterior edges, though in some species the terminations of the forks are united by bone. The sternum in birds is a very important bone. One of its uses is to support the muscles which move the wings in flying ; another to protect the contents of the body from injury or pressure from beneath, and a third to give support and firmness to them. From the number and

importance of these uses, the sternum of birds is of no small value in the distinction of the different tribes; and on that account we shall have to revert to the notice of it in another section.

The furcal bone, or "merry-thought," formed by the union of the clavicles, and attached to the two projecting processes of the coracoid bones, keeps the shoulders apart from each other, and in their proper places during the powerful action of the wings in flight. The more powerful the flight of the bird, the more completely does this bone form an arch, so that it resists that compression which might otherwise take place in the throat and chest. Its form and strength vary much with the habits of the different tribes.

The bones of the pelvis advance considerably forwards; but they are open in the rear for the passage of the eggs. They and the bones of the rump are closely united together. The ribs, too, have very little motion, so that the operation of breathing alters the form and capacity of the body much less than in the mammalia. The greater part of the body may be regarded as a sort of box formed of bones, not breaking by slight pressure (as a box composed of one bone would be apt to do), but still very firm and stiff, stiffer anteriorly in those birds which fly much and powerfully, and more produced, particularly both in the sternum and the ribs, in birds which swim and dive. As a whole, it may be said to admit of no lateral bending; and the little that it admits of in the vertical direction is confined to the lumbar vertebræ.

## THE TAIL.

The bony part of the tail of birds is generally

short, the effective tail, as an organ of flight, being composed of feathers ; but in all birds which have much motion of the tail, the number of vertebræ in that organ is considerable, though each individually is very short, and the whole tapers to a point.

#### THE WINGS.

The wings, or anterior extremities of birds, which correspond in position to the arms of man and the fore legs in the mammalia, are adapted for flight only, or, if they perform any other office, it is merely that of balancing. Their general action in flight has already been partially mentioned ; their several parts, as they appear externally, will be mentioned in the next section ; and their peculiar forms, as adapted to the different habits of the various tribes and genera, will be found in the accounts of these, under their respective names. We shall here only mention, therefore, that the bones of the moveable part of the wing consist of a humerus, a fore-arm, and a hand ; the part answering to the fingers of the latter being very much elongated, with only one finger fully developed, but the rudiments of the others more or less apparent, according to the power of action in the wing. The flying feathers are placed upon these bones, and the thumb generally carries a little plume of stiff but short feathers, which is called the bastard wing, and in some species it is armed with a claw or spine. The head of the humerus is articulated nearly where the scapular bones, which are embedded in the muscles on the shoulder, the coracoid bones which proceed from the anterior parts of the sternum, and the furcal bone, or united clavicles, which projects as an arch in front of the breast, protecting the vessels of the throat, at the same time

that it keeps the heads of the coracoids and scapulars in their proper places, meet each other. The shoulder-joint, or articulation of the humerus, which is the centre of the grand action of the wing, is thus placed on the firmest of all supports—a tripod, which is the only number of supports that will form a sure base upon all kinds of surfaces. In birds of the most powerful wing, these three supports divide the space round the articulation into nearly three equal parts, and they do not differ much in strength; they all “give” a little, so that the joint is not nearly so liable to dislocation as if the point to which it is articulated were fixed; neither is there so much danger of fracture or of concussion to the vital parts by any sudden jerk given violently to the wing.

It is one of the most beautiful parts of the structure of animals, that those organs which have to perform the most violent motions are never directly articulated on an immoveable base, or a base immediately in contact with the spinal column, far less with the bones of the head. There is always the play of a slow-moving joint, or union of some description or other, between the articulation of the moveable bone and that bone which encloses the nervous mass. By this means that mass is made to ride smoothly while the animal leaps, or bounds, or flies, or otherwise acts powerfully and irregularly; just as the springs of a carriage enable those within it to ride smoothly, notwithstanding the jolting of the wheels upon an uneven road.

The scapula, or blade-bone, has less motion in birds than in mammalia, because, with the exception of those mammalia which have flying membranes, the motion of fore-legs is crosswise to that of wings. In the bat tribe there is a slight approximation to

this species of insertion of the humerus in the large clavicles and blade-bones. In those mammalia which use the fore-legs for progressive motion only, there are no clavicles, and bears and other hugging animals have them cartilaginous at both extremities. So that the absence of clavicles indicates motion in the direction of the mesial plane only ; and their presence, motion across that plane.

Some of the birds which can fly, often use the half-expanded wings to assist in balancing them when they run ; and this habit is most frequent with those that have the legs long. Some of the birds which cannot fly, have rudimental wings, which they appear to use for the same purposes. The only bird which has the wings so perfectly rudimental and concealed within the integuments as not to be of any use in



Apteryx.

balancing, is the Apteryx : and it has the legs very short and stout, and, though its habits are not known, it is probably not much of a runner.

Those short-winged birds which dive under water, whether they tread the water itself by means of webbed feet, as is the case with the diving ducks, and divers properly so called, or tread the bottoms



of the shallows with feet that have the toes free, as is the case with the dipper, use the wings in the water. But wings are not very efficient instruments of progressive motion either on the ground or in the water, though they are of advantage in balancing on land, and in ascending or descending in the divers. All wings, whether perfect or imperfect, are formed and articulated on the same general plan; and though they admit of a little inclination to the front or the rear, their principal motions are always across the axis of the body.

From what was formerly said of wings acting more efficiently in an atmosphere rather rare than in a denser one, it follows that they must act still less efficiently in water than in the densest atmosphere. Indeed water is so nearly of the same specific gravity with the bird, that an action of the wings analogous to that of flying in the air, could not possibly be performed in the water. Air—the free air of heaven—is therefore the proper element for wings, and their proper function is flying; so that any other which they may perform must be regarded as a departure from the typical character of a bird, of which feathered wings are the grand external characteristic.

#### THE FEET.

The posterior extremities, or feet, of birds, are their chief organs of progressive motion, and their chief supports when at rest, upon the ground or other solids. But the feet perform more operations than the wings. In some birds they are used for clutching or killing prey; in others for scraping in the ground for food, and also in the digging of burrows and the preparation of other places for the depo-

siting of the eggs ; in others, again, they are used as a sort of hands in climbing, in which operation they are in some species assisted by the bill ; and in others still they are occasionally used in conveying the food to the mouth, or in holding it while it is preparing for swallowing, by the action of the bill. They are also varied to suit the kinds of surfaces which are frequented by the different tribes ; and they serve as stilts for wading, and as paddles or oars for acting in the water. The general characters of the foot and leg of a bird are so well preserved through all their almost innumerable varieties of form, that there is no danger of mistaking them for the feet of any other class. The feet of some of the reptiles resemble them the most ; but still the shape, the articulations, and the covering, even in the part of the bird which is not feathered, are all or each sufficient for distinguishing the one from the other.

The feet of birds are the organs of one of their most important motions ; and thus they are made one of the grounds of that very imperfect classification which science has been enabled to make of the feathered race. As the bill is a sort of guide to the species of food ; and the wings to the kind, style, and partially to the purpose of flight ; so the feet are a sort of guides to the home and habitation of the bird, and also to the place of its feeding, if its habit be not to feed on the wing ; and whether that is its habit or not, can, in some degree, be determined by the characters of the wings and the bill. Birds which habitually feed on the wing have, in general, pointed wings, and can wheel and turn on the tips of them, whatever may be their other characters ; and they have generally either a wide gape or a powerful and rapid action of the mandible, so as to catch their prey by snapping.

The leg and foot always consist of three principal pieces, independently of the toes : the femur or the thigh-bone, the tibia or leg-bone, and the tarsus or foot-bone. The tarsus, like the bones of the wings, answering to the palm of the hand, is always very much elongated; and it is popularly called the leg, though in fact it is the foot. Birds, in general, follow the same law as the mammalia in the use of their posterior extremities as organs of walking; they are digitigrade, or walk upon the toes, and not on the tarsus; and those which walk upon the latter have even a more awkward and shambling gait than the mammalia which have that habit; indeed they can hardly be said to walk at all. The knee joint, or articulation of the tibia with the femur, which bends forward only, appears to be inadequate to the balancing even of a nearly inflexible spine in any but a nearly vertical position. In man we have a flexible spine, balanced with the whole length of the tarsus on the ground, but it is in an erect position; and besides there is the astragalus or heel-bone in man, which not only sustains the balance of the foot, but gives a lever power to the *tendo Achillis*, which, when pulled by the strong muscles to which it is attached, throws the pressure of the body upon the balls of the toes. The human foot is not, however, a fit subject of comparison with the feet either of birds or of the mammalia.

Those birds which bring the whole length of the tarsus to the ground when they walk, or attempt to walk, are but few in number; and they are all aquatic birds, the proper functions of whose feet is swimming and not walking. Their legs are articulated far backward, and they have an oblique motion of the joints for throwing the swimming feet at some dis-

tance from the body. They spend most of their time, and find the whole or nearly the whole of their food, in the water; and such of them as have not the power of flight (for some of them are so exclusively aquatic that they can neither fly in the air nor walk on the earth) deposit their eggs near the margin of the water, so that their terrestrial operations are limited to shuffling along a few feet, or sitting erect upon the rocks, in which latter, and even in the former, the tail assists in supporting them, as is the case with beavers when they stand up.

The head of the femur is articulated rather farther forward in walking birds than in the mammalia; and the femur itself is not so free or so much used in the motion of the leg. The tibia, or true leg, is the part usually called the thigh, or in the larger birds, which are brought to table, the drum-stick. In birds which make much use of their feet, the tibia is much loaded with muscles; and it is generally protected by a profusion of soft and downy feathers, especially in those birds which are much exposed to the weather, and use their toes in clutching or killing their prey.

Many of the wading birds, and some of the running ones, have a portion of the under end of the tibia bare of feathers; but the muscles do not descend so low as that part; and it may be considered as a general arrangement in the structure of birds that the muscles are always under a protecting covering of feathers.

The tarsi and toes, and also the naked portions of the tibia, contain few or no muscles, but are made up of bones, tendons, straps of ligaments for keeping the tendons in their places, and the integuments, which are very firm and tough skin, variously covered

with scales, sometimes imbricated and sometimes reticulated; and there are often pads on the under part of a consistency not very unlike caoutchouc, or Indian rubber, and nearly as elastic and as difficult to wet as that substance.

The toes on the foot, three before and one behind, may be regarded as the normal number in the order; but they are fewer in some of the running birds, and more numerous in some of the other orders. The toes, however, vary so much in the manner of their articulation, in their size and power, and in their appendages, that they do not admit of general description. The toes are the portion of the foot usually taken as the ground of systematic arrangement; though as the principal muscles which move the toes are not in the toes themselves, or even in the tarsus, the whole leg would be a better indication of the habits of the bird; though, being a more complicated structure, an arrangement founded upon it would make the elements of the system apparently a little more difficult. But the difficulty would be apparent and not real; and it is very probable that, if we included a little more character, and thereby gave a little more meaning, to our larger divisions of the several classes of animals, we would both shorten and smooth the road to that accurate knowledge of the individuals, which is the most valuable, and indeed the only valuable, part of the whole. The other method, that which takes but one portion of an organ as the ground of resemblance, is simple only in proportion as it teaches little, and simplest of all when it teaches nothing.

## CLOSING OF THE TOES.

In all birds, the bending of the tibial and tarsal

joints has the same effect in the contracting of the muscles which close the toes. This may be seen in those birds which draw up one of their feet, either to warm it, or to rest on the other; for the toes of the foot which is drawn up are always clutched together, and to open them out with the foot in that position requires an effort. It even requires an effort in the bird to keep the toes expanded. When it rests its weight on the feet the weight causes the effort; but the toes of a dead bird are always partially closed, which shows that a muscular exertion is necessary for keeping them open when that is not effected by the weight. When the bird is dead, the muscles, which act both ways, are of course equally rigid, and the toes close, to the degree at which the living muscles would balance each other, and the leg be in a state of repose.

This tendency of the foot to close when the leg is bent is effected in a very simple manner: the tendons of the contracting muscles pass over the outsides of the bent joints, and those of the extending ones over the insides; so that, by the bending, the former are pulled much in the same way as if their muscles were contracted and the latter are slackened in the same way as if their muscles were relaxed.

All feet which bear on the ground with jointed toes, and partially even those which have hoofs, possess this property, though few of them possess it in the same perfection as the feet of birds.

And when we consider the difference of habit between clutching, climbing, and perching birds, and quadrupeds which have actions somewhat similar, we can at once see that this property is most necessary in the feet of the birds. Mammalia which clutch prey with their paws have a point of rest for their

other feet, either on the body of the prey, or on some other solid substance; and even in those climbing mammalia which are the most dexterous leapers, the spring is taken from the hind feet, and the grand use of the fore ones is to catch hold at the end of the leap. In slower climbers the one set of extremities are always fast while the others are extended; and in the few mammalia (such for instance as the sloths) which may be said to perch, the proper perching apparatus is hooks so formed by the claws and toes that the requisite shape is preserved by stops of bone. Thus, as the flexible spine of the mammalia requires to be borne up by two sets of supports, when it is in a horizontal position, so when they are in action they may be said to have always two points of support upon the ground or other surface which bears them up, a fore and hind one, of the opposite sides, alternately, when they walk; and the two fore and the two hind ones alternately when they bound and leap. The former of these actions is confined almost exclusively to the legs and feet, but in the latter the spine comes more efficiently into play, as may be seen in the leaping of the cat tribe or in the coursing of a greyhound.

Birds deriving no support upon solid surfaces from their anterior extremities, and having no action of the spine to assist them in leaping, and yet having to perch, and not only poise themselves, but find food, construct nests, and perform other operations upon perches far more unstable than any upon which the mammalia have to rest, must be more sure-footed in proportion. The slender sprays of trees, the flexible stalks of herbaceous plants, and all sorts of substances, not only of a yielding nature in themselves, but exposed to the violent action of the winds, by

which both perch and percher are rocked at no moderate rate, are all pathways to one race or other of the feathered tribe. Nor, though at first sight such seems to be the case, is that the footing most difficult to be maintained ; for, upon a bending twig or stem, the perch and percher soon acquire the same momentum, swing together, and have no more tendency to separate than water has to escape from a glass, when that glass is set in one side of a hoop, and the hoop whirled rapidly round on the opposite point. This concert of motion, as we may call it, is general in mechanics, and the application of it is of great service to all birds which feed or repose on perches of the description alluded to. It is the resistance of the bottom and sides of the glass to the centrifugal force of the water, and the resistance of the hoop to the same force in the glass, which keeps these three together, or in concerted motion ; and in like manner when a bird is rocked in the spray, all that it has to do is to resist its own centrifugal force by the clutch of the feet.

But when the bird has to perch on the pinnacles of the rocks, as is the case with the mountain eagles and some of the other mountaineers, and also with several of the more predatory and powerfully-winged sea-birds, it has not the advantage of concerted motion along with its perch, but must either abide at rest, despise the tempest, or drift before its fury. The habitations of those species which sit on the pinnacles of rocks are the very homes of the tempests ; for winds war upon rifted shores and among rugged mountains when the expanse of the sea and the plain are still. Not only this, but these birds live much upon the havoc which the tempest produces among other creatures ; and thus it becomes necessary that



they should be enabled to remain on their watch-towers, and mark its progress. But here, as in all other cases, the purpose of nature is accomplished, and accomplished by apparatus the most effective, and at the same time the most simple.

It is chiefly by the pulling of the tendons which close the toes, by the mere action of bending the joints of the leg, that this firmness on the perch is maintained. Their tendons pull all the phalanges of the toes; and thus the same action, and that not a muscular exertion, which would tire, but a state of greater repose than when the legs are not bent, enables the bird to hold on with the whole foot, and the hold taken by the elastic pads and tubercles is far more firm upon a hard substance than if it were taken by means of claws. The rock perchers also, in general, use their claws in clutching and killing their prey, so that they could not be used in keeping the perch without blunting their points, and thus unfitting them for their proper purposes; neither could a hold merely by means of the claws be kept for any length of time, unless the hold were above the body, and kept by the pressure of that. All perchers by the claws for repose perch with the back undermost, or at least in such a way as that the weight hangs upon the claws as upon hooks, the form of which is maintained either by stops of bone, or by the weight of the dependent body pulling the tendons, and the firmness is given wholly by the latter.

Those provisions for the secure maintenance of their place, in animals, arising from structure merely, and not requiring any muscular exertion, or other effort on their part, which can in any way fatigue them by its continuance, are among the most striking instances of that superiority of design and adaptation

of which every thing that nature produces is an example. We know, from our own case, that if even a single muscle of the system, except those which are employed in immediately carrying on the vital functions, be exerted, not one part of the body, far less the whole of it, can be in that state of repose which is necessary for enabling the active system to recover its tone. With us, an easy position on the couch, in the chair, on the grassy sod, or on the bare earth, according to the habit, and the need that there is for rest, is the position for repose; and if we were to attempt to sleep, clinging by the hands, or in any other way in which our mere weight is not the means by which we retain our position, we should assuredly fall. But birds have to repose in all varieties of situation, and their means of keeping their places are increased and varied accordingly.

## ALIMENTARY SYSTEM.

IN their alimentary system birds are variously formed, according to the general nature of their food. If that food is wholly animal, their stomachs are simple and membranous, and their intestinal canals short, and without cæca. If wholly vegetable, the stomach is more complicated: one part, which is styled the craw, and which is little else than an enlargement of the inferior part of the gullet, being a sort of receptacle into which they can take much more food than the bare stomach can at once receive for the purpose of digestion. In this respect it bears some resemblance to the paunch, or first stomach of the ruminant mammalia; but as birds have no chewing apparatus in the mouth, the food taken into the craw does not return to the mouth, but proceeds into the stomach portion by portion, as the progress of di-

gestion requires. The craw of these birds is generally placed in front of the sternal bones, so that it can admit of distension by a large quantity of food without disturbing the other viscera, or requiring any enlargement of the bony cavity of the body to admit of its distension. Even this position of the craw, which at first seems a very simple matter, is attended with considerable advantage to the bird. The habits of birds require that the size of their body should be as small as possible, and that the capacity of it, as determined by the bones of the trunk, should be as uniformly the same as possible. Now, if this craw, which, as a magazine of food, is sometimes empty and sometimes much distended, were lodged within the bones, it would either press in an inconvenient manner upon the other viscera, when full, or it would leave a vacant space in the cavity of the body when empty. Either of these would be attended with inconvenience, as the pressure on the viscera would disturb the functions, and render the bird inactive, and the additional space would require an enlargement in the cross section, and thus cause the bird to oppose more resistance to the air in proportion to its power of flying, and thereby to the same extent diminish that power.

The avoiding of the same inconveniences requires the existence both of the craw and the true digestive stomach as separate organs. Vegetable food contains much less animal nourishment than animal food, and in many birds there has to be as much and as severe labour used in the procuring of it. The waste of substance, and the necessity of food, is in all animals in proportion to their activity; therefore active vegetable-feeding birds must take a proportionably greater quantity of food than animal feeders of the

same activity. This is well exemplified in the case of pigeons, and also in that of all the finch tribe, which are active birds, and also very vegetable in their feeding.

If this excess of food were taken into the stomach at once, and that stomach lodged within the cavity of the body, the same inconveniences would arise as if the craw were situated there ; and the stomach itself, as containing a greater quantity at once, would either require to be more powerful, or it would perform the function of digestion less efficiently. But, with the addition of the craw as a reservoir, the gizzard, or muscular stomach, which may be said to perform the operations of both mastication and digestion, can afford to be smaller ; and this, besides making the organ more efficient, with the same exertion of muscular energy, leaves room for the greater length of the intestinal canal, and for the cæcal appendages which are necessary in extracting the chyle from the vegetable aliment.

Thus we see that, in the structure of the alimentary system in these birds, there is the same evidence of wisdom of purpose, and perfection of execution, as in that of their external organs. These advantages are not confined to the mere convenience of that system in which they are found. The advantage goes to all the habits of the bird. In birds, as well as in mammalia, the vegetable feeders are the chief prey of the carnivorous ones, and thus they require to be on the alert, and capable of making their escape at all times when their enemies are abroad. But if they took into the true stomach, and had subjected to the process of digestion at once the great quantity of food which is required for their support, they would, as in the case with birds of prey, be incapable of

flight, or, at all events, indisposed to it, after a hearty meal. Their food they must take during the day, and not after dusk, and yet it seems that they require the digestive process to be going on constantly; and thus the moderately-sized gizzard, and the supply in the craw, are remarkably well adapted to their habits; so that, after taking an abundant supply of food, they are nearly as fit for flight as when they are empty.

The carnivorous birds, especially vultures, and other species which feed upon the carcasses of the larger animals, when these are killed by other casualties, are remarkable for the opposite structure of the alimentary system, and for indolence after a full meal. Their stomachs are membranous and simple, and their intestines short, and without any cæcal appendages, so that the process of digestion is with them a much more simple matter. But when they have made a hearty meal, the full stomach presses upon and retards the action of the other parts of their viscera, or, at all events, the process of digestion monopolises the whole of their energy; so that, though birds of long and powerful flight when hungry, they are so reluctant to take the wing after feeding, that they may be knocked down with a stick, or taken with the hands, without making much resistance.

Their power of enduring hunger seems to be in proportion to that of taking food directly into the stomach, and converting it into nourishment by a more simple apparatus; and, unless when they are forced from their retreats by hunger, they are far more retired and uiet than the vegetable feeders. The same analogy holds between the carnivorous and the herbivorous mammalia,—the former come abroad only at particular times, the latter are habitually upon

their pastures, and their hunger begins when the receiving stomach is empty, or nearly so.

Birds which are exclusively vegetable in their feeding, and those which are exclusively carnivorous, may be regarded as the extremes of the class, in so far as the alimentary system is concerned. The former have that system largest, most complicated, and most constantly in action, and the true stomach always a gizzard. The latter have, in proportion to the general size of their bodies, the alimentary apparatus smallest, and also the most simple,—acting readily, but acting, or requiring to act, only at intervals; and they have the stomach always membranous.

Those vegetable feeders that live much on seeds and in temperate climates, which is the case with the majority, require an auxiliary to even the muscular action of the most powerful gizzard, in order so to grind and divide the food as that the gastric juice can act upon it. For this purpose they swallow small stones and gravel; and it has been observed that some of the gallinaceous birds were kept in equal condition and in better health upon much less food when they had access to those auxiliaries. It is not improbable that a small quantity of resisting matter may help the digestion of all stomachs; and that it is upon this principle that brown bread is more digestive by the human stomach than bread of the finest flour, from which the whole of the husky matter is separated.

Intermediate between those two extreme forms of the digestive system in birds, there are many modifications, adapted to all varieties of food. Some of them have the stomach more membranous toward the one extremity, and more muscular toward the other; in some the character of the stomach is par-

tially changed by long continuance on a different kind of food ; and it is by no means improbable that, in some of those species which live in great part upon insects at one season of the year, and chiefly upon vegetable substances at another, the stomach may undergo seasonal changes.

In proportion as any animal, whether bird or not, is more vegetable in its feeding, its abdomen, in a natural and healthy state, is always the more bulky in proportion to the whole body. This is very conspicuous in the mammalia, (in which the size and distinctions are more easily seen,) in which all the grazing tribes are full, and all the carnivorous ones lank in the belly ; but it holds also in birds, though in them it is less conspicuous, as the whole body is covered with feathers, and the several parts are not so easily distinguished from each other. If, however, we attend carefully to the outline of their forms, we may, in most cases, discover a greater uniformity of thickness throughout in the vegetable feeders. This appears not only in the larger birds, in which the difference of other habits may be supposed to have some effect, but even in the small birds.

Generally speaking, too, vegetable feeding birds are not so well winged as those which feed upon animal matters. All the gallinaceous birds are heavy, comparatively bad fliers, and take only very low and short flights ; while the birds of prey are among the most powerful fliers in the whole class ; though even these are perhaps not so constantly on the wing, or so very long flighted, as some of the tribes which feed chiefly upon insects. In accordance with this formation, the vegetable feeders are not so regularly migratory. Some of them, indeed, change their abodes to considerable distances within the same

countries ; but they do not so frequently cross the seas, or range so far in latitude in their migrations.

The vegetable feeders and the animal feeders, among the mammalia and birds, agree with each other in the feeding in the two races, and differ from each other in the different feeders of the same race, in other respects. The vegetable feeders are, in almost all the genera, more or less gregarious, both in the one class and in the other ; and when they migrate, they generally migrate in flocks, often in flocks containing immense numbers. The passenger pigeons of America, and also some of those which migrate seasonally in the longitudes of the east side of New Holland, New Guinea, and the Molucca islands, appear in numbers far exceeding those of any migrant birds of other regions or other species ; and some of those which belong to the latter migration are as gay in their plumage as the parrots, or any other of the finest birds of warm climates. The males are also more polygamous among the vegetable feeders ; and it is among them chiefly that they fight battles of gallantry, though many of the omnivorous ones agree with them in these, and also in some other of their characters.

That increased energy of character, which more or less affects all birds in the pairing season, appears to affect the different feeders in a different manner. Their breeding plumages are much more gay, as compared with the ordinary dress throughout the year, and the naked skin upon the head blooms into more brilliant hues. The eagles and hawks, which are the most carnivorous of the whole race, show the least change, either in colours or in manner, at that season ; but the vultures, in which there is a slight approximation to the gallinaceous charac-



ter, and a more decided one to the omnivorous, show a little more seasonal change ; and, though race after race is constantly breaking in and destroying the regularity of the gradation, there is an increase of change till we come to those families which may be said to bloom and fade yearly, something after the manner of plants.

It is these breakings in of one tribe of birds upon the characters of another, which makes the systematic arrangement of this class of animals so uncertain and difficult ; and the more that we study them, nay, the more intimately and accurately that we become acquainted with them, the less hope have we that any future knowledge can remove the difficulties. The four systems—the food and the three habitats—air, land, and water, present themselves in such varied combinations and proportions, that the conclusion which we might very fairly draw from one character is barred by an opposite one, which follows as naturally from another ; so that we cannot have a chapter of the inductive results of our observation of birds without an appendix of exceptions of still greater length.

But, though we must receive it with exceptions and limitations, there is still observable in birds, according as they depart in their general characters from the rapacious ones, an increase of seasonal change, connected with that energy, which is awakened at the pairing time ; and though the individual characters of this change vary exceedingly, there are two great and not very badly marked divisions of it, the one taking place in those birds which are more vegetable in their feeding, and the other in those that feed more upon insects. In the former, it displays itself in greater brilliancy of plumage, and more

intensity of action generally, especially in the male birds; under the latter it displays itself more in change of place. Not a little of the character of birds, both in themselves, and also as they are by analogy (which they are largely and accurately), indices to the rest of nature, might be worked out upon this principle; but, even though the length of this section did not threaten to exceed all wonted bounds, in treating on the same subject, this is not exactly the place for it. We still want the elements, in the accounts of the modifications of character by the feet and the wings, and also of the bill, as the grand prehensile organ in the feeding system. We shall therefore only further remark that much of the character of the different tribes depends on the varied development of this seasonal energy; and that the character thus produced is much modified, according as the energy is more marked off in the locality which the bird inhabits when it is at first exerted, or prompts it to migration to a distant region.

#### CIRCULATION AND RESPIRATION.

The systems of circulation and respiration, in birds as in other animals, are closely connected, though not so much so as in the mammalia. The circulation in both is performed by means of a double heart, consisting of two ventricles for propelling the blood, and two auricles for receiving that fluid on its return; and connected with these, as in all animals that have the heart double, there are two sets both of arteries and of veins,—a pulmonary set and a systematic one. The circulation is, as has been hinted already, more rapid in birds than in the mammalia, which agrees with the greater violence and longer continuance of some of their actions. But though these more violent

actions,—such as coursing on two feet, as fleetly as antelopes do on four and with the aid of the flexible spine and its muscles, as in the ostrich, plunging into the water like the gannet or the cormorant, dashing through that element like the divers, cleaving the air beyond comparison with all terrestrial speed, as in the falcon, the swift, or the pratincole, or breasting the tempest with the majesty of the eagle, require, and are furnished with a supply of blood, proportional to the waste which their great energy must occasion; yet they are by no means so well suited to an equally rapid breathing by means of lungs. But the application of renovating air to the blood must, in all animals, be proportional to the circulation, and, among vertebrated animals, it is only the reptiles and fishes which have the temperature low and the circulation lagging, and which spend much of their time in a state of comparative inaction, that can carry on their systems in a healthy state with only a partial aeration of the blood.

If the subject is considered according to our plans in contriving and executing, there is thus a difficulty to be overcome in the case of the birds, similar to which nothing occurs in that of any of the other vertebrated animals. They stand more in need of the action of the air than any other animals; and their habits are such that they are less able to bear even the same action, by means of the ordinary apparatus of lungs.

Now this is one of those difficulties which human wisdom could never see the means of overcoming, except in the accomplishment of the very object, the means of accomplishing which are the subject of inquiry; and therefore it is wholly above the reach of the human powers, and in itself a perfect demon-

stration that the works of creation must have originated from One omniscient in knowledge, as well as omnipotent in action. But though in this, as in all other cases, we could never have fathomed the purpose of the Eternal, without the example which he has set, yet the lesson held forth in that example is, when scanned with even a moderate degree of attention (a degree of which any human being is competent), so plain and simple, that a child may understand it. It is the same with all nature ; and if the vain affectation of superior wisdom on the part of those who have attempted to school us in it, had not encumbered and concealed it by the clouds and darkness of words and wayward theories, the learned and the unlearned might read this, the elder and more general volume of " The book of the living God," together, and with nearly the same pleasure and the same profit.

And the means by which the action of the air on the blood of birds is rendered equal to the rapidity in circulation, and consequent necessity of vital repair, in that fluid, without the painful fatigue of ever-panting lungs, is made, like all other contrivances in nature, to answer other important purposes at the same time. The lungs of birds are ample in their dimensions, and have the cells into which air is admitted larger than in the mammalia ; and they are kept in their places by being fastened to the bones. Ramifications extend from them in tubes and cells through the whole cavity of the body, into the hollows of the bones, and in short, along the course of every artery which is not immediately imbedded in those muscles, which are in action during the violent exertions of the bird. The blood-vessels in these muscles are fewer than those in the muscles of the

mammalia, as any one may infer from the greater rigidity of their texture, and the whiteness of their colour. Thus, there is not a blood-vessel of any considerable size in the whole body of a bird, to the coats of which the air has not access during the greater part of their course ; and thus the real action of breathing in birds is not concentrated into one organ, to be toiling and panting there, as it would be in the lungs of the mammalia, but distributed over the whole circulation, and consequently diminished in local intensity, in proportion as it is extended over a greater surface.

This is a subject which it is impossible to bring to the test of numbers, so as to compare accurately the diminution of local action by means of the general access of air to the blood-vessels. There are two difficulties, neither of which can be, from the great nicety of observation which they would require, overcome. In the first place, we know not, and we cannot ascertain, the relative surfaces of the blood-vessels exposed to the air in lungs only, and in the whole system, as in birds ; and, in the second place, we know not the difference of action which the air may have on the coat of a very small blood-vessel, such as those in the lungs, and that of a larger one. We do know that the exposed surface of the vessels in the lungs must form but a small portion of that of the whole vessels in the system, because in the freest breathers, that is, what is usually styled the "longest winded" of the mammalia, which have their blood aerated in the lungs only, or chiefly, the portion which passes through these organs at each respiration of the breath, is only a small fraction of the whole. We know also that the coats of the larger blood-vessels must, in order that the vascular system

may have equal strength in all its parts, have their coats much thicker and firmer than the smaller ones, though we cannot precisely say in what proportion; neither do we know to what extent the difference of thickness in the coats of the vessels diminishes the action of the air upon the contained fluid. Perhaps the thickness of the coats is directly, and the action of the air inversely, in some such ratio as that of the squares of the diameters of the different vessels; but this is a mere theoretic guess, undemonstrated, and incapable of demonstration.

Analogy shows, however, that the advantages which birds derive from this general admission of air to the blood-vessels is very great. The race-horse is quite fatigued with a few miles at his full speed, and so is the greyhound, while the lion himself is in need of repose after a single leap. But birds can maintain their rapid flight during the livelong day, and for hundreds of miles upon the stretch; and when they do, as is sometimes the case, drop down in agitation or in exhaustion, the former seems generally to be the effect of fear, and the latter of muscular fatigue, for they do not pant as the mammalia do when they have over-exerted themselves.

But the advantage in the aeration of the blood is not the only one which birds derive from this peculiarity of their structure. The same air which exerts its renovating influence upon the blood, supports all the more delicate structures which it reaches and surrounds, as a cushion of the most perfect softness and elasticity; so that, by the most rapid motion, and the most violent twitches which the body receives in the changes and turnings of that motion, there can be no concussion of the parts more immediately necessary for the life of the bird.

## CHAPTER III.

### EXTERNAL PARTS OF BIRDS.

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THE subjects to be noticed in this chapter are much less interesting and instructive than those slightly glanced at in the former one; but as the descriptions of all birds are founded chiefly upon the colours of the external parts, and as these are all that we know about those species which belong to science only as museum specimens, this part of the subject becomes necessary in a general sketch descriptive of the class. Its minor importance will, however, enable us to treat it more briefly.

The external parts of birds, as they immediately present themselves to the eye, consist of three kinds of surfaces—horn, naked skin, and feathers. The first of these requires little description, being only the bill, the claws, and partially the scaly covering of the naked parts of the feet and toes, which is most conspicuous on the upper sides of the toes, and the anterior sides of the tarsi. The naked surfaces are also limited in extent, being confined to the head, portions of the neck in some genera, and those unfeathered parts of the feet and toes which are not covered by horny scales. The feathered parts are much more important in the popular description of birds, as it is to their forms and colours that the attention is first attracted.

## HORNY SURFACE.

The horny surface of birds varies in hardness in different species, and may, in general, be said to be firm in its texture in proportion as it is dark in colour. The more powerful birds of prey have the beak and claws black, with a slight bluish tinge; but some even of these have them yellow when in the immature state, whatever may be the colour when they are full grown. This change of colour in horny substances appears to be the effect of atmospheric air and light; and it is not confined to birds, but takes place in the hoofed mammalia, the young of which, in general, have the hoofs yellow, though they turn black after a short time. The forms of the bills and the claws of birds, being closely connected with some of their principal habits, will be noticed in another chapter of this volume.

## NAKED SKIN.

The naked skin of birds has generally a porous or spongy appearance; and in many species it has a bloom of colour in the living state, which is often very brilliant, and displays an iridescence which is not very easily describable, and which fades the instant that life is extinct. The bills of some birds, such for instance as the toucans, are covered with a membrane, in which there is a similar display of colour, that fades in the same manner; but in most birds these portions of naked membrane with perishable colours are on other parts of the body. When there is a naked membrane reflected on the upper mandible of the bill at its base, that membrane is called a *cere*, from its surface having some resemblance to that of wax. When it extends to, or surrounds the eye, it is called a *lore*, which means an armature, or covering. Some-



times there is only a naked spot or tubercle over the eye ; in other cases there is a projection of naked skin on the top of the head, as in the domestic cock, which is called a *comb*, because it is often pectinated, or divided in its margin. Sometimes also there are pendent portions of naked skin hanging from the sides of the under-jaw, or from the cheeks, and these are called *wattles*. In some instances the anterior portion of the throat is entirely covered by tuberculated portions of naked skin ; and that is often capable of inflation, as in the case of a male turkey. In other instances, again, the entire neck and greater part of the head are naked, and often beautifully coloured, as is the case in the king vulture. When a large portion of the throat or neck is naked, there is generally some portion of the neck or breast covered with hair, or at least with feathers very much resembling hair in their form ; but what connexion there is between the nakedness of one part and this species of covering on an adjoining one has not been ascertained.

When the naked skin on the head, or partially on the neck, covers appendages rather than the natural form of the parts, it is found principally in the male birds ; and in the pairing season, these appendages increase in size and heighten in colour, their general colour being red of some shade or other, often with blue reflections ; but in many birds they are, at the season alluded to, of the most intense scarlet. The females of the gallinaceous birds, have generally some portions of naked skin on the sides of the head, which bloom and fade with the season, in the same manner as those of the males, though not with equal intensity.

No particular name is given to the naked skin on

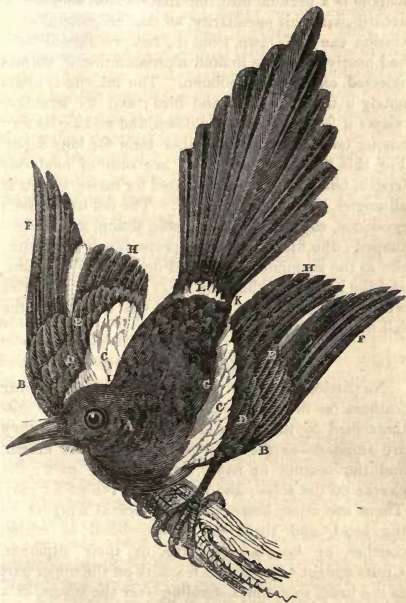
the feet of birds, unless it covers appendages, or extends farther up than the articulations of the tarsi, which are often styled the knees, but which are in reality the ankle joints of the birds. When there is a portion above these unfeathered, it is called the *garter*. It occurs chiefly in running and wading birds, and sometimes it is differently coloured from the rest of the feet. The appendages to the feet of birds consist of margins, lobes, and webs, which have all reference to water, or to soft and sludgy surfaces; and therefore the description of them falls properly within that of the general account of the feet of birds, as characteristic of their haunts and of one of their principal actions.

#### FEATHERS.

With the exceptions above stated, the bodies of birds are covered with feathers. These feathers are of three, or even of four kinds,—down or under-clothing, common clothing, or imbricated feathers, flying feathers, and supplemental or ornamental feathers, of which the uses, in the economy of those birds which possess them, are not very well known.

Before proceeding to consider the situation, structure, and use of the principal feathers upon birds, it may assist those who have not previously studied the subject, to examine the figure in the next page. In this figure, which is displayed for the purpose of showing the more remarkable parts of a bird, A indicates the ear coverts; B, the bastard wing; C, the lesser coverts; D, the middle coverts; E, the greater coverts; F, the primary quills; G, the scapulars; H, the secondary quills; I, the nape; K, the under tail coverts (not shown); L, the rump and upper tail coverts. Feathers vary so much with the habits of birds that it is impos-

sible to select a specimen possessing all the varieties of characters ; and therefore we have selected the



Magpie.

common magpie, as one which is well marked in its general character, and also easily observed, from being of common occurrence and rather familiar in its habits.

It is necessary, however, to bear in mind that the magpie is a peculiar bird, and that its form necessarily accords with this peculiarity, so that no general conclusion can be drawn from it; but we should have had nearly the same limited representation if we had selected any other specimen. The magpie is alternately a tree and a ground bird; and its structure adapts it for leaping up and down, and making its way among tangled branches, rather than for long flight. For this purpose, the wings are only of moderate length, but they are well adapted for taking the air at all angles, and also for turning. The tail too is much produced, capable of considerable action, and wedge-shaped; the first and second properties being requisite in the frequent ascents and descents of the bird, and the last in avoiding the twigs and other obstacles which the bird could not have so well avoided if the tail had been square at the end.

#### CLOTHING FEATHERS.

No particular name is given to the common clothing feathers on the head of a bird, but they are distinguished by the names of the parts on which they are situated—as the front or fore-head, the crown, and the occiput or nape, on the upper part; the cheeks on the sides; and the chin on the under part. There are often, however, supplemental feathers on the head, and these are distinguished as crests, conchæ, or beards, according to their situation. Crests consist of produced feathers on the upper part of the head, sometimes standing over the whole, or a greater or smaller portion of that, and nearly covering the eyes, as in some varieties of poultry; sometimes they are long and pendent from the nape, as in herons, divers, and generally in birds which strike forward with the bill with long and swift motion, in

which the crest appears to answer nearly the same purpose as the feathers on a dart or arrow.

The *conchæ* are formed either round the eyes or the ears, but generally round the former. They are most conspicuous in nocturnal birds, especially in the owls; and they seem to answer some purpose in concentrating toward the eyes the faint light in which those birds habitually seek their food. The tendency to produce enlarged feathers on the sides of the head in some birds of this tribe is so great, that they rise on the sides of the head something in the same manner as the ears of cats; and the species which have feathers standing up in this manner are called "eared owls," or "horned owls;" but the names are not very accurately applied, or at least, they must be understood with some limitations, because the ears or horns are feathers merely, and have no projections answering to them either of the bones or of the flesh of the head. Feathers which form what are called beards, or mustachoes, are dependent from the angles of the gape, or the sides of the lower mandible, and proceed, for a greater or less distance, down the sides of the neck. They are generally of a different colour from the neighbouring parts, and remarkably soft and silky in their texture. Some birds have feathers similarly produced, and resembling these in their texture, upon the breast, the shoulders, or other parts of the neck, or adjoining it.

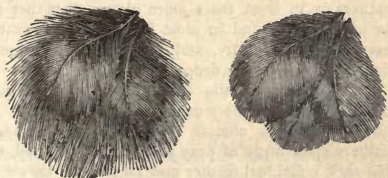
The only general groups of separate feathers on the heads of birds, which get a distinct name, are those which are over the openings of the ears. They are called the *ear-coverts*, and the name "covert" is in general given to all those feathers, upon whatever part of the bird they are situated, which are not merely clothing feathers, and at the same time neither

feathers for flight, nor supplemental or ornamental ones. Thus the word "covert" becomes a general one in describing the plumage of birds, and coverts are styled *upper* or *under*, according as they are on the upper or under sides of those members which they cover. Those of the ears are peculiar as covering, with more produced and downy plumage than that on the surrounding parts, the openings of these organs; and though their use is not very well known, they probably answer the purpose of external conchæ to the ears, and at the same time protect those delicate organs from the action of the air when the birds are in rapid flight.

The feathers on the neck and body of birds are also named from the places upon which they are situated. The neck is described as the throat, sides, and back. The distinctive parts of the body are more numerous; and they are often spoken of, generally, as the upper part and the under part. The entire upper part of a bird includes all that part of its surface which is seen when the head, the wings, and the tail are stretched out, and the eye of the observer placed opposite to the middle of the back. The under part, in like manner, means all that which is seen when the bird is stretched out in a similar manner, and the eye of the observer against the middle of the belly, or rather the posterior edge of the breast bone. But as these general significations of the terms include the wings and the tail, as well as the body of the bird, and as those organs require separate description, the upper and under parts are generally understood in a more limited sense, as not including these parts. Thus when it is said that the upper part, or the under part of a bird is of any particular colour, it is not meant to be asserted that the

corresponding side, either of the wings or of the tail, is of that colour.

The upper parts to which names are given, are the setting of the neck, which is often marked by differently coloured feathers, or produced ones which form a mantle on the shoulders ; the scapulars, or feathered parts over the blade bones, the middle of the back, and the rump or part of the back next the tail, which is often differently coloured from the rest. Upon all these, the feathers, excepting those birds which have supplemental ones, are smooth and close, and so beautifully imbricated, or placed over each other like tiles, that they form a very close and smooth surface, which is perfectly water-proof in some birds, and not very easily wetted in any.



Arrangement of clothing feathers.

The manner in which these and all the other clothing feathers are applied to each other, and also adapted to the shape of the bird, is well worthy of study. Generally speaking, they are placed alternately, or one over two, that is, with its shaft in the opening between them ; but they cannot be said to form regular rows taken in any direction, and they vary considerably both in shape and in size.



They are all however placed in such a manner as that the action of the wind from before tends to smooth them down, and from behind to raise their points, though differently in different birds, and even on different parts of the same bird. The shoulders, and the turns or front edges of the wings, are the places on which the beautiful application of the feathers is most striking, as they are not only the most difficult to fit from their greater curvature, but the ones which are the most exposed during flight. The feathers on these parts are so placed, that let the wind take them as it may, it can hardly raise or ruffle them; and the strength and curvature of the shafts, and the extent and texture of the webs, are all equally worthy of observation.

The general texture of the surface of the upper feathers, is in most cases more glossy than that of the under ones; and in most birds it has more or less of metallic lustre, and generally, though not always, its colours are deeper.

The structure of the clothing feathers of birds might be almost made a means of classification, as it varies both with climate and with habit. These feathers upon birds of prey are firm and decided, so that each individual feather may be traced; they are less so in omnivorous birds, less so again in those which feed chiefly upon insects or vegetable matter, and the least so in birds which are the most exclusively aquatic in their habits. Birds of hot climates have also the feathers more decided in the upper part, than those of nearly similar habits which reside in cold countries:—indeed the study of the structure, texture, and gloss of the general plumage would, though somewhat more circuitously, lead as certainly to a knowledge of the characters of birds, as that of the more active parts of their bodies.



The feathers on the under parts are distinguished as those on the breast, the flanks, the centre of the belly, the thighs, and the vent. But some of these names must be understood with limitations. Thus what are usually called the thighs are in reality the legs of the bird, the thigh bones being to a considerable extent imbedded in the muscles, and capable of but little motion, except in those species which have great action in their feet. That which is called the belly of a bird also requires explanation; for it does not, even in any of the species, answer to the soft abdomen to which that name is given in the mammalia; and in swimming birds the sternum and ribs extend so far backward as that a portion at the vent only, of a size sufficient to allow the expulsion of the eggs, is unprotected by bones.

The feathers of the under part are, generally speaking, smaller in size, and softer and more downy in their texture than those on the upper part. The differences of character indicated by them are not so great or at all events not so striking as those indicated by the upper part. In general, however, there is the same gradation from the more perfect air birds to the more perfect swimmers, the last of which, especially those which inhabit the colder seas and do not migrate far toward the equator in winter, abound in down of the finest description. This down consists partly of a second feather produced at the end of the barrel or tubular part of the principal one, and partly of a separate clothing, each particle of which has its own insertion in the skin, and which has no distinct shafts, or any of the common characters of feathers. This down, whether produced on the feather or on the skin, is always frizzly or flocculent, as well as soft. It thus has no general direction, like the feathers,

but stands every way; and thus is very elastic as well as warm and light.

The different apportionment of this downy part of their clothing to the several climates and elements in which birds move, as well as to their habits, is very remarkable; and many of the swimming birds can remain for days in water very little above freezing, and yet sustain no inconvenience from the action either of the cold or of the water.

The feathers of birds are in themselves, to a considerable extent, water-proof, and all birds are more or less furnished with glands near the base of the tail which secrete an oily liquid. This liquid the birds can reach and extract with their bill and apply it to the feathers, by drawing these between the mandibles. This operation forms part of the process of *preening* or trimming the feathers, in which birds occupy a portion of their time. They do this for three purposes—to strain the water from such feathers as get wet, to smooth the webs of such as get ruffled, and to apply the oily secretion as occasion may require; and they also make use of the bill in removing those decayed feathers which become incumbrances instead of being useful to the birds in their motions.

#### FEATHERS OF FLIGHT.

As introductory to the notice of these, it may not be improper to remark that, generally speaking, the nearer that the clothing feathers of birds approximate to the form of flying feathers, they are always the more firm and perfect in their structure; and that this holds not only in different species of birds, but in the plumage of the same species during its progress to maturity. There is even a gradation

from the ordinary clothing feathers to the flying ones through the medium of the coverts.

In the wings, the bones of the humerus, the forearm, the wrist, and the hand, are free. They, and the muscles on them, are clothed to some extent with feathers similar to those on the body, and partaking of the character of upper feathers above the turn, and under feathers below it, passing imperceptibly into each other on the turn itself. To these succeed the several coverts, of which there are generally three rows, more or less distinct, and more or less produced, according to the species, but generally increasing in length and strength as they approach the quills. These are called the lesser, the middle, and the greater coverts, of the particular quills, or portion of the wing to which they are applied; and there are similar coverts on the under sides of the wings, only these are weaker, smaller and more soft and downy in their texture,—the whole under side of the wing being so formed as to take the greatest possible hold on the air, while the upper side is formed for rising through the air with the least possible resistance.

The quills, or real feathers of flight in the wings, are distinguished as primaries, secondaries, and tertiaries, according to the place of the wing to which they are attached. The primaries are attached to the hand and wrist, forming the extremity of the wing; and they are, generally speaking, the longest and the most powerfully supported by coverts. The secondaries, which are shorter, are chiefly inserted on the bones of the forearm; and the tertiaries on the humerus. In some birds the tertiaries are the shortest quills in the wings; but in others, and these are generally birds which have the habit of running swiftly,

with the wings partially extended, they are so much longer than the secondaries that the bird has the appearance of double wings, one set near the body and a longer set farther off. The quills are usually distinguished by numbers, as the first, second, and so on, counted from the extremity of the wing.

The tails of birds, like the wings, consist of produced feathers and coverts for their support, though the feathers of flight in the tails do not get the name of quills.

Both the wings and the tails of birds vary much in form, in magnitude, and in power of action; and though they are both concerned in the flight of the bird, and partially also in its motions on land or in the water, they do not vary according to the same law, and therefore they do not indicate the same habit. Still, however, as they are both concerned in the flight, or other motion of the bird, they must, in all their apparent discrepancies, be the best adapted to each other.

In those land birds which have not the power of flight, such as the ostrich, the emu, the apteryx, and a few others, none of the feathers have much approximation to the character of flying feathers, properly so called: they more resemble a peculiar species of down, but still it is feathered down, and the different portions are more minutely feathered in their ramifications than even those of flying birds; so that all the produced feathers upon these species are calculated for taking a powerful hold on the air; and the hold so taken no doubt helps to support the birds as they walk along. This use of these produced feathers is rendered more probable by their being more conspicuous in proportion, as the bird is longer on the legs and otherwise better fitted

for swift motion. The emu is not so swift footed as the ostrich, and the feathers upon it are all more nearly of the same length and form. Judging from its structure, for of its habits we know nothing, the apteryx is but a slow moving bird, and the feathers upon it are all pendent and flexible, resembling thatch as much as they do ordinary feathers.

The supplemental or ornamental feathers, of which the uses are not well known, appear on various parts of the body. They are generally confined to the male birds, or at least most conspicuous in them; and in some instances, as in that of the ruff, they make their appearance only during the breeding season. Birds which are subject to additional plumage, or even to rich additional colours in their feathers, during the breeding season, are generally, if not invariably, birds of warm temperament, and excited to contests of gallantry with each other, and other displays of more than ordinary courage, at that season. The affection appears to be one of the whole body, though the effects which it produces are differently localised in different species. Sometimes the additional feathers are on the neck, sometimes in the crest, sometimes in the scapulars and feathers of the back, and very generally in the tail.

The use of these feathers in the economy of the birds is not known; unless it be that the production of them (for feathers appear to be one of the most elaborate of nature's productions) exhausts the surplus of that energy which, from its very violence, might otherwise be injurious to them at those times when they do not require to exert it immediately for those purposes which, physiologically considered, it is intended to answer.

This is an exceedingly curious part of nature; but

it is as obscure as it is curious. In all the living and growing races, there is a bloom or evolution of richer and more intense colour than that which accompanies ordinary growth, attendant upon the process of production. This is less conspicuous in the animal kingdom than in the vegetable ; and in both, those species in which the process is otherwise secret or obscure, partake little or nothing in this rich display ; but it is to the nuptial dresses of plants and of birds that the gay season of the year owes the most of its beauty ; and nature, true to her general law, lavishes the richest of her ornaments upon the most essential of her operations—upon that operation by which alone she maintains all the races of her children, and triumphs over time itself.

As the uses of those supplemental feathers, whether seasonal or permanent, are not known, they cannot be used for any purpose more general than that of being specific or trivial characters of the races in which they appear. The following figure of the swift affords an instance of a bird which feeds exclusively on the wing, and is consequently more dependent on its feathers than on any other part of its organisation.



## CHAPTER IV.

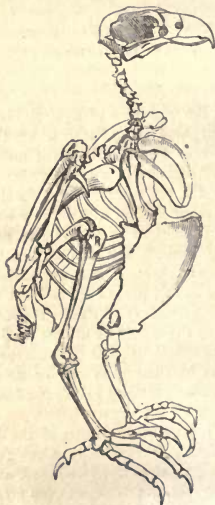
### SKELETON OF BIRDS.

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As it is not the province of natural history, especially of that popular form of it to which this work is restricted, to enter into the details of anatomy, any farther than is necessary to obtain a general notion of the way in which the motions of animals are performed, the present section will be very short. We have already alluded to some of those peculiarities in the bones of birds, which enable them to perform their chief ærial motions; and our main object in again reverting to this part of the subject is to place before the reader a sketch of the bones of what may be considered as the model or utmost perfection of a bird, before proceeding to point out how the classification of birds is founded upon one or more of their three grand actions, as these are dependent upon, or arise out of their varied organisations.

The sketch represents the bones of the Jer-Falcon (*Falco Icelandicus*; *Hierofalco*, of Cuvier), which is the boldest, the most perfectly winged, and, in proportion to its weight, the strongest both for action and endurance of all the feathered tribes. Dwelling in the wilds of nature, subjected to violent winds, to heavy snows, and to long-continued rains, and compelled often to endure long periods of abstinence in those parts of the world where there is not a tree, and hardly even a bush, for the shelter of a bird, and

requiring at other times to range for several hundred miles before it can procure a meal, either for itself or for its young; the jer-falcon, estimating according to



Jer-Falcon.

the average powers and experiences of animals, may be said to have the hardest lot in the whole kingdom. But even upon this, the grand extreme, as it were, of his works, the Creator has not left himself



without a witness; for if the task which the jer falcon is called upon to perform in nature is harder than that of most other birds, the preparation of this falcon for the performance of it is greater in fully the same proportion.

The sketch which we have given of this bird, which is, now at least that falconry is not the fashion, rather rare in substance, in skin, or in skeleton, is taken from a very fine specimen in the possession of Mr. Yarrell, which that gentleman very obligingly lent us for the purpose. It was originally obtained from Iceland; and we believe in part at least cleaned and prepared by marine insects on the Iceland shores; and these creatures are far from the worst preparers of the skeletons of larger animals, when the object is to have them perfectly clean and at the same time quite entire.

#### GENERAL PROPERTIES.

It is impossible to do justice to so complete a piece of natural mechanism in a sketch, and it would be no easy task even for the most elaborate engraving; but the general arrangement of the bones, and their remarkable compactness and adaptation to the powerful actions of the bill, the feet, and the wings, can be easily seen. Of these actions and their organs, as diversified in different tribes, we shall have occasion to speak afterwards; but we may here notice that the jer-falcon possesses all the three in the highest perfection; and that as, although it is a day preyer, it must often prey in lowering and cloudy weather, its power of vision must be strong in proportion. It must also, adapted as its plumage is to the violence of storms, have some very acute means of general perception, otherwise it could not return

to the islands which it inhabits, after its long excursions over the northern ocean.

The most remarkable general property of this skeleton is its compactness, and the equal perfection with which, as an artist would say, all its points are made out. None of the bones are very long ; and those of the legs, as the bird is not much in the habit of walking, are rather short ; but they are firm and well proportioned, and the processes toward their extremities, whether for giving firmness to the joint, insertion to the muscles, or lever power to the tendons, are very conspicuous.

#### SPINE.

The general form of the spine, as it has already been hinted at, can be seen in this example. The vertebræ of the neck all admit of ready motion ; and the position of repose, or that in which all the bones bear equally upon each other, is a curve.

All the vertebræ of the back, at least as far as the posterior edge of the sternum on the under side, are soldered together, and afford a firm base for the blade bones, which are considerably produced, and lie nearly parallel to the mesial line of the spine. The coracoid bones are strong, and enlarged at their extremities where they meet the anterior edge of the sternum, though they are more flattened there, so as to agree in thickness with that bone. The furcal bone is also a perfect circle, and placed with its flat side in the direction of the strain, so that it resists the separating or bringing together of the shoulder joints, the grand centres of motion for the wings, in the most powerful manner that could be obtained from the same quantity of bone. This bone, it will be perceived too, forms a large opening, in which the neck

can play freely, without the least pressure upon any of the important vessels which it contains.

#### WINGS.

All the bones of the wings are well formed, and the fingers, though only one of them is perfect, can be distinctly traced. The humerus is the longest and also the strongest and heaviest bone in the wing; and the lengths of the others diminish in the proportion of their other dimensions; so that though when the wing is moved, the different parts move with velocities proportional to their distances from the centre of action, yet the effect of the entire wing is very uniform, and the bird, when in powerful action, may be said to fly with the whole of it, that is, to strike the air with nearly equal effect with the whole of its under surface. The stiffness of the intermediate joints in such a wing, the perfect freedom of the shoulder joints, and the remarkably steady base which from their size, form, and place, the scapular, the coracoid, and the furcal bone, give to the centre of action, render the flight of the bird exceedingly smooth; and, though it is heavy for its bulk and even for the length of its wings, the jer falcon never appears in the least to labour on the wing. Birds more loosely boned, in any of the respects that have been mentioned, are incapable of this perfect steadiness and beauty of flight. The short winged ones of them flutter, as if they had not wing enough, and the long winged ones have their bodies tossed upward by the down stroke of the wings, and downward by the up stroke, as if their wings were too much for their management. This falcon, however, which has to range over somewhat bare and very stormy pastures, has its wings and its body

adapted to each other with the utmost perfection, so that it can rush onward in any line of direction that it pleases, without the least deviation ; therefore it flies from point to point by the shortest line possible ; and thus while it is the perfect model of power in flight, it is at the same time the perfect model of economy.

The lumbar portion of the jer-falcon's spine admits of a little bending downwards, so that the articulations of the femoral bones, or those joints which answer to the hip joints in the mammalia, can be lowered a little. The bones of the tail are also more numerous and better "made out" than in most birds. This arrangement of the posterior portion of the sternum, enables the falcon to perform more effectively its double action in the air, as by this bending, the foot, with which it strikes its prey, can act so far below the plane of the wings as not to interfere with their motion of flight. Not only this, but it also affords a support to the tarsus, upon the joint of which the whole force of the stroke would otherwise be thrown as a cross-strain ; and, though that joint is a firm one, yet it is contrary to the general law of nature's mechanics, to subject even the firmest joint to the greatest strain which it has to bear in the least favourable position. Indeed, there is seldom any joint subjected alone to a very great strain, in the natural action of animals. As there is but one life in the animal structure, so there is always concerted action when that life is strongly excited, be the object of the excitement or the organisation which it more immediately sets at work, what it may. There is some part upon which, in case of partial failure, the acting part can fall back for support if not for assistance ; and the very fact that organs which have to

perform violent motion, are connected with several centres, and those centres all susceptible of yielding to some extent or other, shows that the animal is organised for a concert of the parts in its action.

## FEET.

There is much firmness in the foot and leg of the falcon, and the position in which the foot is carried when hawking, stiffens the hind toe by pulling the tendon, and that without any muscular exertion, to the very angle at which the claw gives the stroke with the greatest effect. It is an oblique thrust, neither directly against the end of the last phalanx of the bone, nor across it, but in a tangent to the curvature of the claw at its point; and any one upon examining the foot of a falcon, will find that this is the very direction in which a shock can come so as to jar or strain the least possible, and at the same time to divide the pressure most equally among all the joints of the member which acts. If the stroke were given directly in the line of the axis of the toe and claw, the crush or jar would be the greatest possible; and any one who unwittingly strikes the point of the stiffly extended finger against an obstacle can tell how much more painful it is than if the yielding finger struck the same obstacle with double the force. There is another very appropriate illustration: by holding the joints of the legs and feet easy, one can drop upon the feet from a considerable height, not only without risk, but with little pain or shock at the moment; whereas if one were to drop even two or three feet with all the joints of the legs and feet kept purposely extended and rigid, the pain from the jarring would be considerable, and a tumble would be the probable, and broken bones

or dislocated joints, the possible, and indeed the very likely consequences. Thus we see that in nature's mechanics, the contrivances by which purposes are accomplished, are not only the best adapted for those purposes, but they are applied for the accomplishment of them in the best manner, both for success in the end and for safety to the instrument.

This principle is one of the most difficult to carry into complete, or even tolerable effect, in the whole compass of human mechanics; but it is one which nature invariably displays in all her structures, and in all the varieties of their working. This must, however, in the case of animals, and especially in that of predatory animals, be considered true only as affects the animal to which the structure belongs: for as the prey and the preyer are part of the general system of nature, and as such made for each other, the perfection of the system requires that the prey should be taken as much at a disadvantage to itself as there is advantage on the part of the preyer.

And this is well exemplified in all birds which strike, or otherwise capture their prey on the wing, and more especially in the jer-falcon, which may be said to perform that operation in most magnificent style, at least in so far as the slaughter of one bird by another can be considered magnificent. The jer-falcon, at forward flight, and without the excitement produced by the joint effects of hunger and the sight of that which can appease it, can cleave the air at the rate of at least one hundred miles in the hour; but when she works herself to the top of her bent, and then rushes forward in the tempest of her impetuosity, her motion is double, triple, nay, probably more than five, or even ten times that rate; so that if she could hold on with the same speed, she would keep pace

with the motion of the earth on its axis, even at the equator, where it is about a thousand miles an hour, and outstrip it by much in her own northern latitudes.

Hard as are the bones, and tough as are the tendons and ligaments in the foot of the jer-falcon, they could not hold directly against so terrible a rush as this ; and were she to strike against a solid and fixed substance, she would be dashed to pieces by her own velocity—would perish through the very excess of her own strength.

But this violent motion of the falcon, the circumstances under which it is exerted, and the organisation by means of which it is performed, are all admirably adapted to each other. The stroke of the falcon, unlike the spring of the beasts of prey, or even the stoop of the eagle, and the other predatory birds which kill their prey upon the ground, does not, in itself, arrest the violence of her motion ; for when she misses, if she hawks at flocking birds, as she often does, she dashes onwards, and strikes again ; whereas the lion and the tiger must pause and crouch before they can take a second spring, and the eagle must regain her height before she make a second stoop. Thus the prey of these animals, if not captured at the first attempt, has a chance of escape much greater than the prey of the jer-falcon.

When we consider the circumstances under which this gallant bird strikes, and the force of the stroke, which is sufficient to fracture a wing, sever a head, or crush the chest and burst open the body of a bird, we can easily see that the great velocity of the rush is necessary for effecting the natural purpose of the bird ; and that, though the jer-falcon would probably dash herself to pieces were she to exert all her energy in preying anywhere else than in the free air, yet she is exactly the bird, above all others, for

that element. Her prey is of course escaping from her with its best wing, though the agitation produced by such a follower must of course render that wing a little tremulous; but still the motion of the prey must be deducted from that of the falcon, in order to get the true impetus with which the latter strikes. Besides this, the bird has no resistance but that of the all-elastic atmosphere, and the inertia arising from its weight diminished by its motion; and therefore a stroke given with moderate velocity would have very little effect upon it. But the speed of the falcon over the speed of the prey furnishes the power; and the instrument, as already mentioned, sustains no injury on account of its position, and of the communication, and consequent extinction of the shock upon it; first, in the elastic part of the falcon upon which it bears for support; and, secondly, in the air, against which the entire body of the falcon would recoil if necessary, as the smaller hawks may be seen to do when they are flown at too heavy game.

## STERNUM.

Far from the least remarkable part of the skeleton of this model of a flier is the sternum. It will be observed, on looking back to the sketch, that the forks in the posterior portions of that bone are not only united by bony continuations, but that only a small aperture is left in the place of each. The keel, or central ridge of the sternum, is also remarkably elevated, and much produced at its anterior extremity, so that its outline forms a complete arch. We shall afterwards have to compare the *sterna* of different tribes with each other, and with their several habits, as among the means of forming an arrangement of the class, approaching at least to a



natural one. But as in that we must have some model from which to start (the means of proceeding then being comparison, and comparison not being an instrument of knowledge, unless one of the subjects is known), and as the sternum of the jer-falcon is the one best adapted both for exceedingly rapid and for long-continued flight, it is about the best model that we can select. From the shape of this bone, as well as from the general arrangement of the skeleton, we can see that, though the legs are rather strong in their bones, and the muscles by which they are moved are rather powerful, yet that the great strength of the bird is thrown into the anterior part of the body. Here it is not a little remarkable that this form of the body of a bird, while it admits of the best organisation for flight, is also the best one for being propelled through the air, or through any other fluid, be the propelling force what it may. When it is desirable to have a very fast-sailing ship, which shall at the same time make the closest course, or the least lee-way, and therefore get through the water with the least strain from the action of the wind, the shape which answers best for the hull of such a ship is not unlike that of the jer-falcon—full at the bows, and narrowed away at the stern, so as to make the least wake or turbulence in the water behind her. This coincidence of the shape of birds which impel themselves through the air by the energy of their own muscles, with that of ships which are impelled through the water by the action of the wind on their sails, is not a little remarkable ; and it is one of those cases which shows that there is a lesson for our instruction, and an example for our imitation, so far as we can imitate, in all the operations of nature.

Before taking leave of this branch of the subject

we may further remark, that there are three muscles on each side of the keel of the sternum, in all flying birds ; and that the principal action of the wing in flight is produced by those muscles. There is an advantage in this arrangement ; and so also is there an advantage in that arrangement in the legs of birds, by which the muscles of these are placed near the body, and the tarsi and part of the tibiæ formed chiefly of bones, tendons, and ligaments. By the arrangement in the wings, the wing itself is rendered lighter than if muscles had been distributed over its whole length, to any greater extent than is necessary for stretching and bending the local joints. Not only this, but the circulation of blood necessary for the support of much muscular energy, and the supply of the waste which that would occasion, could not be carried on without an extraordinary propelling power, in organs which move so rapidly as the extremities of the wings. Here, again, we may perceive a remarkable coincidence of advantages. That structure of the wing which adapts it best for being an organ of support and progressive motion jointly in the air, is also the one which renders it the most easily moveable and the most easily nourished, so that the labour, whether mechanical in the muscles, or physiological in the energy of life by which the muscles are worked, is always the least possible in proportion to the motion produced ; and thus while every bird has enough and to spare of energy for the average performance of those functions required for its place in nature, it is at the same time an instance of the most perfect economy in the whole of its furnishings and arrangements.

Of the three muscles on each side of the sternum, by far the largest one is that which depresses the

wing. It is called the great pectoral muscle ; and, in birds of powerful flight, those two muscles are heavier, or contain more substance, than all the other muscles in the body. The second muscles raise the wings, and prevent them from turning on edge, which neither of the other muscles could do without impeding the freedom of their proper motion in working the wing upwards and downwards at right angles to the axis of the body. There is, however, a slight oblique motion in the elbow joint of the wing, by means of which this third or central muscle causes it to strike partially forwards, at the same time that the great pectoral muscle makes it strike downwards.

Such are some of the motions of the more efficient wings of birds, and such some of the instruments by which they are performed ; but from the jer-falcon, in which they are the most perfectly developed and the most in accordance with the whole skeleton and other structure,—and therefore form, along with the most predatory claws and beak, and the digestive organs the best adapted for subsistence upon recent flesh, the most direct means of arriving at the habit and character—there is a gradual decline of the efficiency of the wings, as compared with the other active structures, until we come to the ostrich, which has only a sort of rudimental flaps to steady it as it runs, the penguin, whose rudimental wings seem to answer only the same purpose in swimming, or the apteryx, whose wings are covered by the skin, thatched by the feathers, and seem to answer no purpose whatever. But though there is this gradation, and though in as far as the wings, and all those parts of the skeleton, and the muscles which are connected with the wings, are concerned, we can trace it with comparatively little difficulty, yet it is so far from taking the habit

of the bird along with it in any other respect than that of mere flight, that one pair of wings carry us to the sea, a similar pair to the forest or the plain, and a pair still similar to the cliff of the mountain. Nor are the purposes for which the wings carry the birds, and also us in the study of them, less varied than the places,—wings very similar to each other, act to capture warm-blooded animals, insects, fishes, berries, seeds, and so endless a variety of substances, that we are compelled to examine the other characters of the bird before we can arrive at any certain conclusion respecting the office which it performs in nature, or the use to which it may be applied in art. We are not, however, to attempt making a classification of birds, but to explain the principles of one which is already made ; and therefore the shortest as well as the simplest course would be, first, to mention the classification, and then to point out those peculiarities in the three grand actions of birds, and their requisite organisations, upon which that classification is founded.

In the ring thrush, a figure of which is below, the actions of walking and flying are pretty equally combined.



## CHAPTER V.

### CLASSIFICATION OF BIRDS.

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IN this we shall adopt chiefly the arrangement of Cuvier, not that it is perfect, or even free from objection in all its parts, but because the well-earned celebrity of its author has given it a stability in the general opinion of mankind, the overturning of which would require much knowledge and more hardihood; and be, till more knowledge is obtained, after all a work of supererogation, except in some of the details; and, in order that the external distinctions of birds may be seen, a figure of one characteristic specimen of each division is inserted.

Cuvier divides the whole class into five orders,—Birds of prey (ACCIPITRES); sparrow-like, or hopping birds (PASSERES); climbing birds (SCANSORES); poultry birds (GALLINIDÆ); running and wading birds (GRALLIDÆ); and web-footed birds (PALMIPEDES). This certainly has the advantage of that simplicity of which it partakes in common with other *artificial* systems of the works of nature, that the first step in the knowledge of it is very easily taken. But it has, at the same time, all the counterbalancing disadvantages. It does not simplify the knowledge of birds; it is only simple because it conveys very little knowledge. When we come to grapple with the real knowledge, we must go to more minute

divisions, and encounter much more labour; but even thus much is a beginning, and may prove an incentive to some, though it may also lead others to be content with the shadow without the substance, as has been remarkably the case with the Linnæan artificial system of Botany.

As we cannot show the connexion which there is between the three great systems, to which the bills, the wings, and the feet, are, as it were, the keys, without some notice of the general characters on which the orders are founded, or at least their fitness for being such a foundation, we must devote a few words to each.

#### ACCIPITRES.

This order is the most natural in the system, and it is so, because it is founded not upon a single character, but upon the general habit of the birds, in the formation of which all their leading



Falcon.

organisations bear a part. The distinctions of the two primary subdivisions of diurnal, and nocturnal

or crepuscular feeders, are distinct, so that the one cannot, in any species, be mistaken for the other;



Barn Owl.

and though, especially in the diurnal division, there is a very considerable gradation in all the leading characters, so that those at the one extremity differ much from those at the other, yet there is enough of general resemblance preserved, in the beak, the feet, the wings, and even the plumage, to distinguish them from the birds of every other order.

#### PASSERES.

This is a much more numerous order than the birds of prey, and by no means so natural. This might be expected from its extent, and also from the name, which being that of one genus, or species of bird, that of the sparrow, can have little meaning as descriptive of an order.

The five sub-orders or tribes, into which it is divided, improve it a little, but still they are far from perfect, as they bring together in the system, birds whose structures and habits are very different from each other. These five sub-orders are, *Dentirostres* (toothed bills), which are, generally speaking, feeders upon insects or mollusca, though some of them occa-

sionally kill birds; *Fissirostres* (open bills), in which the mandibles do not shut close for their whole length, which are chiefly insect-feeders, and catch their prey by hawking on the wing; *Conirostres* (conical bills), which have the bill more or less enlarged at the base, and tapering to the point, which are more miscellaneous in their feeding, but differing so much in their characters and habits, that no one can be selected properly descriptive of the whole tribe; *Tenuirostres* (slender bills), which feed much on larvæ, and other small animals in the soft state, but catch them in such different situations and ways, that they can hardly be said to have one very striking character in common; and *Syndactyles* (united toes), which agree in that structure of the feet, and in several characters, though they differ in others.

That the last of these tribes or subdivisions of the order is founded upon the structure of the feet, and all the others upon that of the bills, is of itself sufficient to show that they cannot be very accurately descriptive of the birds.

*Dentirostres* is far from accurate, because the birds have a notch in the bill rather than a tooth, and the bill is feeble. The falcons are the true dentirostres, the tooth in the bill being one of their leading characters, and they are the most typical birds in the order accipitres. Besides, these birds are not the only ones which have a notch in the bill, for some of the divers, and other fishing birds, that have not the tomia of the bill serrated, for the prehension of their slippery prey, have it notched towards the tip. This subdivision of the order contains birds so different, both in appearance and in habit, that it does not admit of much useful general description;



because the characters applicable to one part of it could not be applied to other parts without so much modification as would render them almost entirely new.



Nightingale.

The *Fissirostres*, or open bills, are much better. They are but few, and though some of them are nocturnal, and others diurnal, yet they agree tolerably well in their general habits. Their bills are all very broad at the base ; they are very wide in the gape ; and they do not close in the length of the tomia, so as to cut or bruise hard substances. The whole division are consequently insect-feeders, and feeders on the wing, as this form of bill is not adapted for picking food out of crevices, or even off the ground.



Goatsucker.

The *Conirostres*, though not quite so vague as *Dentirostres*, are still by no means well or generally described by the name, as any one will perceive upon

finding that it includes the lark, the raven, and the bird of paradise, three species which are unlike each other in appearance, character, haunt, and manners. The name is not indeed accurately descriptive of the bill, as it appears generally in birds of the division. No doubt the bill is, generally speaking, enlarged at the base, and tapering toward the tip, straight, or free from any notch in the tomia, more firm in its general texture, and especially in its cutting edges, than the notched bills of the first division ; but it is conical only in a few genera, and most conspicuously so in the grosbeaks and finches. In other genera it is of a great variety of shapes, sometimes angular, sometimes arched in the culmen, sometimes couler-shaped, and, in fact, of so many different forms, that it cannot with propriety be described by any one general epithet, for the more accurately which that epithet were descriptive of the bill of one genus, it would be the less descriptive of that of others.



Bullfinch.

There is, however, a shadowy sort of general resemblance in texture and function among those bills, though it is not very easy to find an appropriate name for it. The texture, at least at the cutting edges, is always firm ; these, in general, close for the whole of their length, and thus they are capable of

bruising hard substances, such as seeds with tough coats, and also for digging or boring into the ground in quest of earth insects, or of albuminous roots. Sometimes, as in the case of the crossbills, the bills of those birds have a very peculiar structure and action ; and, generally speaking, the muscles which move the bill are more powerful, and consequently the head is more enlarged than in the species which feed more exclusively upon insects.

The birds of this division certainly range awkwardly together, whatever name they may be called by ; and yet it is not very easy to separate them into groups more numerous than families or genera, in a manner that would be much less exceptionable.

The species which may be considered as forming the one extreme of the division are birds of powerful form and firm plumage. Many of them are voracious, and somewhat gross in their feeding. They eat all manner of carrion and garbage, have no great objection to kill any animal which they can master, especially if they find it in a sick or weakly condition. Some



Jackdaw.

of them occasionally hawk after small birds on the wing, but that is not a general habit with them ; they proceed by stealthiness and craft rather than by daring, as the accipitres do, and in general attack only

that which they can take at a disadvantage. They are also great plunderers of the nests of other birds.

The species which may be regarded as forming the opposite extreme of the division are birds of very different characters and habits. They are of small size, not much disposed to attack other birds for the purpose of preying upon them, and, generally speaking, vegetable feeders, though most of them add worms and the larvæ of insects at the time when they have their young.

These two have been named from the general nature of their feeding—the first, *Omnivora*, or general feeders; and the second, *Granivora*, or feeders upon



Goldfinch.

grains, or vegetable seeds. These names are not, in themselves, very precise, as *Omnivora* is rather too general a name, and other birds are scarcely less omnivorous than these, as, for instance, poultry are very miscellaneous feeders. *Granivora* is quite as vague, as pigeons, and some other birds, feed as much on the seeds of vegetables as the birds of this division.

Still, as applied to the extremes of the division, these names, with some explanation, would not be undescriptive. But it would not be easy to make a perfect separation of the two, for their characters pass so gradually into each other, that there are many genera of which it would be no easy matter to decide whether they are more omnivorous or more

granivorous ; and thus their place in the one group or the other would be much more a matter of fancy than a matter of science.

This blending of characters on the confines of the different divisions, in what manner soever those divisions are made, is, in addition to the confusion produced by the three principal means of classification, one of the great difficulties in the proper arrangement of birds. If the comparison may be allowed, birds are like the tints of the rainbow ; we can call these red in one part, yellow in a second, green in a third, and so on ; but no art can fix a line anywhere in the bow which can so divide colour from colour, as to enable one to say, " all on this side is yellow, and all on the other side is red." Even the colour which we can name the most readily is of no measurable breadth as one uniform tint ; for the moment that we, for instance, lose the red on the one side of the yellow we begin to find the green on the other ; and therefore, however small a portion of the breadth we take, we always find that, as compared with the whole, it displays more than one tint.

It is very much the same with birds ; and birds, like rainbows, are children of the sun, more affected by that luminary than any other vertebrated animals, and partaking more of those radiant hues which the pencil of the sun alone can limn. We never can draw a definite line between order and order, or group and group ; and as little can we find even a single genus which has no conformation or habit in common with another. When we put the rest of the rainbow out of consideration, we can give a name to the tint of any particular part ; and, in like manner, when we take a single species of bird, and examine it without reference to the rest of the class, we can

describe all its appearances and habits, so far as they are known to us, in a manner perfectly satisfactory. We can thus study birds, and know them, and learn from them, with perfect ease and certainty; but we cannot classify them.

The great locomotive powers of birds are among the chief causes of this. What with their ordinary journeys, and what with their seasonal migratory ones, they are here, there, and everywhere. Sea or land, mountain or plain, waste or cultivated field, we find them there, as inhabitants or as passengers; and there is not a spot of land or spot of water but may become the inn of a wayfaring bird. Their clothing adapts them well to the weather; and it is necessary that they should not be very particular in their food, for they are exposed to many changes of it, and must frequently take what they can find without any choice. It is for this reason that classifications founded on the shape of the bill fail so much in other respects; and this is peculiarly the case with the *dentirostres* and *conirostres* of Cuvier's order *Passeres*, whose bills are very differently formed in the different genera.

The *Tenuirostres*, or slender-bills, form a much more natural division, though they too vary considerably in the different genera, both in the kind of their food and in the places and manner of finding it. Their bills in general accord with the name in being slender; but the smallness of their diameter is no indication of weakness. On the other hand, they are very firm in their texture; and though, from their form, they are not so well adapted for breaking hard substances between the mandibles as the larger hard bills of the former division, they can reach their food in places which are not accessible to these.

Many of them are bark birds, which run in all directions upon the boles and larger branches of trees,



Nuthatch.

and extract the insects or larvæ which are lodged in the crevices. Some of them run upon walls and rocks, and catch spiders in the same manner; while some again hover over the nectaries of flowers, from which they extract honey or small insects. They are an interesting race, from the agility of their motions, often for the brilliancy of their colours, frequently for their great power of wing as compared with their size, and not unfrequently for their extreme littleness. The humming-birds, which make the air under the action of the equatorial sun so gay with gleamy tints as if all the gems and the finest metals were flying about, belong to this division; and some of them, while to appearance not bigger than humblebees, have the sternum and all the apparatus of flight nearly as well developed and as perfect as in the jer-falcon.

But though this division is a very natural one, it is doubtful whether the bill is the best foundation for their natural distinction from other birds, as it is neither their most constant nor their most conspicuous character. The bill is always slender at the tip, and it cannot be said in any instance to be thick in proportion to its length, but it is often a large bill for the

size of the bird, and it varies considerably in shape. Thus in the nuthatch the bill is straight, very strong for its thickness, being fortified with angular ridges on the culmen and at the edges of the mandibles; and thus it is capable of digging into the bark of trees, or hewing open the shells of nuts. It is partially a vegetable and partially an insect feeder. The rest of the family or division have the bill of weaker structure, generally larger, more slender, and not so straight; and some of the humming-birds have the tip of it so formed as to answer as a sucker. Thus, though the bills of all may without impropriety be said to be slender, yet slenderness is not a character of them, neither have they any one remarkable character which is common to the whole.

The feet form a better, or, at all events, a more constant character. These are all of the kind of double climbing or perching feet; and the using of these as characteristic of the division, rather than the mere slenderness of the bill, which, as has been said, is not a very constant character, is attended with some other advantages. It leads more naturally not only to the following and last division of this order, but to the order which Cuvier has placed next in succession, and which, if we take the general habits of the birds in both, has really more of what is called natural affinity to this division than it has to the one which Cuvier interpolates between them.

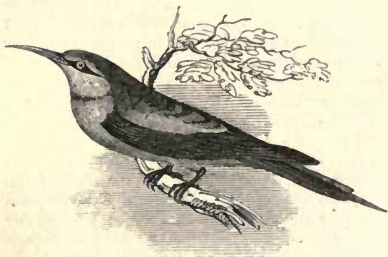
The *Syndactyli* form the only division of the order *Passeres*, which Cuvier classes from the structure of the toes; but if the leading character is, as it unquestionably ought to be, taken from the most efficient part of the organisation, then this is the very last family of birds which should have been characterised by the feet. All the division are energetic and active birds;



but their feet are not only the least efficient parts of their own organisation, but they are among the least efficient for any active purpose, that are to be found in the whole class. There are birds which are worse walkers, though these are but lame at that kind of motion, and not much in the habit of using it; but then in most, if not all, other birds, which have the feet badly adapted for walking, they are on that account better adapted for some other purpose. They are climbing or swimming feet in proportion as they are ill adapted for walking; and even in the case of the swifts, (though the common swift has got the name of *apus*, or "footless,") the foot, short and weak as it is, is well adapted for taking hold on an upright wall, or the face of a rock; and the toes and claws have that form which is the very best adapted for these purposes. But though the feet of the birds of this division are, of course, as well adapted to the purposes which they are intended to answer, as the feet of any other birds, yet those purposes are not very important, nor very constantly required in the general economy of the birds. Such of those birds as nestle in holes in the earth, which is a habit with many of them, use their feet adroitly in the digging of those holes; and they can also perch upon bushes or trees; but they generally feed upon the wing, and never use the feet for any purposes, save those of digging and repose.

The birds of this division have some resemblance to each other besides the mere shape of the feet; although none of the names by which they have, either in whole or in part, been called as a group, is very applicable. Those which have been styled *alcyonidæ*, after the kingfisher, have neither the form nor the habits of that genus, as it lives in great part upon small fishes, while those other genera which are

classed with it live much upon insects. The hornbills, or rhinoceros birds, which, along with the same description of feet, have many of the habits of omnivorous birds, could not be brought within any group, the characters of which were to be taken from the bill. Indeed the bringing together of the birds which are included in this division, appears to be rather in order



Bee-eater.

to prevent them standing alone, than because of any well marked general affinity between them.

#### SCANSORES.

Cuvier's third order SCANSORES, or climbers, though named from the habit, is in reality, like the last division of the second order, founded upon the structure of the feet, and therefore the name of ZYGODACTYLI, or "yoke-tocs," which has also been given to them, is fully the more accurate of the two. A style of motion, or of any other habit, taken singly, is rather a loose ground of classification. It is so with climbing in the case of birds of this order. It is not

climbing generally, but climbing in a particular way, which is descriptive of them ; and then that does not apply to them all. They are not the only climbers among birds ; for the nuthatches, and especially the creepers, which are, in the same system, classed with the slender-bills, and others of the anisodactylic birds, are much more adroit and graceful climbers than these.



Wryneck.

Birds of this order are all, almost without exception, tree or forest birds : the greater number of them are inhabitants of the rich forests of tropical countries ; and these are generally gay in their plumage. Indeed, the woodpecker and wryneck of our own country are showy birds ; and perhaps the one of most sober plumage, though peculiar from its habits, and inter-



Cuckoo.

esting from the time of the year at which its note is heard, is the common cuckoo.

The feet of these birds are grasping rather than climbing feet. The exterior front toe is reversed, so that the toes act two against two, which is the reason why the birds are called zygodactylic, or yoke-toed. In some of the species the feet are used in the same manner as the grasping feet or hands of the tree mammalia ; and as some of these climbing mammalia use the prehensile tail as a fifth hand, some of the climbing birds use the bill or beak as a third one. Those which have that habit, have the upper mandible hooked at the tip ; and the acting parts of both mandibles are short, but very strong, and act with much force, like nutcrackers. The muscles which move these powerful mandibles, give considerable enlargement to the sides of the head. Those which



Macaw.

have this habit are mostly vegetable feeders, and live among the twigs, nestling in the holes of old trees.

Taking the whole together, they are not a very natural order, even in the use of that part of their organisation after which they are named ;—for whether, with Cuvier, we call them “climbers,” after the habit, which is not general, or with others “yoke-toed,” after the structure, which is general, though much modified in the different genera, their feeding the structure of their bills, and many of their modes of life differ greatly from each other.

In their feeding several of the genera of this order bear a considerable resemblance to the Gallinidæ, or poultry birds, at least to those species of them which are natives of the forests of warm countries ; and there are two genera, if not more, natives of Africa, which appear, as it is usually expressed, to “connect” the two, that is, which partake of the characters and display the habits of both. These are the genus *Corythair* and the genus *Musophaga*, the former inhabiting southern Africa and the latter the more tropical parts of that continent. They have partially the bills and wings of the poultry tribes, though from the forks in the sternum being less deep, and that bone in consequence stiffer, they are birds of more continued flight. Their chief relation to the climbing birds consists in the structure of the feet, which have not, however, the toes acting so generally two against two, as in the birds which properly belong to the order, though the exterior so readily admits of a reversed position. They are tree birds nestling in holes ; and the one which is known in southern Africa is chiefly a vegetable feeder, feeding upon wild fruits. It is a bird of beautiful plumage, bright green, with some of the quills crimson, and an elegant crest on the head. It has sometimes been classed with the cuckoos, apparently from the structure of the feet ;

but there appear to be but slight grounds for warranting such a conclusion.

Great allowances must be made for mistakes and errors in the classification, and even in much of the description, of the birds which Cuvier has brought together in this order. With many of them we are abundantly familiar, but there are many others which inhabit only the depths of the tangled and almost impenetrable forests; and the manners of these are of course as little known as their haunts.

## GALLINÆ.



Turkey.

Cuvier's fourth order, the gallinaceous or poultry birds (GALLINÆ, or rather GALLINIDÆ, for the other genera have of course only resemblances to the common domestic cock (*gallus*), and are not identified with it), form in many respects a natural order; because though there are great differences of appearance and habit, and still greater difference of climate and haunt,—some, as the ptarmigan, dwelling only on the mountain tops in cold countries, and others, as the peacock and the jungle fowl, dwelling only in the wooded parts of tropical climates,—yet there is a general character which runs through the whole. They are not birds of powerful wing; and though many of them perch in trees, few or none of them

find their food there. They are ground birds ; and only cull the seeds of those herbaceous plants which they can reach when standing, and gather such other seeds, insects, worms, and various succulent or farinaceous vegetable substances, or often animal ones (for some of the genera are not very particular in that respect) as they find on the surface, but scrape up the rubbish with their feet, in search of such substances suited to their taste, as may be found under it. The march of the males is stately, and they are often very gay with ornamental plumage peculiar to their sex. They are all, however, heavy and laborious fliers ; and make but little use of their wings, except when alarmed, or in reaching those perches upon which they pass the night secure from the attacks of foxes and other predatory mammalia which hunt during the night but do not climb.



Ptarmigan.

The flight of the gallinidæ is so peculiar, that it might be taken as their descriptive character, with fully as much propriety as any other action is of a division of birds ; and certainly with more than climbing can be as characteristic of the last order. The domestic cock, for instance, is quite a soldier in his wars ; and like a *gallant* soldier (and he himself is the type of pugnacious gallantry as well as the original of the name) he fights for the honour of the victory, and not, like a mercenary, for pay and “pro-vend.” When he leads forth the dames of his seraglio

to a public breakfast in the newly-expelled litter of the stable, his strut is quite Oriental, and might of itself guide one to the knowledge of his native clime ; but when he attempts flight, there is a sad falling off; the bravery of the soldier and the strut of the bashaw are no more, and the lord of the dunghill vexes the air with encumbering wing, and flies less gracefully than a bat or a beetle.

This laborious and painful flight, for it is certainly laborious to the birds themselves, as they can continue it only for a short distance, and if it is not painful to them, it is painful to look at, is common to the whole order properly so called ; and on this account Cuvier appears to have departed from his usual attention to structure as forming the basis of classification, in uniting the pigeons with this order. The pigeons are birds of ready wing, and have much more command of the air than the true gallinidæ ; and besides, the habits of the races are in almost every respect different from each other. Pigeons are monogamous, and though they breed often, each brood consists usually of only a single pair : the gallinidæ are in general, though not in all the species, polygamous, breeding once, or at most twice in the year, and their broods are numerous. Pigeons are, in many of the species at least, migratory, and they both migrate and associate in numerous, and, in some cases, in countless flocks : the gallinidæ are never migrants and those species which are mountaineers would rather perish in their alpine habitations than descend to any great distance on the plains ; and when they associate with each other, it is at particular seasons rather than habitually, and in families, or at most in packs of a few families, and not in large flocks. Their daily range is indeed so limited, and they use the wing so little in seeking their food, that a very



large flock of them could not subsist in the same locality.

Pheasants, though they have the same style of flight as the rest, are certainly not the worst fliers ; and yet there is a very striking difference between the common pheasant and the common pigeon in point of capability of endurance in the same locality. Where pheasants are kept in numbers, a preserve is made for them, which is understood to afford them not only shelter, but the greater part of their food. Common pigeon-house pigeons seldom have any pasture preserved for them, and cultivators drive them off from their crops. The native habitations of vast numbers of the parent stock, too, are often in rocks or places comparatively barren, where they must range to great distances for their food—for pigeons require proportionally more food than the gallinidæ, and, indeed, than most other birds.



Ringdove.

Now if pheasants and pigeons *naturally* belonged to the same order of birds, we might surely, under these circumstances, expect that the pigeons should suffer most from casualties. If not, there could be but small propriety in uniting the two families of birds into one order ; for if there is nothing more of similarity in the several members of the order than that structure of organ, or habit, or

whatever else it may be upon which the order is founded, then truly the formation of the order is a very idle matter on the part of him who establishes it, and a very deceptive matter to those who seek for information from it. The name of the order, or other group, should, no doubt, be founded upon one of the most striking coincidences in the genera that compose it; but if there are not other coincidences behind to which that one is the key, then any attempt to get information from the system will be somewhat like an attempt to get a knowledge of Macedonia from Fluellin's comparison between it and Monmouth:—"There's a river at Monmouth, and I'll pe pound there's a river at Macedonia; and they call it Wye at Monmouth, and it is out of my prains what they call it at Macedonia; but it is as like as my fingers to my fingers, and there's sawmons in them both." This, though not brought out with the same graphic exposure of its absurdity, is very often the kind of analogy which the systematists in natural history propound for the edification of mankind; and even the acute mind of Cuvier, which was less frequently bewildered than that of most naturalists, must have been lost in the fog when he united the pigeons with the gallinidæ.

To those who already know the characters and habits of birds, or any other animals, it is of little consequence in what juxtaposition the several kinds of them are presented; but those who have the knowledge to acquire, and resort to the system for aid in the acquiring of it, of necessity conclude that there is some general correspondence in the nature of those which are united in the same order, or other division; and if, as in the case of poultry and pigeons, there is really no such correspondence, they either waste their time in vain search after that which is not to be

found, or they turn from the system (and, in part, from the subject) with disappointment, as promising that which it cannot perform.

The feet of poultry and of pigeons are both adapted for walking on the ground, and those of some species of both are adapted for perching: their bills, too, are both adapted for ground feeding, though not exactly for the same kind of surfaces or of substances; but when thus much has been stated, the parallel is nearly at an end. Thus far may be seen at first sight of the two; and when we come to study them more intimately, there is nothing, even of inference and analogy, in the general history of the one, that can lead us to the general history of the other.

The different casualties of the pheasant preserve and the pigeon-house show that, physiologically considered, the two races have little in common; that— independently of difference of power and style of flight, feeding, incubation, nesting and breeding, texture and flavour of flesh, and all other particulars— there is a difference in the whole nature of the birds, as they stand related to the course of natural events. The pigeons have, as has been stated, only a lodging in the pigeon-house, while the pheasants have both cover and food in their preserve—that is, not merely shelter while they are at rest, and accommodation for their nests, but food, and protection from the weather while they are gathering it. But under all the apparent differences of accommodation, the pigeons thrive best. As their numbers increase they extend the range of their feeding excursions; and though on these they have to use the wing much, and often to contend with the severity of the weather, they do not appear subject to any casualty of nature, but to thrive as well and be as healthy when they range

over many miles as when they are kept at home and fed by the hand. The pheasants, on the other hand, cannot endure even their natural powers to increase beyond a certain limit ; for (as was not many years ago proved at Wanstead, in Essex) if they are allowed, even in the most favourable preserve, to increase beyond a certain limit, *epizooty* falls on them, and they die by the score, not of hunger or any other perceptible cause, for they die in good condition, and the mortality continues till their numbers are reduced considerably below what would be left by a judicious sportsman.

Our native gallinidæ have not, perhaps, been so carefully studied ; but there are well authenticated instances in which excessive preservation has been followed by, if it has not actually produced, *epizooty*, both in the mountaineers and the inhabitants of the plains. If such were the case only with pheasants, their foreign origin, and the many mild climates of which they are natives, might be alleged as the cause ; but as the ptarmigan is the highest dweller of all our native birds, and the grouse live in more bleak places than the pigeon, and as they are subject to the casualty from which pigeons are exempted, we must conclude that the whole of the gallinaceous tribes, of which these are the most hardy, are physiologically different from the pigeons, and tempered to the elements in a very different degree. Taken alone, this would be a good argument against uniting the two in the same order ; but when taken along with the structural, and even the textural differences of the birds, and the differences of all their actions and habits, it becomes irresistibly conclusive ; and gallinidæ and columbadæ should unquestionably form separate orders in any system pretending to be natural.

If this is done, each of the orders becomes well-defined as well as natural ; and they do not even clash or get confounded with each other on their confines, as is the case with many of the other orders. The structure, the action, the habits, and the general character, as inferred from the whole, are all so constant in each, and so different in the two, that if we know one genus well, we never can be at a loss with any other in the order ; neither can we, in any instance, confound the two.

The fluttering and apparently painful flight of the gallinaceous birds may excuse a few sentences of explanation, as it is one of their general and most striking differences from other winged birds, and as the explanatory notice of it will throw some further light upon the structure of the organs of flight. This becomes the more justifiable, because the more necessary and useful, when we consider that the superiority of the flesh of the gallinidæ to that of all other birds, as human food, if not dependent upon, is at least intimately connected with their imperfect power of flight.

When we speak of the flesh of any animal as an article of food, it is always the muscular part of the animal which is chiefly understood. We cannot exactly estimate the power of muscles upon common mechanical principles, because the energy of life in the animal to which they belong is always an element and one which we can subject to no calculation. But the quantity and texture of the muscle are also elements ; and though we cannot say that the power of action varies exactly in any one of them, or in both jointly, yet it does increase with their increase and diminish with their diminution. Now, air birds,

whose action is chiefly performed by the wing, have almost the whole muscular structure of their bodies concentrated upon that; and if they have to remain long in the air, and contend with the wind there, the structure of the muscles is proportionally rigid, and they are, of course, difficult of mastication and digestion. In these cases, extra dressing, whether by the action of the dry fire or by boiling, does not cure the evil; for though these muscles become more easily divided in proportion as they are more dressed, they become at the same time, and perhaps in a greater proportion, more dry and tasteless, and less digestive and nourishing. A dinner of the pectoral muscles of well-seasoned eagles, or the larger hawks, would be serious labour for the jaws of even the most willing masticator; and bating the bitter taste, a rook of five broods would make almost as tough a meal as oakum or old junk. These qualities decrease as the birds make less use of their wings; and in those birds which are not allowed to fly at all, while fattening for the table, the muscle is more juicy and tender than in any others. But that preparation may be overdone, by the bird having less exercise than accords with a healthy state of its system, and then what is gained in tenderness and even mass of flesh, is more than lost in flavour and wholesomeness. If the inactivity is unnatural and the food abundant, the tendency is an over-production of fat; and the fat of birds is the least wholesome of all fat. It consists chiefly of *elain*, and not of crystallisable fat, and as such it very readily passes into an oil, difficult of digestion and very much disposed to become rancid. A barn-door fowl, which roams freely as it lists, enjoying plenty and variety of food, and clapping its wings and flying a little if so inclined, is, in point of

flavour and wholesomeness, worth all the penned birds that ever were "prepared for the market." This is, as nearly as can perhaps be obtained in Britain, the natural state of the bird; and though there is no doubt something of the influence of name in the matter, the fact of their living and feeding in a state of nature is one grand cause of the preference given to the wild gallinidæ. But the flesh of these also is tougher and more dry in proportion as they are more in the habit of using the wing; and therefore if they cannot be dressed before they stiffen at all, they require to be kept till incipient putrefaction makes them tender; and when they are very high, the organs of taste and smell sometimes have disputes about their real worth.

Thus, the qualities which the flesh of the gallinidæ derives from their small tendency to flight, renders them more immediately valuable to man than any other birds; and the very same circumstances, taken in conjunction with their other habits, render them among the most easily obtained. They are also among the most prolific, and instead of vanishing before the progress of culture, as is the case with many other birds, they increase in proportion as man cultivates the ground. The partridge comes where man ploughs, and in proportion as he plants, pheasants increase in numbers.

The chief use of the wings of the gallinidæ, besides enabling those which perch during the night to reach their perches, appears to be safety against quadruped foes. Their fluttering gets them, perhaps, sooner above the reach of these than if they had a more steady and forward style of flight. From birds of prey they may be said, one and all, to be incapable of escaping on the wing; their safety from these



consists in crouching among the clods or lurking among the herbage ; and their general colours are such that they are not easily distinguishable from these. Their wings are short, broad, and concave, and they are also looser in the plumage of their under sides than the wings of almost any other birds. All these qualities make them take a great hold on the air, which assists them in "working upwards," though it renders even that direction of flight more laborious. They can thus reach the height of escape from a ground preyer, or that of perching, upon a more perpendicular line, or with less forward motion than birds of more powerful wing. The same form of wings enables them to drop down more readily than almost any other birds, except those which, like the sky-larks, drop from a great height, and 'acquire an impetus from the descent. This power of quick descent is as advantageous to them as that of speedily rising, for they drop so quickly into their cover that one can hardly point to the precise spot, and the difficulty of so doing is increased by the wheeling motions which they have when in the air, and also by their running in a different direction from that in which they were flying, before they squat, or otherwise pause, for the purpose of hiding themselves.

Thus their apparently clumsy and ungainly wings are as well adapted to their peculiar habits and haunts as the finest and firmest wings that cleave the air. It is also worthy of notice that, as their power is not concentrated in the wings, but diffused over the body, all the parts of which have more or less of motion in their several actions of walking, running, crouching, standing up for observation, and others, the whole body comes more into action, and labours more during their flight, than in the more elegant fliers.



This is an instance of a very curious habit of the bodies of animals, which is so general that man himself is not exempted from it. It is this: if any one system of the body, be that system what it may, whether external or internal, is to work in its most graceful and efficient and least laborious manner, it must work alone, and the rest of the body must be trimmed to its accommodation, and not in a state of excitement or action. This is a proof that the principle of animal life in the individual is one, in the same manner as the intellectual principle in man is one. If the breathing, or the circulation, or the digestion, labours violently, the external organs become unfit for motion; and if the whole body is excited, no one organ of it can perform its function so well as if the rest of the body were tranquil. In man, this is called self-possession, coolness, or firmness, and every one knows its value; in other animals it arises from a different cause, but its effect is nearly similar.

We find the difference between the wholly excited and acting body, and the acting of one part only, with the others trimmed or borne in accordance with its action, well exemplified in the spring of the lion or the tiger, and the stroke of the falcon. In the beast, the impetus is given with the whole body; in the bird it is given with the wings only. Thus it is momentary and exhausting in the former, but in the latter it may be continuous, with comparatively little abatement of energy.

The flight of the gallinidæ may be regarded as only a sort of semiflight. It is performed with the whole body, and partakes of the exhausting character of every motion so performed; and the faster that these birds attempt to fly, they can fly for the shorter

time: they never fly fast but when they are excited, and they very frequently scream as well as flutter, showing thereby that they are in a state of unnatural excitement—that such flight is not their natural habit.

And when we examine their structure, we find that the whole body must act when they fly. The deep forks or clefts in the sides of the sternum, render that bone flexible; the form of the furcal bone, which is that of the letter Y more than that of an arch, and with the branches not placed with that side to the strain with which they would be stiffest; and the looseness of the blade-bone; all conspire to render the socket of the humerus unsteady and capable of play in all directions. The whole side of the animal thus works in lessening the effect of the wing-stroke, and at the same time fatigues the bird more than would be done by a firm wing. The muscles are also, as has been noticed, of less firm and enduring texture, in proportion to their bulk. Thus the gallinaceous bird is, by its structure, kept to its element as an inhabitant of the earth, and rendered incapable of soaring with the air-birds, to share either the grandeur of their flight, or the dangers to which they are exposed on the wing.

But while the loose and fluttering wings of these birds keep them to their own element and place in the world, they are not less adapted to their habits and necessities there, than the swiftest and most enduring wings are to their different element. We have already mentioned how well they are suited for escaping the foe or gaining the perch; and the looseness of the scapular socket is not the least beautiful part of their adaptation. The haunts of the birds are among shrubs, and bushes, and tall herbage, and they have often to use their wings and get quickly

above their ground enemies from among these. They have also to close their wings among interruptions, and with as little rustling of the wing or that which disturbs it, as possible. The broad wing and the loose and moveable nature of its articulation, answer another purpose in the economy of these birds, which though not so immediately important to the individual, is equally so to the race: the females gather their young under their wings in the early stages of their existence. This protection of nature appears to be necessary, as the young of these birds are but lightly covered with down, as there is no formal nest for them, and as they are, even in the perching species, unable to perch till they are fledged. They have, however, more use of their legs, more general activity, and are better fitted for finding their own food when they have the skill, than the young of any of the preceding orders.

This state of the young when produced, corroborated as it is by their general structure and habits, very clearly points out the place of the gallinaceous birds in a natural system of arrangement. If the birds of most powerful wing, and of which the air is the principle element—the races which most perfectly answer the definition of the term bird, in being most exclusively dependent on their wings,—are to be placed foremost in the system, as they unquestionably ought to be; and if the gradation is to be regular from them to the races which are wholly dependent on the earth, and can neither fly nor swim, and proceed from them to those which are wholly dependent on the water; then, unquestionably, the proper place of the gallinidæ is immediately before these ground birds, which have less power of flight than they, and after the pigeons.

This mode of arrangement, as might very readily be proved by an induction from the particulars, after we have obtained an outline of these, is borne out by a regular gradation in all the leading habits of the several races from the time that they leave the shell till they become parents, and display those instincts which complete their mature character in the way in which they provide for, or otherwise treat their young. There are apparent anomalies in such an arrangement, because at some parts of it there seem blanks, where the characters of the one division do not meet those of the next one so as to preserve the continuity; and there seem at other places to be redundances, where two races, different in some of their characters and habits, have others so much in common or so equally, that it is not very easy to say which ought, in strict propriety, to be placed first. In some instances, these wants and redundances, these breaks and doubles in the chain, so to speak, exist only in our partial view of the matter. But when we consider that birds, in one or another of their varied tribes, inhabit the whole land and sea, and that the characters of these are, in some places, uniform over a considerable range; and in others constantly varying; that some are exuberantly productive, and others bordering upon sterility; we may easily see that the birds must crowd both in species and in numbers to the places of abundant and varied production, and be fewer and more uniform where food is scanty and nearly all of the same description. The natural series of birds is thus not one which can proceed by uniformly equal distances between race and race, but by distances varying with the haunt, and the varying abundance of the food for them, whether local or seasonal. Indeed,

the species of birds most frequent in any country change with its other changes, whether natural or artificial.

## ECHASSIERS.



Heron.

Cuvier's fifth order, which is a very numerous one, and includes birds very varied in their appearances and habits, is that to which he gives the name of ECHASSIERS, or, "stilt birds,"—birds, generally speaking, with long legs, all capable of walking, and many of them fleet in that motion, but varying much in their powers of flight, and also in the shape of their bills, according to the nature of their food, and the places in which they seek it. They are otherwise styled *Oiseaux de rivage*, birds of the water's edge, bank birds, shore birds, *grallæ* or waders, and *grallatores*, or *grallidæ*, birds resembling wading birds. They are also sometimes divided into two orders or sub-orders, *Cursores* or runners, and *Grallidæ* or waders. But no name, whether founded on one haunt, habit, or peculiarity of structure, as all of those are, will suit the whole, neither can any general definition or description be so framed as to be explanatory of the whole.

There are few or none of the orders already men-

tioned, which do not reach the water's edge in some of their genera ; and even the most aquatic of the sea-birds are reared on the shores, and compelled to seek the shelter and safety of these when the ocean is in its fury. Some of the eagles fish ; some of the omnivorous birds seek their food within flood-mark when the tide ebbs ; the swallow tribe skim the surfaces of pools ; almost all the *syndactyli* live in holes in the banks, and the kingfisher is named from the manner in which it finds its food ; even the common pigeons are found wild in sea-beaten cliffs ; and one species at least of gallinaceous bird, has the feet partially webbed, and frequents marshy places. When therefore we speak of a " bank bird," our expression is exceedingly vague, unless we go on to explain at length how it is employed on the bank, and that explanation would give us the information as well without the name as with it. This is therefore a portion of the class, and it is a large and important portion, which is not clearly set forth in the system.

The distinctions of runners (*Cursores*), and waders (*Grallidæ*), are applicable and definite enough, as expressive of the extremes of the order ; though walking and wading are motions of the same kind and performed with the same organs, only with a difference of the element, and a difference of the organs to adapt them to these. But they interfere on the confines ; and there are some, indeed many, of the species which perform their ground motions so equally on the land and in the water, that they cannot with propriety be considered either as walkers or as waders. If, however, we separate those species which have no aquatic habit, but are found upon dry places only, and they are habitually found upon pas-

tures more arid than any other ground birds, and consider them as **CURSORES** (for they are all swift of



Stilt.

foot, and the majority of them are incapable of flight), making them a distinct order; and then include all the others in another order **GRALLIDÆ**, or birds



Snipe.

which can and occasionally do wade, we shall perhaps come as near to accuracy as is possible without a much greater, and indeed an inconvenient number of primary divisions.

Cuvier divides the order into five principal groups or families, to which he has to append some genera which do not conveniently come within any of the groups.

The first group, *Brevipennes* (short-wings), consists of the ostriches and other land birds which cannot fly; but the name is not very accurate; and the group to be natural and preserve the gradation should include some birds which can fly, such as the bustards, which form the connecting link between the gallinidæ and the ostriches.



Bustard.

The second group, *Pressirostres*, includes those birds which have the bill hard and compressed laterally; and which are long on the legs, and have the hind toe wanting or merely rudimental. Some of them are bank birds, but none of them wade deeply in the water; and their proper character is that of



Lapwing.

running birds. In a natural arrangement, some of them should precede and some follow the ostriches.



The third group, *Cultrirostres* (knife-shaped, or ploughshare-shaped bills), is pretty natural, though the epithet does not express the shape of the bills of many of them. They are, in general, long-flighted birds, ranging far and wide, especially in those countries which are subject to alternate drought and inundation. Many of them are true waders, and perhaps the most typical birds of all the grallidæ.



Adjutant.

The fourth group, *Longirostres* (long-bills), is also tolerably natural, though the single epithet "long" is hardly sufficiently expressive of bills of so many different shapes and textures, as are possessed by these birds. Some genera of this group have so much the habits of the former, that there is a very

natural transition from the one to the other ; but very many of them are marsh birds, seeking their food in boggy earth, sludge, and ooze ; and these in general have the bill flexible, and provided with nerves and vessels, so that it is a more sentient organ than the horny bills. As they find their food more by the touch of the bill than by sight, they are often nocturnal or twilight feeders, and remain in the cover of the tall aquatic or marsh plants during the day. On this account they are often really resident in places from which they are supposed to migrate.



Curlew.

The fifth and last group, *Macroductyles* (large-toes), differ more in their characters in proportion to the number of the genera. They are, as it were, on the confine of the order, and begin to partake something of the swimming character. This is the case with the *coots*, which have the feet lobed, and so articulated that they are not very efficient for walking. There are others, again, which, though they are not found in arid places, can hardly be said to be aquatic in any of their habits, or even to resort to the margin of the waters, of which the common corn-crake is a familiar instance. These, and some others, have considerably more affinity with the gallinidæ than many of the other genera, and even groups, which are interpolated between them in the system. The

Pratincoles, Flamingoes, and some other genera which Cuvier appends to this group, without meaning it to be understood that they naturally belong to it, are also of a mixed character. The Pratincoles have at least some of the characters of those insectivorous birds which have syndactylic feet, and also some of those of the gallinidæ; and it does not appear that, though they frequent the margins or surfaces of the waters, they are in any respect wading birds. It is also not very easy to assign the proper place of the flamingoes in any system which pretends to be quite natural.



Corn Crake.

We must not, however, either wonder, or be perplexed in our inquiries, at these apparent anomalies. It has been hinted, that the rich places of nature are those at which birds appear to interfere with, or, if the expression may be allowed, to *overlap* each other, agreeing in some of their characters, and differing in others; and as the margins of the waters are the richest places, and the places which are most permanently rich in the food of birds, it is natural to expect that upon these there should be the greatest interference of race with race, and consequently the greatest difficulty in so separating them from each other, as to give distinctness to their systematic arrangement.

## PALMIPEDES.

**PALMIPEDES**, or webbed-footed birds, form Cuvier's last order of this class ; and in so far as that they can launch themselves upon the waters, and be in their element there, they are a natural order. But they are not the only birds which can swim, for some of those of the former order can swim readily, and others can do it occasionally, although their feet are not webbed, but have only partial membranes, more or less produced, attached to their toes.

If we were to take a regular gradation in the birds of this order from those which have the feet the least adapted for acting upon the water, to those which have them the most so, we should begin with those which have the toes only lobed and margined, and proceed to those which have all the four toes united by one membrane or web. But the other active systems of the birds interfere with this arrangement, and their varying powers of flight interfere with the classification which otherwise might be founded on the structure of the feet, and render it imperfect.

Aquatic birds have wings of very varied structure. Some have about the longest and most powerful ones of all the feathered tribes ; others have them short and round, and some are almost wingless, though there is no sea-bird so completely so as the apteryx. Their wings are also used for very varied purposes. Some use them habitually in feeding ; some in ranging the surface of the ocean ; and some chiefly for migration from place to place, as changes of season and of food may require.

Their bills vary nearly as much in structure. Some have the form of spears for transfixing fishes, upon which the birds dash from a considerable

height ; some are toothed in the tomia, for catching the finny prey as they drive through the waters ; some are fitted for cutting and tearing the carcasses of the larger sea animals, which are often floating dead on the surface ; some are adapted for collecting oil on the surface of the waters ; and others for dabbling in the mud in the shallows.

Organs so differently formed, and applied to so many purposes in so many ways, render the division of aquatic birds into natural groups no easy matter, though some of the groups are as distinct and well defined as any of those of the land birds. Cuvier arranges them into four tribes.

The first of these consists of *Divers* (*Brachyptera*, or "short wings"), which have some affinity with the

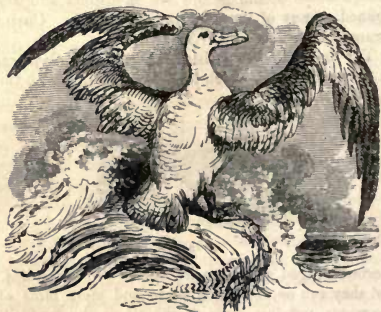


Diver.

shortest winged and most aquatic of the bank birds, and they run on, becoming more and more birds of the water, and less birds of the air or the land, till those species are arrived at which can neither fly nor walk. The show of resemblance may be said to run to a termination in this group ; for, as the latter can only swim and dive, and there are no other birds which can do either in greater perfection, there is no point of general character upon which any others can be connected with them. The popular name is also not quite precise, because, though they

are probably the only birds which drive through the water, they are not the only divers.

The second group, **LONGIPENNES** (long-winged birds), agree well with the name in that part of their organisation to which it applies. They are the birds which career over the surface of the ocean, and make the shores lively with the motion of their wings, and clamorous with the sound of their voices. Their food and their manner of obtaining it differ so much, however, that they do not admit of any general description.



Albatross.

The third group, **TOTIPALMÆ**, or birds with the feet "entirely webbed;" that is, having the hind toe considerably produced and included in the membranous web, as well as the other three toes. These birds are much longer winged than those of the preceding group, and they are good swimmers, and some of them at least can dive; but the peculiar structure of

their feet, and the use which they make of them in walking up to the surface of the water after they have plunged into it from a considerable height, render them very distinct from the other sea birds.



Darter.

The fourth and last group into which Cuvier arranges these birds, *LAMELLIROSTRES*, or flat-billed birds, comprehending ducks, geese, swans, and allied genera. There are considerable differences of haunt and habit among them ; but still they are distinct, and well-marked as a group. But it is doubtful whether they should occupy the place which Cuvier assigns them, as they more resemble the divers in all their general characters than they do the birds of the two intermediate groups.

Such is a short outline of the systematic arrangement of birds, as proposed by the most scientific general systematist of modern times. Many parts of

it are imperfect, and some are obviously faulty ; but the imperfections are much more easily felt than amended, and the faults much more easily seen than corrected. These imperfections and faults are also of the less importance, inasmuch as it is in the individual genera, or, at all events, in groups much smaller than most of those which have been mentioned, that the real history of birds must be studied. We shall now, in three successive chapters, shortly examine and compare the bills, the feet, and the wings of birds, as the foundations of their leading characters.



Shoveller.



## CHAPTER VI.

### COMPARATIVE FORMS OF THE BILLS OF BIRDS, AS ILLUSTRATIVE OF THEIR HABITS.

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THE armature of the jaws of birds, which answers the same purpose in their economy which the lips and teeth do in that of mammalia, always consists of two mandibles, one placed over the other, and opening and shutting chiefly by the motion of the lower one. This organ is sometimes called a *bill*, and sometimes a *beak*, but the distinction of these names is not very clear. Bill is, however, the more general of the two, in the usage ; for all beaks may be called bills, but all bills cannot be called beaks. According to the popular understanding, which, rather than any etymological definition, is the rule in popular language, the mandibles of a bird, in order to entitle them to the name “beak,” require the three attributes of firmness of texture, power, which requires considerable depth and breadth in proportion to the length, and curvature downwards, with pointedness at the tip of the upper mandible, and projection of it over the under one ; but the precise degree in which these are required, as well as their relative proportions to each other, are indeterminate. Those to which the term beak is more generally applied are the mandibles of birds of prey, and those of the parrot tribe, and some other vegetable or omnivorous feeders which use this

organ in breaking hard substances, or in assisting in the operation of climbing.

All beaks, whether used for one purpose or for another, have a considerable resemblance to each other, not only in the shape but in the mode of using. They are always cutting or bruising instruments, the effect of which is produced by pressing the one against the other, and not by striking with the point or darting, as is the mode of action in many bills. The forms of the tomia or cutting edges, are therefore the leading distinctions of different beaks, and the indexes to the different characters of the owners in so far as these depend upon those instruments ; though there are also some corresponding differences in the shape and strength. In the tomia of beaks there is a slight resemblance to the teeth of animals, as indicating the nature of their food. Those which are carnivorous have the tomia irregular in their outline, approaching in form to something like a tooth ; and those which are more exclusively vegetable feeders, have the lines of the tomia less broken, and the acting surfaces adapted simply for breaking or bruising rather than for tearing asunder. Some of the latter are, however, more strongly formed than any of the former ; because the shells of some fruits upon which certain species at times feed, require more force to break them, than is required to tear the average consistency of the flesh of animals, even in the most recent state. But the bills of the most vegetable feeders have little or no lateral motion by which they can prepare the food for the stomach by grinding ; and that appears to be the chief reason why birds of this description always have muscular gizzards, strong in proportion as their food is more difficult of division.

These characters of the tomia belong to bills as well as to beaks, though bills have in many instances additional characters, such as being serrated, sometimes with little teeth reflected backwards along the whole line of their margins, and at other times with small transverse channels, or furrows, along a certain breadth at the margin. The first of these descriptions belongs principally to birds which dart upon fish, or other slippery prey; and the latter to those which dabble in the sludge, and, as it were, sift the water and mud from their food by means of the channels. The former are generally hard in their consistency, so that they may penetrate and retain their hold like barbs; the latter are more frequently soft and flexible, and there is reason to believe that they are endowed with sensation, by means of which they can distinguish the food from other substances, and thus retain the one and reject the other.

Bills are, however, of so many forms, and so different in the texture of their substance, that no general definition can be made descriptive of them. If omnivorous, they are generally stout, sharp at the tip, and with ridges on the culmen, or centre of the upper mandible, and also often at the tomia of both; and these ridges, which render the bill much stronger and stiffer than if the same quantity of horny matter were equally distributed over the entire surface, often give a quadrangular form to the section of the bill. Bills which dig into the bark or wood of trees, into hard ground, or into other substances which offer considerable resistance, are also provided with ridges. This is the case with even those very small bills which pick minute insects and larvæ from the crevices of bark, and thus such bills are often much stronger than others, which, having a larger diameter, look more

formidable. All bills, too, which are used in striking or thrusting with the point, are fortified by ridges, and such bills never have so much curvature in their general shape, as that the line joining the tip and the centre of the base falls anywhere without, or even near the surface of the bill. If they act both by thrusting and by cutting between the edges, the ridge of both mandibles is usually a little arched, the arch in that part being the form which, with an equal quantity of matter, enables the mandibles to compress any substance between them with the greatest force. But if the thrust be the only powerful action of the bill, the ridges of the mandibles are generally concave, with the curvature increasing towards the base of the bill, something in the same manner as that of the bole of a tree increases near the surface of the ground. This is the outline of greatest stability, and as such it is adapted for lighthouses and other structures which are much exposed to strains from the action of the wind or the waves. In those bills, this enlargement toward the base, over which the tip is generally situated in a perpendicular line, causes the bill to strike with more precision, and also with much less jarring of the cartilaginous substance by which it is united to the bones of the head than if it had any other form. Thus we see that in those organs of birds which have not generally any sensibility or proper motions of their own, the same mechanical perfection is displayed as in the more sentient or more active parts.

We need hardly say that the bill or beak is adapted to the general structure of the bird, because all the parts of every organised body, be the organisation what it may, are always the best adapted to each other, and to the whole ; but there are certain

other parts of the structure with which the bill has a more immediate agreement. If the bill has to tug and wrench in tearing asunder the food of the bird, the neck has always great strength and great power of lateral motion united. If the bill has to strike forwards, the neck admits of less lateral motion ; but it moves the head in the direction of the stroke with great celerity. Thus, the blows of the woodpecker are given in such rapid succession that the motion of the bill can hardly be seen, or the strokes counted ; and though the neck and bill of the heron tribe appear unwieldy, they strike out with amazing rapidity.

The adaptation of the bill to the other acting parts of birds depends, however, in no small degree upon their habits ; for, after all, it is to the habit that the whole parts of the bird are adapted. Thus, though the taking of the same food, generally speaking, requires a bill of the same structure in its working parts, yet as that bill is brought within reach of the food in different ways, and by means of different organs, it must be so modified as to accord with these.

If the principal action of the bill consists in detaching the food or breaking it, it is always short, or only of moderate length, and stout in proportion to its length ; if the bill is used in hewing or digging for the food, it is longer, straight, and hard and pointed at the tip ; if it bores into sludge, it is still longer, straight, broader at the tip, and generally sentient, so as to discover eatable substances by touch ; and if the bird feeds in the free air, or on the clear surface of the ground, the bill is, in general, of moderate length. But all birds which capture living food, either in the water, or concealed among herbage, by a sudden thrust of the bill, have it long.

There are other purposes to be answered by the form of the bill besides the mere capture of the food, and adaptation to the place where it is, and the manner of getting at it. It is a general law in the economy of animals, that they shall be safe while they are feeding, at least from dangers connected with the food itself, or the place where it is.

Now, besides being pruners and weeders to the vegetable kingdom, and a sort of general scavengers for removing the waste of all nature, birds appear specially appointed for keeping within proper bounds the numbers of fishes, mollusca, insects, and reptiles. The power of production in all of these is very great ; and, with the exception of the fishes, which settle matters by eating each other (often their own species), this productiveness is far above the average support, or even the room which there is for them in nature. The tadpoles which appear in one brook would, were they all to live and breed, speedily cover a county with frogs ; the caterpillars on one branch would, if so breeding, soon clear a forest ; and the snails would speedily multiply till not a green leaf were to be found. The ophidian and saurian reptiles are, in many of their species, co-operators with the birds ; but they frequent the places where the food of birds is abundant, and they are not fitted for long migrations. The motions of molluscous animals are proverbially slow ; and though many of the insect tribes are clever on the feet, the wing, or both, they are not capable of long journeys. Locusts and some other tribes do migrate ; but no insects can continue long on the wing. They want the feathers, the characteristic organs of long flight ; and though their muscles act to very considerable advantage, they

must move their wings so incessantly that they are soon worn out, and fall to the earth.

There is here a very beautiful chain of adaptations, which is worthy of study in itself, besides being intimately connected with the general economy and structure of birds. All these natural trimmers of the exuberance and removers of the waste of growing nature are wanted, up to the full amount of their powers. But they are so wanted only for a season ; and though that season varies in length in different latitudes and climates, there is not a spot on earth where it could be perennial, or even of one whole year's unbroken duration, unless the laws of the whole system, that is, the qualities of the several parts of which it is made up, were totally changed. The vegetables could not bring all their "brairds" and buds to maturity, nor would the earth supply sowing ground for all their seeds ; and the creatures, of whatever kind, which keep down the superabundance of these, would, in like manner, speedily overstock the room that there is for them. But still they must all have that elasticity by means of which they can instantly adapt themselves to the changes of the system. The earth consists of a definite quantity of matter, occupying a definite space ; and to that quantity and that space all the productions of the earth must be capable of accommodating themselves, otherwise the system would be imperfect.

The earth itself is, perhaps, at once the best index to the system of the earth's productions, and the best illustration of the mode in which that system works. It careers round the sun, altering its distance from that luminary, and the rate of its motion, every moment, and differently affected as its own attendant moon, or any other body in the solar system, is dif-



ferently situated with respect to it. But though *altered* it is not *disturbed*; the balance is never deranged, and we are so far from feeling the inequalities of its motions, that it is only after the most profound investigation that we become aware of their taking place. The law which God has given it is a perfect law; and no case can arise to which it does not apply with the same ease and the same certainty. If the motion requires to be accelerated or retarded, in order to keep up the perfect balance, the very necessity for the change is, in itself, the cause of that change; and, be the aberration ever so much, there is always a principle inseparably connected with it, which, in due time, produces a return.

Just so with the growing and living productions of nature; if the general circumstances are such as to harmonise with an increase, there is no waiting for that increase as man must wait in his workings, and no toil as he must toil to bring it about. The necessity and the supply come so simultaneously, that the one cannot be called the cause and the other the effect. They at once prove their origin from the same cause; and that that cause is no part of the system of nature, although intimately familiar with it all in extent and in duration.

The preservation of the whole system of nature requires that, at certain pauses, and those not very wide of each other, the races which, among their other uses, put the birds in motion, must be as "the dry bones in the valley of death;" but the Author of nature has so ordered that, when their activity becomes necessary, there is "a spirit" breathed upon them from the system, which can, unseen, and in an instant, pass over them and recal them to life and activity. Thus the cold winter of the polar climes,



and the withering drought of the equator, are alike necessary for preserving the energy and the beauty of the world.

All preyers, and birds in an especial manner, as being the most discursive rangers, are highly valuable. They give play to the energy of life generally in that which they individually destroy; and but for them the earth would become rank and foul with the carcasses of those tribes which must perish and be renewed in the different seasons.

In the performance of these labours, many species of birds have to prey upon animals, the immediate contact of which with the body of the bird would be attended with fatal consequences; and in other cases the prey is in places which the bird cannot, with safety, approach too closely. The parts of birds which are naked of feathers, whether they are covered with horn or with skin, contain few muscles or blood-vessels, so that they are not easily wounded or otherwise injured in such a manner as to affect the general economy and action of the bird. This is the more necessary on account of some of the creatures upon which the birds feed being capable of inflicting poisoned wounds, all of which would be painful in the fleshy parts of the bird, and some of them very speedily fatal. It does not appear that the animal poisons, known by the general name of venom, are deadly, or even in the least injurious, if they are not taken into the circulating blood. Whether they must be so taken by direct introduction into a blood-vessel, in order to produce their fatal effects, or whether the poison may be carried into the circulation by the lymphatics, which pour what they collect into the veins through the thoracic duct, is not clearly ascertained; but as the effect of those

poisons always shows itself locally, near the place of the wound, before it injures the system generally, it is probable that a direct mixture of the venomous fluid with the blood is necessary, in order that it may produce its destructive effects ; and this is rendered the more probable from the fact that the same fluid may be taken into the stomach without the smallest injury, by animals to which it would prove fatal in a very short time if taken into the blood.

Many birds feed upon creatures provided with poisoning apparatus,—as the bee-eaters and other species feed upon many insects that have poisoned stings ; and various species of birds feed upon serpents which have poison fangs. Now, all those birds are so constructed, that those parts of their bodies which could be seriously injured by the sting or the fangs, are kept out of the way. If, like the bee-eaters, they capture stinging insects on the wing, the bill is long, and the tongue either short or indurated, so that no part of them which comes in contact with the insect, is liable to be hurt by its puncture or its venom. In those species which eat poisonous snakes, the bill is long, and the tarsi also, so that all those parts of the bird which are vulnerable by the reptile, are elevated above its reach after it is once pressed to the earth by the feet, when it is not at once killed by the stroke of these on the head, which is a very common habit with birds in the case of such prey. If food which is thus dangerous is taken by the bird on the wing, as is the case with wasps and other venomous insects, the bill is long, and the tongue either short, or callous towards the tip, so as not to be very liable to injury, if the snap of the bill, which however is seldom the case, should fail in despatching the insect.

If the food is in itself harmless, and not liable to escape rapidly, or to require a quick dart of the bill, that organ is short, and any inconvenience which may arise from the distance at which it is below the level of the body, or from the difficulty of the surface on which it is found, is usually got the better of by the length and flexibility of the neck ; but as a long and flexible neck is neither so steady nor so quick in its motions as a shorter one, the bill and neck are seldom both long unless in those species which take their food from the water, by darting rapidly on it by an aim taken when the eye and head are above the surface. Birds of this structure usually find their food on the margin of the water, or in the shallows ; and there is hardly any instance of a bird which feeds on the wing, having both a long bill and a long neck.

The same observation applies to birds which seek their food while launched on the waters. Swans, geese, and those ducks which never get wholly below the surface, though they get with the head perpendicularly under them, and hang, as it were, upon the water by means of the feet, have the neck, and generally also the bill, much longer than the divers which plunge wholly under water ; and the legs of the latter are articulated more in the rear, which makes them more efficient organs of motion through the water ; but the birds could not recover their horizontal position on the surface, by means of them, so easily as those swimmers which have not the habit of diving. Those ducks which do not dive, turn on the articulations of the legs, and bring their heads to the surface with very little progressive motion ; whereas the divers rise head foremost, and always at some distance from the place at which they plunge. The common duck gets the head down chiefly by

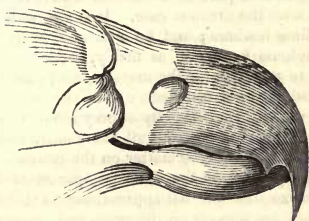
the action of the neck ; the plunger by a swing upon the webs of the feet, the whole length of the body acting as a lever. The diver, too, can make the body follow the bill, as guided by the eye when under water ; and the bill is compressed, or at all events narrowed and rounded at the tip, so as to make it readily available in that action ; whereas the bill of the dabbler, which does not dive, is probably available only in the sludge, and incapable of capturing prey that can move swiftly. Dabbling ducks rarely capture even the fry of fishes, in those shallows which they frequent ; but these are the principal food of many of the divers.

The bills of birds are, however, so much in harmony with the other parts of their organisation, that it is impossible by any description, however lengthened, to give a clear and satisfactory notion of them, even in their leading function of feeding instruments. They have, in many species, other offices to perform ; and though these are subordinate to the alimentary function, as the functions of the mouths of all animals are, yet the bill must necessarily vary with every natural operation to which it is applied.

The secondary functions of bills are chiefly preening the feathers, climbing, constructing nests, and defensive or offensive operations not connected with feeding. These functions are performed with so apparently equal ease by bills of so different forms, that it is not easy to say which answers the best ; and then the comparative merits of bills, as working tools, can hardly be so generalised as to convey any information useful to the student of ornithology. We shall therefore proceed to give some instances of bills belonging to well-known or well-marked species, as illustrative of the several orders.

## BILLS OF THE ACCIPITRES.

The annexed figure of the bill of the jer-falcon may be regarded as the most perfect type of those of diurnal preyers upon the wing. It is short, compressed, and so formed on the culmen that it is perhaps stronger in proportion to its size and quantity of matter, than the bill of any other bird.



Jer-falcon.

The tooth is prominent, the notch well defined, and the tomia curved in the greater part of their outline. The form of the tip of the lower mandible is peculiar, acting with a sort of sliding motion against the hook of the upper one; and this sliding motion is in part communicated to the tooth and notch, and to all the irregularities in the lines of the tomia. The action of the mandibles is, in consequence of this form, compounded of the direct cut of a chisel and the drawn cut of a knife. We shall find the same sort of action, partially at least, in some of those sea birds which live much upon floating carcasses, though in these it is a simple slide at the tip, without any notch or tooth.

This is not so much a killing beak, as a tearing

one ; and it answers in the economy of the bird, to the tearing grinders in carnivorous mammalia, the claws performing the operation of killing in the falcons, just as the canine teeth do in those. It is not suited for thrusting or striking ; and therefore it is not so formidable as a weapon as some of the straight bills ; but it takes a very firm hold ; and there is no soft part of an animal which it will not divide with the greatest ease. It is also well formed for pulling feathers ; and by means of it the falcon can deplume her game, as neatly, and with as little injury to the flesh, as the most expert poulterer. It can also cut open the birds, divide the tendons and ligaments, and when scarcity of prey renders economy necessary, it can separate all the joints, and leave not an atom of eatable matter on the bones.

In proportion as the different species of falcons and hawks have the bill approaching to this typical one, they are preyers on the wing, and consequently preyers upon birds, killing their own game, and eating it in the recent state. In proportion, too, as they have this structure of the beak more perfect, they fly at "higher game," or birds of more powerful wing. The plumage of these is more firmly set, and the tendons and even the muscles are much tougher than in birds of lower flight ; and besides, the low-flying hawks, harriers, and buzzards, strike prey upon the ground ; and prey upon small mammalia, or occasionally take a mess of carrion or garbage.

It is thus not without some shadow of reason that the high flying falcons were called "noble," and the low-flying ones "ignoble ;" for there is a sublimity in their style of hawking, as compared with that of the others. They are the genuine birds of prey ; for though they descend to the earth to strip and eat

their game, their preying is, in a state of nature, confined to the air, the appropriate region of birds.

The peregrine falcon is probably next to the jer; but the gradation in the beak is not very strongly marked among the high-flyers; for the smaller ones, such as the merlin and the sparrow-hawk, have it very beautifully formed, better adapted certainly for dividing and tearing flesh than any instrument of human contrivance.

Through the low flighted hawks there is a gradual departure from the model of the jer-falcon, till we come to the beak of the kite, which combines some of the characters of the falcons with some of those of the owls. And the feeding of the kite is of the same mixed character. It captures birds when it dares and can; but it does so chiefly on the ground, adds mice and reptiles to its mess; and although a bird of fine wing, and one of the most airy hoverers of the race, there is no dash or dignity about it.

In the eagles we have a further modification of the bill. It has no decided tooth in any of them, neither is it so strongly formed in proportion to its size as in the high-flying falcons, even in the most powerful of the race; and in the fishers, the outlines of the tomia are nearly even. New characters present themselves in this division of the order; they do not contend with their prey in the air and on the wing, and they feed more upon mammalia than the hawks, though they also make great havoc among the larger ground birds. We shall, however, be better able to understand those differences when we come to consider the feet and wings.

The beaks of the vultures are much feebler than those of any of the species already noticed. Instead of the arched outline, which, though it gets flattened in the others from the falcon downwards, is nearly an

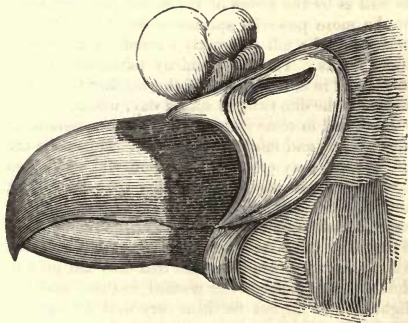
unbroken curve from the tip of the beak to the posterior part of the skull, the vultures have a depression at the base of the bill, and another in the middle in some of the species. The bill is also much longer and also wider in proportion to its height, and the cutting edges of the tomia are in all the species nearly, and in some of them completely plain; it is also without the sliding action at the points of the mandibles. Thus it can grasp a larger portion of substance than the beak of the falcon; but it can separate that only by simple pressure of the mandibles against each other; and, independently of its being without the sliding or tearing motions, the mandibles are neither so stiff for pressure nor moved by such powerful muscles as those of the other diurnal birds of prey.

From their mode of feeding, and the substances on which they feed, vultures do not gain from the velocity of the points of their long mandibles that which they lose in power from the diminished strength. In birds, and in animals generally which snap, the velocity makes up for the loss of power; and though the greyhound cannot hold fast like the bull-dog, his momentary bite is sharper. It is the same with many of the long-billed birds; but the vultures are gnawers and not snappers; and they are not so able to divide recent flesh as the other diurnal accipitres. Therefore, their chief food is carrion, or the bodies of animals which have become tender by the progress of putrefaction.

The annexed sketch of the beak of the vulture may be regarded as the opposite extreme in the diurnal accipitres to that of the jer-falcon already given. But the vultures do not lead by a natural gradation from the more typical diurnal preys to the nocturnal ones. They point to another portion, or rather to



two other portions of the class. In the forms of their bills they have some approximation both to certain species of the gallinaceous birds, and to certain tribes of that division of Cuvier's great order, Passeres, which, for want of a better name, we shall call omnivorous ; and it is not a little remarkable that, like the gallinaceous birds, they have naked skin upon the head and neck, and that skin *blooms* in the season as in these.



Vulture.

The nocturnal birds of prey have the bill more slender than the day-feeders, generally much hooked from the base, compressed, sharp at the tips of both mandibles, smooth in the outlines of the tomia, and without tooth or notch. It takes up the connexion with the bills of the diurnal feeders rather from one of the characters of that of the kites, than from those of the vultures, which, in their general structure, may

be considered as the lowest in the diurnal division; and this might be expected, as the nocturnal feeders—the owls—are not feeders on carrion, but in general kill their own game, chiefly mice, and other small mammalia, which have been mentioned as forming, in part, the food of the kites.

But, though such is the general food of the majority of the owls, and though they have the habit of wounding and disabling such prey by the snap of the bill, as well as by the clutch of the talons, there are some of the more powerful species which have different habits, and the bill differently formed, to agree with those habits. These are chiefly inhabitants of the north, and in certain states of the weather they come abroad in the dim twilight sort of day, which, at some seasons and in some states of the weather, obtains in those dreary and inhospitable climes. Mammalia are the general prey of those more powerful owls upon such occasions; but it is said that they also attack and despatch birds, especially when these are exhausted and overcome by the violence of the weather. They have been described as giving chase on the wing, but it has not been said that they kill prey in the air; and indeed, the muffled feathers and soft flight of owls do not fit them very well for such an office. They are popularly called “eagle owls;” and if there is any propriety in the name, they should kill their prey on the ground, though they may seek for, and in so far follow it in the air.

In proportion as the birds of this order depart from the type of the jer-falcon, they seem to be incapable of depluming their prey, or depriving it of its indigestible covering, or taking the flesh from the bones. In proportion as they are thus incapacitated, they take the indigestible parts of the food into the

stomach. But these do not pass the pylorus into the intestinal canal. They remain in the stomach till all the parts fit for the nourishment of the birds are separated, and then they are discharged by the mouth in sapless balls, called "castings," or quids. The species which have this habit cannot, of course, feed upon animals of any considerable size—not larger than they can swallow, because they cannot masticate; and though an owl can separate the viscera of its prey, it is not capable of disjoining the bones even of a mouse.

We have entered somewhat more into details respecting the bills of this order of birds than we shall be able to do with those of the remaining orders; but they are not only well marked in their structure and habits, they are also in no small degree the typical members from which a general notion of the class can be best formed.

#### OMNIVOROUS BILLS.

In the order of Cuvier's classification, an outline of which has been given in a former section, the bills of the *dentirostres* should follow those of the birds of prey; but though these have generally a notch in the upper mandible, and often in the under one, none of them has the bill suited for tearing the recent flesh of warm-blooded animals, as in the falcons, and their claws are so formed as to be organs of motion and support, and not killing instruments. Their general habit, if birds which are so diversified in their appearances, powers, haunts, and manners, can be said to have a general habit, is that of feeding upon insects and their larvæ, in what may be called the "free state;" that is, when they are so situated as that birds have not to hawk for them on the wing, or

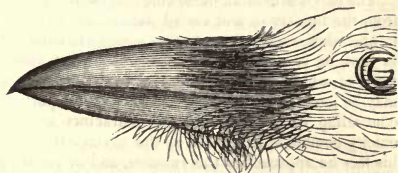
to dig them out of the earth, the bark of trees, or other places of concealment.

The bills, in order to accord with that general habit, do not require the firm texture and powerful action of those of the accipitres. As many of them have to seize their prey quickly, as they often catch it while it is on the wing, though they do not fly after it, rapidity of motion, both in darting at the food, and in opening and shutting, with firmness and sharpness at the tip, are the requisites of such a bill ; and lightness in its general structure is essential to the quick motion. Hence, these bills are, in very many of the species, so thin and weak that they are not able to break the coat of a vegetable seed between the edges of the tomia, and their owners are called *soft-billed* birds. If an arrangement were to be attempted from the bill, as adapted to a certain species of food, the insectivorous birds would have to be taken from several orders, because the feet and wings vary with the manner in which the birds get at their food.

The *omnivorous* bills, and even many of those of the birds that live much upon seeds,—the *conirostres* of Cuvier, have considerably more resemblance to those of birds of prey than the *dentirostres*. They vary much, as might be supposed in birds which inhabit so many places ; but perhaps the most typical of the whole, and the one which takes up the connexions most closely and naturally from the vultures, is the bill of the raven, a resemblance to which may again be traced through many genera.

This structure of bill is intermediate between those of the vultures which feed principally upon carrion, and of the woodpeckers and analogous races which obtain their food (chiefly insects and larvæ) by dig-

ging or thrusting into cracks in the bark of trees, and fissures of rocks. It is inclining to straight, and can inflict a severe wound by thrusting ; it is ridged and arched in the culmen, and firm in the tomia, so that it can cut by the pressure of the mandibles ; it is a little hooked at the tip, and waved in the tomia, so that it can keep a firm hold, while the owner tugs and tears by the motions of the neck ; and as it is long, the snap of the point is very sharp from the rapidity of the motion. It is, in short, a very serviceable bill—a bill of all work, as it were ; and when properly examined, it is found to answer well with the omnivorous habit of the owner.



Raven's bill.

And the raven, though not very numerous in any place, and though dwelling in solitude, pairing for life, and not being very prolific (as is the case with most birds of prey), is one of the most generally distributed of birds. Almost every other species has some country which it can claim to a very considerable extent as its own ; and even though it is migrant, and passes the different seasons in places some thousands of miles asunder, it returns with the season, not only to the same latitude, and to the same land, but often to the very same spot. The raven is no migrant,

except in shifting a little with the seasons as the supply of food varies, but never quitting the same district; and yet there is no country in which the raven is not found native. The margin of the desert, of the jungle, or of the forest, in the hottest climates,—the heights of alternate cliff and copse in temperate climates, or the rocks and heaths, and even the lichen-clad margins of the inhabited earth near the poles, are all equally the abodes of the raven; and let the sun blaze, the wind blow, the rain pelt, or the snow drive, with ever so much intensity, his dusky wing or firmly set foot is in its element, and the wreck of the rest of nature is to him the season of plenty.

The raven is thus an exceedingly typical bird; and from the numerous and varied habits, and structures in accordance with those habits, which are combined in him, he is what may be called a sort of central type, in which the characters of many other races may be found, though rudimental, or at least partially concealing each other. Those characters are also chiefly combined in the bill of the raven; though in his feet he approaches the vultures, and in his wings partially the low-flying hawks.

In tracing the gradation from the raven through the analogous races, we find that the bill gets less and less powerful in those characters in which it most resembles those of the vultures, namely, its adaptation for tugging and tearing the flesh of animals from the bones. But the raven is also a preyer. He rarely, though sometimes, hawks on the wing, and when he does so, he strikes with the bill, not with the claws; but he preys much on the ground, on young birds, the smaller mammalia, and even the larger ones when disease or casualty brings them within his reach.

Of the others, the carrion crow most resembles the raven ; but its bill is neither so formidable as an instrument of slaughter, nor so capable of tearing the



Raven.

flesh of recent prey. The culmen of the upper mandible is not so much arched, nor the tip so much hooked, and consequently the bill can neither cut so well nor hold so firmly. This bird accordingly eats large animals, chiefly in the state of carrion ; and finds much of his food in the eggs and callow young of the ground gallinidæ.

The other crows, on to the rook, have the bill more and more approximating to straightness ; and in that bird we have certainly an approximation to the ground birds which feed upon seeds ; and different as they are in their appearance, and many of their habits, there is a correspondence in nature between the rook and the skylark, which brings them to the same field for their food.

The bill of the raven and crow, is continued through the magpies, the rollers, and several other birds, which differ more and more in the other parts of their structure and in their habits, till we come to those races which are more and more tree birds, and when they become chiefly so, have a considerable part of their character in the feet.

There is still another division that may be traced from the crow tribe, and the portion of the character of the bill which they carry along from the raven, is that of snapping with the mandibles. We find this rudimentally in the jackdaw, a little more developed in the chough, and so on till we come to those birds which catch insects upon the wing ; and here again we find a subdivision : one race having the toes united, and terminating in the bee-eaters, and other tribes with bills very long, sharp at the points, slightly arched, not very heavy, but beautifully formed for possessing the maximum of effective strength and ready motion. The other subdivision leads to the swallow tribe, in which the bill is not so much an instrument of death as of capture ; and they, as well as the former subdivision, are dependent on the air for the chief part of their food ; and, as might naturally be supposed, have their proper characteristic in the organs of flight.

To trace out these connections with all that minuteness which they would require, in order to see clearly the resemblances and differences of birds, as depending on the nature of their food and their organisation for capturing it, would far exceed the limits to which this sketch is restricted. But the hints which have been thrown out may serve to call the attention of observant readers to this very instructive part of the subject ; and if such should be the case, the object of what has been said will be, in a great measure, accomplished ; and that object, if we are to allow that the great business of human life, is pleasurable enjoyment—is one of far greater importance than those who have not reflected on it are aware of. Birds are always about us, in a state of nature, go almost where we will ; and the greater part of them, instead



of seeking safety by escape from our view, as is the case with all those animals which cannot fly, and which are not too formidable or too repulsive to our prejudices for our remaining to examine them, seek it by rising and spreading themselves out, as it were, for our examination in the free atmosphere. Hence, when we are abroad, be it for pleasure, for health, or for business, the birds are an ever-open book, in which every one may read as he walks or rides; and thus turn to a means of acquiring the most useful knowledge those hours which to them who have not this habit are not only utterly lost, but which are even painful in the passing.

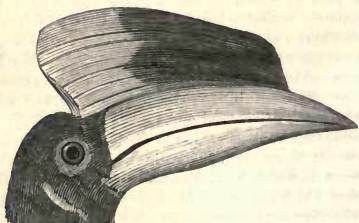
There is in this last circumstance, and it is one the pain of which is felt by every one who is not absolutely seared to indifference, a most useful lesson. If we throw idly away those portions of time which we cannot employ in our ordinary business, they fail not in galling us for the neglect, and if we persevere in the idle habit till it ceases to be galling, the mind is thereby so unnerved and broken down that, if we do not seek ruinous escape in dissipation, we become unfit for those very avocations, our eagerness for success in which is the cause why we neglect that nature which should afford employment to our minds in the necessary pauses.

It is worthy of remark and remembrance that, in all those revivals in which nations have come back from a state of listlessness and decline to vigorous action and improvement, the study of natural history has always formed an early and a prominent part; and that, in all the fallings-off, that study has been among the first to be neglected. As it is with nations, so it must be with individuals; for the one is merely the sum of the other, and the sum can

be nothing but equal to the individual parts of which it is made up, either in quality or in quantity. But to return to our more immediate subject.

Many of the foreign species of omnivorous birds differ greatly in their bills, as well as in their general appearance, from those which are met with in the British islands. The most remarkable of these are chiefly inhabitants of warm countries; and the hornbills (*Buceros*) and birds of Paradise (*Paradisea*) may perhaps be regarded as the two extremes, at least in peculiarity of structure.

The following figure of the bill of one of the hornbills of India and the Oriental Isles, will give some notion of the form of this singular organ.



Hornbill.

The bills of the other species differ from that of this one chiefly in the form of the horny enlargement on the base of the upper mandible; but as that is not developed, or at least does not attain its full size till the birds arrive at maturity, which takes three or four years; and as it is not nearly as much developed in the females as in the males, it is subject to

so many variations in the same species, that it can hardly be depended on as a character. From the figure it will be seen that the true bill of these birds has not the robust thrusting form of the bill of the raven, but more resembles that of the chough ; and notwithstanding its formidable outline it is feebler than even that.

The basal enlargement is cellular, and all parts of the bill are comparatively weak. The mandibles are also more or less notched or serrated along the whole of their cutting edges. This bill, if we except the horny enlargement, the use of which in the economy of the bird is not known, approaches to those of the toucans and other enlarged-billed climbing birds of the tropical forests, only in these the upper mandible is much more enlarged, instead of having the enlargement in an appendage. Leaving the appendage out of consideration, the bills which those of these birds resemble most nearly are those of the aracari, only it will be seen on referring to the figure at page 269, that the aracari has the better formed bill of the two. Still, however, there is so much resemblance between them as to lead to a presumed correspondence in the habits of the birds, though their feet indicate a different haunt. Both genera eat carrion, eggs, insects, and occasionally vegetable substances ; and both are rather indolent and lurking birds in their general habit. The toes of the aracari are yoked, so that it is a branch bird, inhabiting living trees, among which it jerks about something in the manner of the jay. The hornbills have the toes free, like the rest of the omnivorous birds ; and though most of them can perch readily and firmly, they prefer perching on dead branches to those which are covered with

foliage. When on the ground they do not walk, but hop as magpies do.

A bill of this form cannot be efficient against any very powerful animal, because its great size and length, and light structure, render it impossible to close the mandibles with much force, though the bill may snap at small objects with much less labour on the part of the bird than if it had been of stronger texture. These birds connect the omnivorous races pretty closely with the insect feeders; for though they all eat carrion when it can be procured, the various insects which breed in and consume rotten wood in the tropical forests appear to form the chief subsistence of those hornbills which are more exclusively forest birds; while those which feed more on the ground pick up ground beetles, which are also numerous in those localities. The serrated margins and snapping motion of those large but lightly formed bills are sufficient so to crush an insect as that it can be advantageously taken into the stomach; and when they have recourse to carrion they seem to be equally attracted by the putrefying animal matter, and the larvæ with which it is inhabited.

The other extreme, birds of Paradise and analogous genera, as may be seen by the figure, have bills smaller and firmer, and approximating more to those of the gallinidæ; and though they are understood to feed less exclusively on the ground than any species of that order, yet their food bears no inconsiderable resemblance; and it is not unworthy of remark, that the native localities of the more remarkable of the perching gallinidæ and the birds of Paradise border with each other in their native localities, as the peacock in India, the Argus pheasant in Sumatra

and Java, the birds of Paradise in the isles to the east, and flycatchers more generally in the forests.



White-crested Flatbill.

To explain, or even to enumerate, all the varieties in the bills of those omnivorous tribes, and the differences of food and haunt which those indicate, would be incompatible with the nature of a general sketch; but the subject once entered on, is one of very easy study; and there is scarcely any tribe, at least of land birds, traces of resemblance to which

may not be found in one species or other of the omnivorous race. Still, however, there is a definite character in the bills of the whole, and that of the raven is not completely lost even in the hornbill or the bird of Paradise.

The whole race are also what is usually termed "foul feeders." Their voices are harsh, but, generally speaking, they are capable of being taught to articulate. They are also familiar birds, and not difficult to be tamed, partly, perhaps, from their indolent habits, and partly from their voracity. Generally speaking, they are prying and hopping creatures; and when they seize living prey, they jump at and stab, or snap it with the bill. Altogether, they are a serviceable race, and their labours tend much to preserve vegetation both in field and in forest in places where they are numerous.

#### BILLS OF THE CONIROSTRES.

These form the first natural division which we can trace from the omnivorous bill of the raven, upon that part of its compound character which relates to the action of the mandibles against each other by pressure in the simple division of hard substances. Bills of this description are without any notch or tooth; and they are always of firm texture, on which account the small birds that have them are often styled *hard-billed* birds, in contradistinction from the insect feeders, which have the bill with a tooth or notch, but of comparatively slender structure.

Birds having bills of this description vary much in their structure and habits; but generally speaking, they may be considered as more peculiarly birds of temperate and even cold climates. This is what might

be expected. In tropical countries, the vegetation of trees may be said to be constant, and the ground vegetation is in a great measure propagated by bulbs, or, at all events, the seeds of herbaceous plants do not strew the ground there either so numerously, or for such a length of time, as they do in regions where the winter is more decided. There is thus not much food for, at least the ground species of the Conirostres, in tropical climates, and where they are found, they are not so migratory in their habits as the soft-billed birds. In such climates as that of England, their grand feeding time is in winter, because the fields are then covered with seeds, which are softened and sweetened by the action of the weather, but have not begun to sprout; and perhaps there is no race of wild animals so serviceable to cultivation in such climates as these birds. They come in vast crowds, and clear the stubble field of the seeds of weeds, which, if they were to spring up, as of course they would do, if not gathered by the birds, would completely choke the crops in the following season.

The bills of all these birds are thick and strong, enlarged at the base, sharp at the tip, and the mandibles are often fortified by a margin, which, acting upon the tough rinds of seeds, bursts them, and extracts the farinaceous part, which is much more readily and effectually done by the flat grinding margins of the bill than it would be by sharp edges. The different effect of these two kinds of form in effecting this purpose may be perceived by any one who tries to crack a nut with a pair of scissors, and another with a pair of nut-crackers of the same lever-power.

The birds which have those bills do not feed exclusively, or at all times, upon seeds. Indeed, it will

readily be understood, that at those very times when these birds stand most in need of food, that is, while they are preparing their nests and rearing their broods, the supply of seeds for them is very limited compared with what it is in winter. The groundsels, and various other wild plants, keep flowering and producing seeds with little interruption all the year round ; but the supply from these, even where farming is conducted in the most slovenly manner, would not support the tenth of those flocks which feed on the fields in winter. Accordingly, though there are a few tribes which eat the seeds of those plants, these form but a small portion of the whole, and there are very few genera which are not, to some extent or other, animal in their feeding during the nesting time. It is worthy of observation, too, that at that season they disperse over the breadth of the country, so that more than the pair, or the family, when these grow up, are seldom seen together, or in anywise associated, even though the same species should collect in thousands during winter. This is a wise provision in nature ; for the birds crowd to the fields at the very time when their presence there is most useful ; and again, when their individual labours are more immediately required in reducing the numbers of insects and worms, they are distributed over the country.

The bills of those birds are familiarly exemplified in that of the common house sparrow, which may be considered as about the average. As is the case in the birds of prey, the smallest bills in this order or division are often the most efficient. The tits are perhaps those which, among our native birds, connect the conirostres most immediately with the feeders on tree insects, or rather, perhaps, with the omnivorous



tribes, and they are equally remarkable for the smallness and the efficiency of their bills. The bottle tit (*Parus longicaudatus*) has the bill so very short, that it barely appears beyond the produced feathers at the base; yet this minute bill is one of the most active, hardy, and efficient little instruments in the whole animal economy. It can bite sharply and hold firmly, and there are few birds which construct more elaborately beautiful nests. Though on a very small scale, the bill of this interesting little bird is a perfect model, the maximum of usefulness with the minimum of matter. The bills of the other species of the genus are all finely formed, though none of them are quite equal to this one.

The bills of this genus partake a little of the characters of those of some of Cuvier's *tenuirostres*, though they are capable of performing more severe labour than most of these. They do not break the hard crusts of seeds by squeezing them between the mandibles, but rather hew them asunder by strokes of the bill, and in the same way they dig into the folds of buds and the crevices of bark for the larvæ and the eggs of insects; nor have they any aversion to carrion when it comes in their way.

The bearded reed bird, which has generally been described as one of the genus *Parus*, has the bill intermediate between those of that genus and the finches and linnets. It is stout in proportion to its size, but it is slightly curved in the upper mandible, and thus it is a bruising bill rather than a thrusting one. The habits of the bird correspond. It lives in reeds over the marshes, the seeds of which are not so hard in the coats as the seeds of plants on dry ground.

The larks may be regarded as more directly con-

necting the conical-billed birds with the insectivorous ones ; and they have so many points of resemblance to the pipits, which are insectivorous, that these used to be included in the same genus. The buntings stand in nearly the same relation to the larks that the bearded reed bird does to the tits, one of them at least is a reed bird, and they are all more vegetable in their feeding than the larks.

The finches and linnets have the bill the most perfectly conical ; and they are thus the most typical birds of the order. They are vegetable, or nearly so in their feeding, at all seasons. Extending over a great range in latitude, and inhabiting places very different in their vegetation, from the dense forest to the bushless waste, they feed very indiscriminately on the seeds of trees and herbaceous plants, and often the thick tunics of wintering buds. Their bills are simply bruising bills, though they vary in form, size and strength, according to the food of the birds. In general, however, the mandibles are of equal length, and very sharp at the tips. The following is the general type.



Finch.

The crossbills form a very curious exception to the bills of this order of birds, as will be seen in the

following figure of the common crossbill (*Loxia curvirostra*), which is of the natural size, and taken from a dissection by Mr. Yarrel, to whom we are indebted for the original and the best account of this curious organ, and the mode of its action.

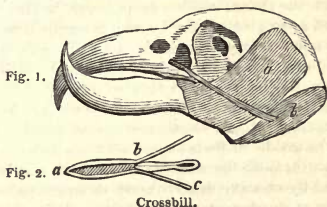


Figure 1, is a profile of the bill, with the skull and the principal muscles. The one marked *a*, and situated in the posterior part of the skull, is articulated behind the centre of motion in the articulation of the jaw; and the one marked *b*, extends before it as far forward as the gape; but these are assisted by other muscles.

Figure 2 is an outline of the tongue, which is as curious as the other parts of this feeding apparatus.

It will be seen that both mandibles have a double curvature; the upper one is curved downwards and the lower one upwards, and the one curves to the right and the other to the left, so that the points cross each other; and Mr. Yarrel found them to be about three-eighths of an inch apart when the bill was closed at the basal part. In the figure the upper mandible curves to the right and the under one to the left; but that arrangement is reversed in many of the specimens. The side to which the mandibles turn is thus not a specific character of the bird.

The upper mandible is united to the frontal bone of the skull by plates of bone which are a little flexible, so that that mandible has a little lateral motion. This agrees with that very general law in the animal economy, in virtue of which every part which is subject to violent motion or pressure is always so formed as to give a little, by which means a sudden strain upon the moving part is not so forcibly propagated to the rest of the body; but beyond this limited motion, the base of the upper mandible is very strongly supported. The lower jaw, the sides of which are deep and strong, and the coronoid process near the middle of their length, is so much elevated as to give them all the stiffness of triangles, and is articulated by concave sockets upon spherical processes on the *os quadratum*, and thus they admit of lateral and oblique as well as vertical motion in that mandible. The pterygoid processes of the upper jaw are very long, and the pterygoid muscles correspondingly large; and when the jaws are fully closed, that is, when the coronoid process on each side is brought into contact with the pterygoid on the same, the mandibles are crossed to the full extent. The muscles of that side of the head to which the lower mandible curves, are larger than those of the other side, so that their action has a tendency to draw the mandible toward that side; but as the closing muscles, which have their insertion before the centre of motion, pull the mandible to that side, the opening ones, which are inserted behind that centre, pull it to the other; and thus the parts come in contact when the bill is opened. The action of the bill thus resembles that of a wedge, by the mandibles sliding upon each other, and thrusting the points asunder at once with great force and great firmness.

Before stating how this bill is used, we must advert to the tongue, which is an important part of the whole organ. Fig. 2, on the cut is an outline of the upper side. A portion of the tip from *a* to *b* is in the form of a scoop, raised at the sides, and thin and rounded at the extremity. This scoop is composed of horn, supported by a particular bone, which is articulated to the os hyoides or common bone of the tongue *cc*, at the point *b*; and one set of muscles bind the joint at *b*, and thereby depress the point of the scoop, and draw it backwards; while another extends the joint, and projects and elevates the scoop. The tongue has thus what may be called a sort of elbow joint, and the scoop performs the office of a sort of hand in picking up those substances to which access is procured by the oblique motion of the mandibles. The bill thus performs the functions of two bills; and one of them could not be performed by a bill of any other construction.

The way in which the points of the mandibles move, draws them into any substance of which they can take hold. If that substance is of a texture not to be cut by the points, they split it open by their wedge-like action; and if it is a softer substance, they at the same time cut it in the cross direction. Whatever may be the depth of the opening, the eye also sees to the bottom of it, and the scoop of the tongue can reach it. The upper mandible is the part of the bill at rest, and therefore to whichever side it bends, the head is bent to the other, and the eye on it commands all the space, which the point of the under mandible pushes open, from the contact to the greatest extent in crossing.

Crossbills are found chiefly in the extensive pine forests of the northern latitudes, where they live upon

the seeds of those trees. These seeds are contained under tough woody scales, which continue pretty close for some time after the seeds are ripe; and the chief labour of the bird is to raise these scales by the oblique motions of the bill, till the seeds can be scooped out by means of the tongue; and they do this, or even split a piece of dry wood into strips, with great rapidity. Sometimes, from causes not very well understood, as they are not regular migrants, they leave their native forests in considerable numbers, and do no small damage to orchards of apples by splitting the pulp in pieces to get at the pips.



Crossbill.

The strong muscles on the sides of the head give them something of the air of parrots; and though they are not climbers as these are, they resemble the parrot tribe a little in their plumage. One species (*Loxia pytiopsittacus*) is popularly termed the parrot crossbill. Indeed, though their habitations are in the opposite extremes of climate, and the parrots get at their food by climbing, and prepare it by cracking the rind or shell with the mandibles, while the crossbills get at theirs by flight, and raise the scales without separating the cone from the tree, yet the two families have many points of resemblance.

## INSECTIVOROUS BILLS, OR DENTIROSTRES.

The insectivorous birds, when properly restricted, consist of those genera only which have the common normal feet with three toes before and one behind, all articulated on the same level, and thus have their more peculiar characters in the bills or the bills, than the wings. They are inhabitants of woods, copses, and bushes, those being the places where insects are most abundant, though some of them inhabit the margins of waters, and nestle in holes of rocks, or under stones. They all take their food either standing on the ground or perching on the sprays, or they dart upon it by short jerks from the ground or the perch. Their bills are accordingly all snapping bills, generally light in their structure, having the upper mandible rather longer than the under one, and notched near the tip, but not so sharp pointed or so firm in the tomia generally as the bills of vegetable feeders. The point of the bill is the prehensile part of it; and the culmen of the upper mandible is usually a little arched to support that part. In those genera which are characterised by superior boldness the bill is compressed, and the upper mandible hooked at the tip, while in the feebler ones it is rather depressed, and the tip straighter.



Butcher Bird.

The shrikes, a figure of the bill of one of which is annexed, are the most daring birds of this division,

and the ones which connect it most obviously with the predatory or omnivorous birds; but the resemblances are much slighter than those which can be traced between order and order in other parts of the system. The larger beetles form the principal food of the shrikes; and as many of those in the larvæ state, and some of them when perfect, are destructive to vegetation, shrikes are useful birds to the cultivator,



Shrike.

while, as they do not eat vegetables, they do him no harm. The shrikes are, however, chiefly woodland or hedge birds, and leave the open fields for the pasture of rooks. They do not inhabit the very cold countries, as their staple food is not so abundant in these. Many of the beetles on which they feed have the elytra or wing-cases very hard, almost proof against the action of the bill, notwithstanding its strength and its notches. In these cases, the birds are understood to stick their prey upon thorns, and divide and eat it at their leisure by the strokes of the bill. It is also said that in this way they bait the hedges for the purpose of capturing the feeble insectivorous birds; but though they do sometimes kill birds by pinching their necks between the mandibles as they do beetles, these and some other habits which



are attributed to them would require to be well authenticated. The bill of the shrikes can both strike and squeeze more powerfully than that of most of the division; but still it is properly an insectivorous bill.

The next gradation of this character of bill is in the thrush tribe, which have the middle and outer toes united, so as to form a firmer walking foot than that of the shrikes; and they are accordingly more of ground feeders. They partake more of the vegetable feeding character; inhabit colder climates, and live upon berries in the severe weather; but mollusca and worms form the principal part of their summer food. But whether animal or vegetable, these birds prefer soft food—mollusca to worms, and viscid pulpy berries to farinaceous ones or seeds. Their flesh is in consequence more sweet and juicy than that of many birds; and these qualities are increased by the small tendency they have to flight, unless when, as is the case with those that summer in the more inhospitable climates, they are obliged to migrate.



Missel Thrush.

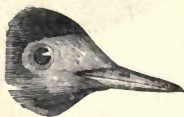
In accordance with these habits, the tomia of their bills are sharp cutting edges, as the hardest labour they have to perform in feeding is breaking the shells of snails, which they do by hewing them to pieces with the point of the bill. The preceding is the general figure of these bills.

The ant-catchers, dippers, menura, manakins, todies, fly-hunters, fly-catchers, and a number of other races, chiefly inhabiting the warmer parts of the world where insects are most abundant, follow these, varying in their bills with the nature of their principal food, and in their other organisations with their haunts and action; but all agreeing in the general structure of the bill as insectivorous, and generally having it of such consistency as that it can bruise or divide a hard crusted insect. The greater part of them also agree in residing where food is more permanently to be found, and consequently not being so much given to distant migration as many of the insectivorous races which remain yet to be noticed.

To these again succeed the chats, wagtails, chanters, warblers, and analogous genera, having the bill generally feebler, feeding on larvæ and soft insects, generally sweet singers, much affected by the vernal season, and migrating to warm climates in the winter. In them the notch in the bill is not quite so conspicuous; and in the wrens, especially the crested wrens, it approaches in some of its characters to the bills of



Common Wren.



Robin.

the *Tenuirostres* of Cuvier; and in the pipits to that of the larks, though the insectivorous character is not lost even in them.

#### BILLS OF THE TENUIROSTRES.

These are chiefly, though not all, insect feeders, and have their bills slender and without any notch at the

tip ; but they differ considerably in form with the places where the food is obtained, and in consistency with the nature of the food itself. They are bark birds, wall birds, or rock birds, yet some of them range the air for their food, and others seek it in the nectaries of flowers. The feet rather than the bill form their distinguishing character. The nuthatch, which is a



Nuthatch.

climber, has the bill straight, angular, and very strong, and it feeds much upon nuts, the shells of which it punches open with considerable activity. The tree creepers which also run on the boles of trees, and dig in the crevices of the bark for insects, have the bill of moderate length and angular, but a little curved. The wall creepers have it very long and slender, and angular only at the base. The nectar suckers have the bill weak and very slender at the tip, and the tongue extensile, tubular as a sucker, and cleft at the tip. The humming-birds have the bill in general long, and the tip of the tongue formed as a sucker ; but the bill is in some of the species straight, and in others crooked. The hoopoe has the bill very long and slightly arched, and feeds on tadpoles and other produce of marshy grounds. But the bills of these birds are so unlike in their forms, and differ so much in the uses to which they are applied, that none of them can be taken as any thing approaching to an average of the whole ; and indeed the character of

the anisodactylic feet is not much more perfect, for in some, as in the nuthatch and creeper, it is a most efficient climbing foot, yet in others it resembles more the common foot of many of the insectivorous birds.

## BILLS OF THE FISSIROSTRES.

As all these birds use the bill, and the bill only, in the capture of their prey, and as they catch it on the wing, the bill affords a very good general character. They are all feeders upon insects, and generally capture them by speed of flight. They fly at smaller game, and capture it only with the bill; but they admit of a division into diurnal and nocturnal, something resembling that of the birds of prey. The diurnal ones are the swifts and swallows, the former the longest flighted of birds and the most unwearied on the wing. The latter soft and loose feathered, and rather clumsy in their flight, as is the case with the owls. This subdivision con-



Goat-sucker.

tains the goat-suckers and the *Podargi*, some species of which bear a resemblance to some of the owls, and have stronger bills than the rest of the family.

The bill in all of them is remarkable for the wideness of its gape, and the breadth of the mandibles at their bases; and it is sometimes provided with a viscid secretion to which the insects adhere, and at others with moustaches, in which they are caught, or at least prevented from escaping out of the mouth.

The bill of the common goat-sucker is probably the most typical of the whole, at least it is more exclusively used in preying; as the bird not only feeds in the twilight, but flies with the eyes in such a position as that they can be of little or no use.

## BILLS OF THE SYNDACTYLI.

The bills of the syndactylous birds also differ considerably in their forms, because the food differs in kind; and there is no doubt that it was on account of this difference of the food that Cuvier named this division after the structure of the feet, and not that of the bills, for the kind of food is the principal ground of his arrangement. But in the case of birds the kind of food is not so descriptive of the whole character as in the mammalia, because the form of the bill depends also upon the manner in which the food is arrived at.

In the birds which should properly belong to this division, the prey is arrived at on the wings, though Cuvier, from having taken the united toes as the general character, has included in it the hornbills, which, in some of the species at least, are as truly omnivorous as the crows, feeding on carrion, and of course feeding on the ground, not on the wing.

Leaving these out, there remain four genera, all of which have the bill long, and catch their prey by the snap, or quick compression of the mandibles against each other. The bee-eaters (*merops*) have the bill rather long, tapering to the point, slightly curved in

its whole length, and sharp in the cutting edges. That of the motmots (*prionites*), which, in some respects, answer in America to the bee-eaters of the eastern continent, is much stouter, having a considerable resemblance to the bill of hornbills, though without the enlargement at the base of the upper mandible, by which the bills of that genus are distinguished. The bill of the motmot is serrated in both mandibles, and the tongue is barbed or feathered like that of the toucans. Indeed, it should seem that this genus, as well as the former, ought to be included among the omnivorous birds, notwithstanding the syndactylic feet; the feet of birds in this division come so little into play in those which really belong to it, that they are hardly of sufficient importance for being made the ground of classification. Besides, these birds kill other little birds, either by gnawing them between the serrated edges of the mandibles, or beating them against the ground. They are indeed chiefly ground birds, bad fliers, and though in great part living upon insects, they catch them upon the ground; and almost the only habits which they have in common with the typical birds of the order, are living solitary, and nestling in holes of the ground.



Kingfisher.

The kingfishers have the bill robust, quadrangular, and straight; and though it is a fishing spear rather

than an insectivorous bill, it agrees with that of the bee-eaters in being used on the wing. The preceding figure of that of the common kingfisher of Europe will give some idea of its general form.

The remaining genera of this division, none of which are European birds, have the bill bearing a considerable resemblance to that of the kingfisher, which may be considered as the most characteristic bill.

## BILLS OF THE SCANSORES.

These, the climbing, or *Zygodactylic* birds, have no general character in the bill which can be applied to the whole, though in the smaller grades into which the order may be divided, the bill is sufficiently characteristic of the food and manner of feeding.

The whole order are forest birds; and, with the exception of the woodpeckers, some of which inhabit



Spotted Woodpecker.

the cold or the medium climates, they are all tropical birds, or birds of the warm countries; of those wild forests which have been sown by the hand of nature, and in which every tree is the very best adapted to the spot on which it grows. Every animal of these teeming climes is also produced under circumstances

the most favourable to its development and subsistence ; and the energies of life of all kinds, obeying that grand stimulus of material life, the sun, is in the very maximum of activity. Man is the only creature that languishes, or appears to be out of his element, not merely in his mental powers, but in his physical structure. This by the way is a proof, among many others, which the study of nature in all its varieties affords, of the existence of a spirit in man—an immaterial principle, and consequently one over which material death and dissolution have no power. For if he were wholly material, and obedient only to those physical laws to which the whole of material nature is subjected, he needs must be in the state of greatest development in those places where natural action is the most intense. It is no argument to allege that these ardent climates are not so well suited to the human constitution as those which are more temperate ; for though this may be true of a native of Europe visiting those countries, it is not true of their native population. Nor can it be said that, physically, man is better adapted to the colder climates than to the warmer, but rather the reverse. Man has naturally no furry coat like the polar mammalia, nor downy feathers like the polar birds ; and his only natural clothing is a sort of thatch to the head, as if more immediately to protect that portion of his fabric from the action of the vertical sun. Therefore, in as far as man can be said to be physically adapted to one climate more than another, the adaptation is to the warm rather than to the cold. But we find that the more energetic and valuable part of his character is less developed in those places where nature also is most energetic, and where he, if he were merely the produce of material nature,



should, according to all the evidence that we have, be most energetic also.

But though here, as in all cases, man must be put aside as being *over* the system, not *of* it, the rest of the system in these beaming and blooming lands works vigorously and, at the same time, beautifully in concert. The birds may, in all countries, be regarded as the keys to natural history; because in consequence of their aerial nature, and their capacity of better accommodating themselves to such food as they may find when they are very hungry, they can so speedily adjust themselves to changes of season, that the adjustment is made before we are aware of the necessity for making it, as the bird is to us the harbinger of that very change in nature, of which its change of place or of action is the consequence.

There are no places to which the native birds are better keys than the tropical forests. The great majority of them—all this order, with the very few exceptions which have been noticed, are forest birds either on the trees, or passing from tree to tree, or if they feed on the ground in the open places, not ranging on foot, as the ground birds of our latitudes do, but finding a full meal at the places where they alight.

The vegetation of every region determines the character of all its living inhabitants, and though the birds, as the most sensitive to change, are the keys or indices, the vegetable tribes are the foundation of the whole, which support many of the animals immediately, and the rest indirectly through the medium of each other. There are few small farinaceous seeds in those forests; and the leaves of the trees are not so succulent and so well adapted for the food of insects as the deciduous leaves of the mean latitudes.

Their average production is perhaps not so great as that of our forest trees, during the short period that they are in activity ; but in all tropical countries the season of growth is double, and in many it is of more frequent occurrence, and where there is humidity enough the growth is constant. The leaves are required for shade ; and as natural circumstances always produce that very organisation or structure which suits them best, the shading leaf is firm in its structure, and not liable to be gnawed and eaten like the more tender ones.

Woody substance is that which has the tendency to accumulate to excess in those forests ; and, therefore, the great body of the insects there attack the wood of the trees. As these insects have much labour to perform in clearing the forests of their lumber, they exist in proportionate numbers, generally social, and in bands which no man can count. These crowd all parts of the trees, and indeed many of the spaces between them ; but they are on the boles and branches, and in the decaying wood, rather than on the leaves. The winged ones, too, crowd over the trees and the flowers of those climbing plants, with which the boles are entwined and the branches interlaced. These are, however, more seasonal than the races which inhabit the trees, or rear themselves huts and towns on the ground ; and therefore they do not form so large a portion of the food of the more typical scandent birds. The bee-eaters, the cuckoos, some resident and others migrant, and the warblers, and other soft-billed birds which are driven from the temperate climates as the winter sets in, are the chief consumers of this more temporary produce of the tropical forests.

The same absence of farinaceous seeds which pre-

vents the number of ground-feeding birds from being so great in these places, also prevents the smaller seed-eating mammalia. The small mammalia there gnaw bark, and roots, and bulbs and fallen fruits. The number of insect eating reptiles is also very great. All these contribute to the food of the omnivorous races of those climbing birds; but though some of these eat eggs often and birds sometimes, the destruction of bird by bird is not so great in those forests as on the more bleak and barren portions of the earth. There is no scope there for the rush of a falcon, or the stoop of an eagle; and in the depths of the forest, the birds stand more in danger of preys that commonly crawl, than in those which have wings or even feet. The snakes are the greatest enemies both of the birds and their eggs. Vultures are found in the openings of such forests, for places where there is so much production, and by consequence so much waste of life, require a great deal of scavengership; and where the forest "crops out," towards the mountain, there are also hawks and eagles; but in the depth of the shade, bird is in a great measure at peace with bird. Accordingly, though there are some very curiously formed bills among them, there are none that can be considered as of a very murderous character, for the most formidable ones belong to those which feed on vegetable substances; and the owners are so completely tree birds that the bill is a climbing instrument, by the hooked upper mandible of which they can, if necessary, hang a considerable time without sustaining any injury.

The bills, though not admitting of typical example or description, as appropriate to the whole order, may yet be conveniently explained in groups.

The first group includes the bills of the jacamars, the woodpeckers, and the wrynecks. The bill in all these is straight, fitted for digging into the bark of trees, and extracting insects and larvæ; and though some of the birds are of considerable size, and the insects on which they feed remarkably small, yet they pick them up with wonderful celerity. The following figure will show the general character of the bill.



Green Woodpecker.

The woodpeckers have the stoutest bill and the best fitted for hewing into timber. The wrynecks as frequently pick up saw-flies and other small winged insects, which alight on the bark for the purpose of depositing their eggs; and the extent and freedom of motion in the neck are both very remarkable. The American jacamars, though they do not peck, have the bill resembling that of the common kingfisher; but their congeners of the East have it more slender, and a little arched, inclining to the form of that of the bee-eaters, and they are not so much in the habit of climbing as the others.

The cuckoos have the bill of moderate length, but differing in form and structure in the different genera of which the group is made up, as these differ considerably in their feeding and other habits. They do not dig in the bark for insects; and they inhabit the

copses and open forests rather than those which are deep and tangled.

Between the cuckoos and the toucans there occur several genera with bills very much diversified in shape, and with the owners of course as miscellaneous in their feeding. In general, however, they are insectivorous, but they also eat small earth animals, and sometimes the more succulent vegetable substances. The keel-bill is named from the strong projecting ridge or keel on the culmen of the upper mandible, is one of the best known and most remarkable of these, remarkable alike for the universality of its agreement with its own species, and with all other creatures, excepting those that serve it for food, and for the miscellaneous nature of its feeding. It alights on the backs of domestic animals, and clears their coats of insects.

Of all this order, however, and indeed of all birds, with the exception perhaps of the hornbills, this instrument is most singularly formed in the toucans. There are two genera; toucans proper (*Rhamphastos*), and aracari (*Pteroglossus*), of which the systematic names are not very descriptive, as each has the character expressed by both. Each is *rhamphastos*, large bill, or, colloquially, "beaky;" and each is *pteroglossus*, winged-tongue, or feather-tongue; but the toucans have the bill largest, always exceeding the section of the head, and sometimes as large as the whole body, while the bill of the aracari is not thicker than the head. The following sketch will show the general form of the bill of the toucan.

The general substance of this vast bill is cellular, with the partitions of the cells so very thin that, large as it is, it is very light. In the living state the covering membrane is very finely coloured with prismatic reflections, but these soon fade after death.

The rudely serrated edges are a little firmer than the other parts, but still they could not injure any but a very soft animal.



Toucan.

The tongue is stiff and cartilaginous toward the point, and for some distance pectinated on each side with stiff cartilaginous fibres, which give it something the appearance of a feather.

From its structure we may readily conclude that a bill of this description can be little more than a prehensile instrument, unfit for breaking a hard substance, or cutting a tough one. It seems, indeed, to be a sort of mortar, in which soft substances are in so far pounded by the action of the curious tongue, as that they can be swallowed. Insects, probably the naked and the more tender shelled mollusca, and the eggs and callow young of little birds, are the food of these birds; in search of which they hop about the trees, and though their wings are rather short, they fly tolerably well. The two genera are not very different in their food, or in their other habits; but besides the difference in the size of the bills, there is a remarkable difference in colour, which runs through all the species. The prevailing character of the true toucans is black, relieved with brighter tints on the throat, breast,

and rump; that of the aracari is generally green, relieved on the same parts with red or yellow.

Though they belong to different orders as well as to different parts of the world, there are some resemblances between the hornbills and the toucans; and the one family of birds performs in the one continent nearly the same office which the other family does in the other. We have a similar instance, with something approaching to the same difference of character, in the *merops* of the eastern continent, and the *prionites* of the western. Indeed, in all cases in which the birds or other animals of tropical America and the tropical parts of Asia and Africa can come into comparison, we find that those of the former part of the world indicate forests more close and tangled but less abundant in fruits than those of the latter.

Of all the climbing or zygodactylic birds, the parrot tribe, in its several divisions of macaws, parrots, parroquets, and cockatoos, are the most typical, the most exclusively inhabitants of trees, and the least frequently found upon the ground. The species are very numerous, and the individuals are, in such places as are very favourable to their habits, in incredible flocks. They are all chiefly vegetable in their feeding, but some subsist more on the kernels of those forest trees which have hard membranous or shelly coverings, and others more on the pulp of fruits, rejecting the kernels or pips. But whatever may be the nature of their food, there is a general character of the bill which runs through the whole tribe; and, though those which feed more upon pulpy fruits have the bill more enlarged in its cross dimensions than the others, yet the figure of one bill is a very good index to the whole—better than in any other tribe of birds at once so numerous and so varied.

This tribe are more peculiarly characteristic of the tropical forests than any other of the feathered races; because, though they are often found flying over the open places between clump and clump of the trees, and shifting from place to place as they exhaust the supply of food, they are more in the trees, and, feeling the perfection of their climbing powers, are less apt to take wing on being observed, than any race which inhabits the same places. They are constantly in motion, except when they seek their repose, which is usually in the islets of rivers, or other places which are not easily accessible, where they resort in numbers; and when they are in motion they are abundantly clamorous. Their natural voices are very harsh, but they are easily taught to whistle, to articulate, and to imitate very varied sounds.

It is not owing to the form of the bill or the tongue that parrots or any other birds articulate, because their organ of voice is at the lower or pulmonary end of the windpipe, and not at the larynx or upper end. But their powers of articulation are sometimes really wonderful: the coincidences between the questions put to them and the answers which they return, must in all cases be regarded as purely accidental; and they claim their appearance of understanding, just as the predictions of pretended seers do their supposed knowledge of the future, from the fact that the ninety nine cases in which there is no coincidence are forgotten, while the one case out of the hundred in which the answer agrees with the question is remembered and repeated.

The disposition which these birds have to imitate sounds, not only different from their own hoarse cries in their native forests, but from any which they can hear there, are, however, indications of a very curious



instinct, but of one which, as is the case with all instincts, it is vain to hope for an explanation upon the principles of reason.

The leading uses of the parrot's bill are, breaking hard vegetable substances, and climbing. A pair of nutcrackers is the nearest comparison to it in artificial instruments, but the bill is beyond all comparison the more universal and effective. This bill does not snap or acquire any force of momentum before it comes in contact with the substance to be acted on. It works wholly by pressure; but the pressure is accompanied by a sliding motion, which differs with the degree of exertion. The lower mandible is raised by very powerful muscles, and it is at the same time pushed a little forwards; the upper mandible has much less motion than the lower, but still it has more than in most birds; and when the bill is exerted with great force, it has a motion downwards and backwards at the same time. The substance acted on is thus wrenched round at the same time that it is pressed by the cutting edges of the mandibles; and every one who has attended to the subject, knows how very much a cutting operation is assisted by accompanying it with a wrenching one.

The muscles which move the mandibles are very powerful, and give that peculiar fulness which appears in all the cheeks of the tribe; and the motion of the upper mandible, limited as it is in space, brings the whole of them into action. It is these compound motions of the working parts of animals, which enable them to act with so much less exertion than our mechanical contrivances; and taking time and effect both into the estimate, there is no tool by means of which the shell of a hard nut could be broken, without the expending of far more than double the power

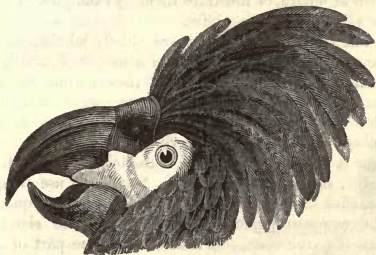
which is expended by a parrot. The tongue is of considerable use in guiding the substance to the most effective part of the mandibles; and even the motions of the neck are of service in breaking detached substances, as well as in detaching fast ones.

Very hard substances are broken between the point of the under mandible and the hook of the upper one, the lower side of which is slightly hollowed and roughened like a mill-stone by means of angular furrows, with their apices directed towards the tip.

The bills of the falcon, the crossbill, and the parrot may be reckoned the three most powerful bills in the action of the mandibles that occur in the whole class, and as their action is wholly structural, not deriving any assistance from momentum, they may be reckoned the three most perfect species of mechanism—the first, for tearing; the second, for wrenching open; and the third, for breaking and bruising; and all of them are so formed as to have compound motions.

There are several tolerably distinct forms of bill in this very numerous and abundant family. The parroquets, which fly much from branch to branch in search of their food, have the bill smaller than the others, not exceeding one-third the length of the head, and not very broad; but it is very firm in its texture, and perhaps proportionably the most powerful of any. The parrots, properly so called, which are the most scendent, have it half the length of the head, and very thick and strong. The cockatoos, which inhabit more marshy places, and live upon softer food than the others, have the bill feeble. The maccaws, which use the wing more than any of the others, and find much of their food on the tops of forest trees, have the bill large, as long as the head, and very sharp. When birds feed wholly or partially on the

wing, the bill is generally larger in proportion as the food is smaller. The ground parrots, which are better walkers than the rest, have the bill large, but the food appears to be, in part at least, taken by the tongue,



Cockatoo.

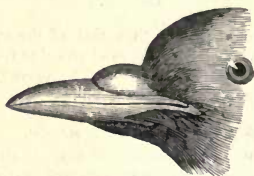
which is more slender than that of the others, but capable of being protruded, and armed at the tip with a horny portion cleft in two. The above figure will show the general form of the bill.

#### BILLS OF THE COLUMBADÆ.

We have already mentioned some of the reasons why the dove or pigeon family should be separated from the poultry; but as both are chiefly ground feeders, and as some of both perch on trees, and others sit or squat on the ground or on rocks, we may expect some correspondence in the form of their bills. The pigeons are, however, more vegetable in their feeding; and though they are by no means elaborate nest-builders, some of them at least do much more in that way than the gallinaceous birds.

There are three forms of bill among the pigeons, each corresponding to a difference of habit; but they differ so little from the bill of the common pigeon, and that is so well known, that we need not describe them at length, or illustrate them by examples. They are all simple feeding bills.

The tree pigeons, which are chiefly inhabitants of the warmer parts of the eastern hemisphere, and live upon the seeds of trees, which they gather on the trees themselves, and migrate from region to region after their food, have the bill strong, considerably arched, compressed and very sharp at the tip. In some it bears a resemblance to the bills of the smaller hawks, only it has no tooth, but in its use it approaches more nearly to the bills of the parroquets. The common pigeons have the bill more slender than the tree ones, and flexible for some part of its



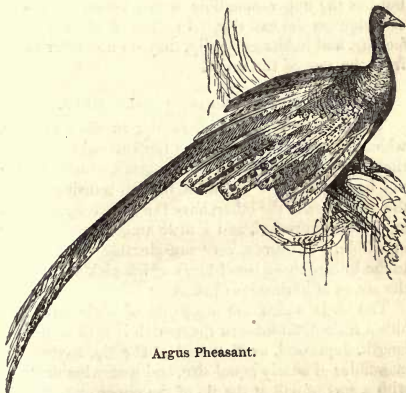
Pigeon.

length, and they have their characters the more decided the more exclusively that they are found on the ground. The long-legged pigeons of the oriental isles, which are large and heavy birds, and more exclusively confined to the ground than any of the others, have the bill still more slender in proportion

to their size ; and in some of their habits, as well as some of their characters (such as having naked skin on the head), they resemble the gallinidæ. Both agree in having the nostrils pierced in a membrane at the base of the bill, and protected only by a cartilaginous scale, and not by hairs or feathers.

#### BILLS OF THE GALLINACEOUS BIRDS.

The gallinaceous birds are all ground feeders, though they vary a little in the nature of their food, and the places where they find it. The whole of the tribe have the head very small in proportion to the size of the body,



Argus Pheasant.

and the neck so long that the point of the bill can not only reach the ground, but command a considerable extent of it when the body is in a horizontal position.

The bill is in most of the genera rather short, arched in the upper mandible, and strong and hard at the tip. Indeed the bill of the common fowl, of which it is unnecessary to give either description or figure, is a very good average type of what may be termed a pecking bill. The two genera which have the bill different are the peacock pheasant (*Polyplectron chinquis*) of the east of Asia, and the genus *Tinamus* of South America, where they are called partridges or quails. Both of these have the bill straight, and longer and more slender than in the rest of the order; and in the American genus it is depressed, but has the upper mandible strengthened by a keel or ridge on the exterior. In their food, manner of feeding, and habits generally, they do not differ much from the rest of the order.

#### BILLS OF THE SHORT-WINGED BIRDS.

These have the bill very similar to the gallinidæ, which might be expected from the correspondence of their habits in feeding. The bustards, which, though not bad fliers, form the most natural transition from the one order to the other, have the bill strong, conical, or little compressed, and a little arched in the upper mandible. It bears a very considerable resemblance to the bills of those small birds which pick seeds from the stems of herbaceous plants.

The birds which are incapable of flight have the bills a little different. In the ostrich it is of moderate length, depressed, or flattened at the tip, having the mandibles of nearly equal size, and somewhat flexible, with a sort of nail at the tip of the upper one, but the tips are obtuse or rounded. It bears a slight resemblance to the bills of geese. This is the first indication of a grazing bill which occurs in the class, viewed

in the order in which we have considered it ; and the habit of the bird corresponds. The nhandeu, or ostrich of South America, has the bill shorter, and rather compressed toward the tip, which, however, is obtuse and furnished with a nail like that of the African ostrich. The cassowary of the south-east of Asia, has the bill compressed in its whole length, with a horny knob at the base, and a keel on the upper mandible which makes it stiff; but the lower mandible is flexible. These feed more on fruits and seeds than the others. The emu of Australia has the bill very similar to that of the South American ostrich.



Agami.

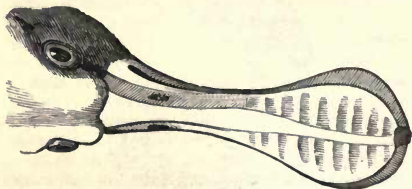
The most singular bill of this order is that of the apteryx. The bird is altogether a singular combination ; the body of an ostrich, the feet of a fowl, and a bill more like that of the ibis than any other.

## BILLS OF THE PRESSIROSTRES.

These birds all seek their food on the ground, though not in the same places. It consists of worms, and other small ground animals, which are sought for in all places, from the dry waste to below the stones on the margin of the water. The bill is in general slender, and not very long; it is sometimes compressed, sometimes depressed, sometimes stiff, and sometimes flexible, so that it does not admit of general description, farther than that it is adapted for picking up small animal substances from surfaces bare of vegetation.

## BILLS OF THE CULTIROSTRES.

These birds have the bill, in general, very large and powerful, generally pointed at the tip, sharp, and sometimes toothed or serrated in the cutting edges. But though, in all the genera which Cuvier has included in the tribe, the bill is very robust, it differs so much in



Spoonbill.

form and size, as hardly to admit of an average description. Thus the agamis, which are chiefly vegetable in their feeding, have the bill short and conical, not very unlike that of the poultry; the herons and bitterns,



the first of which are fishers, and the others rather miscellaneous in their feeding, have it straight, or nearly so; while that of the spoonbills, as may be seen by the preceding figure, has very little of the knife-shape, from which the group is named.

The cranes, storks, and several other genera, all of which act the part of scavengers, and most of them are migrant, have the most typical bills. Among these are the adjutant of India, and the boatbill of tropical America. The latter bill is a very singular one. It resembles two boats applied the one to the other, and while the greater length of the tomia is trenchant, as in the storks, the tip of the upper mandible is hooked, with a tooth on each side, and that of the lower is pointed. It is understood to feed indiscriminately on fresh water crustacea, on reptiles, and on fishes.

There are, however, so many forms of bills among the birds of this very curious division, that no one can be selected as typical of the others, and the whole are by much too numerous to have a place in this short sketch. These diversities in the form of the bill show that, how much soever the birds which are arranged in this division may resemble each other in their haunts, the nature of their food, or their habits, the bill is not the part of their organisation after which they should be classed, though, in proportion as this part of their structure is less fitted for being the character of the group, it is better for distinguishing the genera.

#### BILLS OF THE LONGIROSTRES.

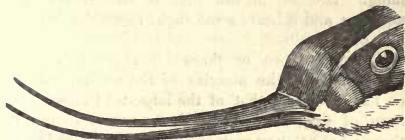
The bills of this group, like those of the preceding one, do not admit of an exact average definition, farther than that they are all of con-

siderable length, and generally less firm in their texture than most of the bills that have been noticed. But though they have no general form, they have a sort of general character. The birds which possess them are all feeders upon animal substances, which they seek upon the ground, generally in humid places, and some of them in the water; or if any of them eat vegetable matter, it is only that which is comparatively succulent, such as the bulbous roots of aquatic plants, or seeds which have been macerated in the water till they become soft. Many of them are flexible, consisting of a cellular bony substance, containing blood-vessels, and covered by a sentient membrane. They are a sort of intermediate between the bills of the land birds and those of ducks, and, as distinguished from the dabbling bills of the last of these, they may be called groping bills.

Some of them inhabit warm countries, and follow the lines of those rivers which are subject to periodical overflowing, picking up as their food the water reptiles, and other small animals, which are either driven from their retreats in the banks as the water rises, or left stranded when it subsides. The most remarkable of these are the genus *Ibis*, which have the bill very long, and bent from the base. In them it is harder than in most of the group, and not covered by a sentient membrane, but the mandibles are weak and flattened, so that, in arranging the birds according to their bills, these cannot be included among the cultriostres, though, in their general habits, and also in the places which they most frequent, they resemble these more than they do the average of the present group. The more formidable prey, which they cannot so easily master with the bill, they dash forcibly against the ground, or stamp it to death with the foot.

The majority of the group inhabit countries which are not liable to be parched by the sun, or they resort to such countries in the hot season ; for, though many of them seek their food chiefly upon sandy or gravelly surfaces, they all seek it near the waters ; and in the winter season they either resort to the shores of the sea, or migrate to climates nearer the equator.

Many of them seek their food by boring into the ooze and sludge, and in proportion as they have this habit more, their bills are longer, straighter, and more soft, flexible, and sentient. They are chiefly night or twilight feeders, because the ground animals of marshy and humid places come abroad then, but retreat and are still during the day. The time of their feeding thus renders the sentient bill of more avail to them than a hard one would be. During summer, when food is plentiful, and vegetation rank on the marshy grounds, one may traverse these the whole day without seeing a bird, or even hearing a note or a rustle ; but as night sets in, they make the wilds alive with whistling and screaming. The bills of snipes and



Avocet.

woodcocks may be considered as typical of this portion of the group. The avocets, which have the most singular bills of the whole, are more of day

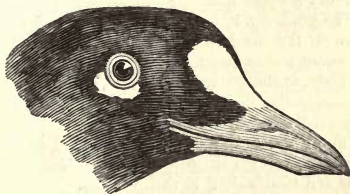
feeders than the rest. They feed by scooping in the runs of water, not by boring.

#### BILLS OF THE LONG-TOED BIRDS.

These are also feeders on the margins of the waters, and the length of their toes affords them a firm base on slippery ground or upon tall herbage, among which chiefly they seek their food. Those which are less aquatic in their habits have the bill short, compressed, arched on the upper mandible, and sharp at the tip, having some resemblance to that of the gallinaceous birds; and those which are the most aquatic have it depressed, and produced on the forehead in a horny plate. Intermediate between these, there are others which have the bill longer, more slender, and enlarged toward the tip, as in the plover. The most striking character of these birds is the length and narrowness of their body, in consequence of which they can glide through the herbage with great ease and rapidity. The feathers of most of them are waterproof, and though the toes are never united by membrane at their bases, they are more or less margined for swimming. The bill of the coot is one of the most aquatic; and it bears some slight resemblance to the bills of the gulls.

There are two or three other genera of birds which frequent the margins of the waters, and live on food similar to that of the large-toed ones. The form of their bills would thus connect them with these; but as they seek their food in places bare of herbage, find it less abundantly in any one spot, and must therefore range more on the wing in quest of it, all the other parts of their structure are so different that the connexion is not a natural one. These genera are, the flamingos, which resemble the herons

in their haunts and many of their characters, but they live on mollusca and reptiles rather than on fish; the pratincoles, which subsist chiefly upon insects which they capture on the wing; and they in



Coot.

some of their habits resemble the bee-eaters, and the carrion bird of Australia, *Chionis necrophaga*, which has no type among European birds.

#### BILLS OF AQUATIC BIRDS.

The bills of which some account has been given, bring us to the margin of the water, and we have only to notice the birds which find their food in that element. The general characters of these depend less upon the bill than those of the land birds, but there are two well marked divisions: those which find their food at the bottom of shallow waters, and those which feed chiefly upon what is buoyant in the clear water,—though the first eat floating substances when they come in their way.

The first comprises the geese, swans, and ducks, which are all really ground feeders, only some of them feed almost exclusively on ground covered with water, and their bill and neck vary according to the depth of water with which their feeding ground is

covered. As they are unable in all cases to see their food, they have the bill with a covering more or less sentient. They have the mandibles broad and flat, though often with an enlargement at the base of the upper one.

The gradation is from the geese, which feed fully more on the humid meadows than in the water, to the swans and swimming ducks, which never plunge the body, to the diving ducks which go to the bottom in considerable depths; and thence it passes to the habitual divers, which capture their food in the water, not at the bottom, and thus have the bill of a different form. As this gradation proceeds, the birds become more and more animal in their feeding.

Geese, which feed chiefly upon vegetable substances, have the bill elevated at the base, narrowed and rounded at the tip, comparatively short and stout, furnished with a nail at the point of the upper mandible of harder texture than the rest of the bill, and often of a different colour. The sides of the bill, which come in contact for a considerable breadth, are fringed with cartilaginous protuberances resembling teeth. This form of bill cuts grass something in the same way as the ruminant mammalia, which have the anterior part of the one jaw with cartilaginous ridges in place of teeth.

Swans, which are also chiefly vegetable in their feeding, but which feed more upon the roots of plants under water, have the upper mandible enlarged at the base, but the bill is larger than in the geese, of equal breadth throughout its length, and not so firm and robust.

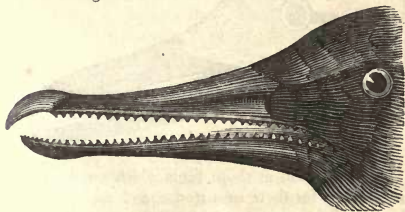
Swimming ducks, which are omnivorous, but prefer animal substances picked up on the land or dabbled for in the water, vary a good deal in their habits, and

their bills correspond. The common duck, which may be taken as the average, has the bill most flattened, and of the softest texture. These ducks have the neck lengthened, and plunge the anterior part of the body in the water till the axis is nearly perpendicular; but they do not get so deep as to have the joints of the tarsi immersed.

The diving ducks have the neck and bill shorter than the swimming ones; but still they feed not in the volume of the water, but at the bottom, and upon mollusca, worms, spawn, and other soft substances, and rarely if ever upon fish. This is the chief reason why their flesh is much more juicy and finer flavoured than that of the true aquatic feeders.

But there is a gradation in the diving ducks, the pochards, who resort more to the fresh waters, and the rich mud banks on the estuaries of rivers, have the bill much broader and flatter than the gannets, which may be reckoned the most seaward of all the duck tribe; and there is a considerable trace of the fishy flavour in the flesh of the latter.

The mergansers combine the characters of the

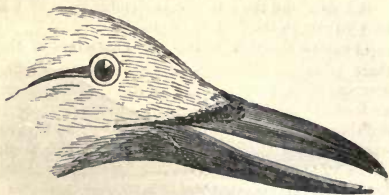


Merganser—*mergus serratus*.

diving ducks and the true divers; they catch their prey in the water, and not at the bottom; but they

are not formed for following it like the divers. They therefore require to have the bill of a more prehensile form than the one, and better able to retain its hold than the other. Accordingly, they have the bill lengthened, firm in its texture, nearly cylindrical, hooked at the tips of both mandibles, and serrated with reflected teeth along the cutting edges. They live upon fish and reptiles, and their flesh is rather rank in flavour. The preceding is a sketch of the bill of the red-breasted merganser.

The divers and guillemots drive through the water with great rapidity, and transfix their prey with the sharp points of the mandibles, or wound it with the snap of the tomia, which in some of the species are furnished with a notch. This notch, which is of a very peculiar form, quite different from that in the bills of the rapacious or the insectivorous birds, is well shown in the bill of the foolish guillemot (*Uria troile*), of which a figure is annexed.



Guillemot.

In proportion as those birds which are dependent on the sea for their subsistence, and capable of following their prey to some distance under water, become less capable of motion on land or on the wing, their bills increase in power. We have exam-



ples of this in the razor-bill and the puffin, which though they can fly, do not habitually perform that operation ; and still more in the great auk and the penguins, which have very powerful trenchant bills. With these one set of the sea birds may be said to terminate ; and they bear nearly the same relation to the water that the ostrich and apteryx bear to the land—it is their principal, and almost their exclusive element.

In the rapid sketch which we have taken of them, we have traced the birds in their regular gradation, from those that feed on foot upon the land, to those that feed by swimming and diving in the water. But the birds bring us out to sea on another element—the air ; and there are tribes which take up the connexion from the heron and the kingfisher, which fish in the fresh waters only, and the succession continues till we come to races which are as discursive over the sea as the swallows and swifts are over the land.

But as all these nestle on the shores (for there is no bird that breeds in the water), and as none of them can be insect feeders on the wing over the sea, there being no insects there, there is not the same diversity of habit among them as there is among the air-feeding birds of the land. The living produce of the shoreward parts of the sea, the waste and refuse which the sea casts up, and the waste which floats on its surface, are the three principal classes of the food of marine birds.

There are none of these birds which prey directly upon other birds, as the accipitres do upon land ; and therefore there are none of them which have crooked talons or beaks like these. It is true that several of the eagles fish, and, though none of them refuse land prey when they can obtain it, there are

some which depend more on the sea than on the land ; but they are land birds, clutching their prey with the feet, and altogether unfit for swimming. Some of the sea-birds also prowl along the shores, and eat the eggs and the unfledged young of other birds ; and there are some which rob others of the prey they have taken, by making them disgorge it from their stomachs ; these last are birds of strong bill and powerful wing, but still their characters, though different from those of all land-birds, resemble those of the omnivora more than the accipitres.

The birds which make the most natural transition from the herons and other tribes which fish in the fresh water, are those which Cuvier calls *totipalmi*, or entire-footed, from their having all the toes included in one web. These, though not the birds to which the name of " sea-eagles " is usually given, are the ones which in their habit much resemble the eagles ; they dash into the water, and seize that prey which they have previously discovered by the eye, only they seize it with the bill. But most, if not all of them have a double habit ; as they also catch prey while swimming on the surface ; but they live more upon live fish, and less upon the offal of the sea than most of the other races.

The bill of the gannet, of which a figure is given, may be considered as the most characteristic of these bills.

It will be seen that it is stout at the base, nearly straight, has both mandibles serrated, and both tips a very little bent. Its outline is that which gives the greatest stiffness with the same quantity of materials ; but the upper mandible, as in all bills which act very powerfully, has a little motion. When the bird descends with velocity, this bill transfixes like a spear,

and retains its hold like a barbed hook. The darter and the tropical bird have their bills formed in a manner similar to that of the gannet, and they also dart or descend on their prey; but the darter is a more landward bird, perching on trees, and fishing chiefly in the fresh waters, or in those salt lagunes where there are mangroves; and the tropical bird is more discursive over the sea.



Gannet.

The cormorants, which fly lower, have the bill less capable of thrusting with the point, or of resisting a strain on the base. Its thickness is more uniform, and the upper mandible is much more hooked, while the lower one is truncated, and a small portion of the bill has an oblique cutting motion. There is a trace of the carrion bill in it, and the mandibles are not serrated. The birds which have this bill do not fish in the same style as the gannets and darters. The bill of the albatross, which is a very wide-ranging bird, has still more of the carrion shape; but it has also a sort of tooth on the bend of the mandible, and thus can lift prey out of the water.

The true scavenger's bill on the "high seas" is that of the petrels, of which the fulmar's is typical.

The angular portion at the tip of the upper mandible of this bill, and the bend on the lower, which acts against it, are both very strong and hard, so that it is well adapted for tearing the flesh of whales and of the larger fishes when their carcasses float dead on the sea. By that most efficient part of the bill being carried at an oblique angle to the water, while the bird swims or skims the surface, it can easily pick up all manner of garbage, however minutely divided, and even sip the oil which floats on the sea.

The numbers of these petrels are immense, far greater than those of any other birds—a single flock is sometimes seen as numerous as would cover the surface of a county. They afford a very striking instance of the vast productiveness of the sea; for they, numerous as they are, are only one of the races that subsist on its refuse. But when we consider that the sea is more than twice as extensive in surface as the land, and that it is inhabited to the depth of many fathoms, while the land can (as the barren places compensate for the elevations, whether of hills or of vegetables) be reckoned only as the one surface, we are within the limits when we say that the productive power of the sea is a thousand times greater than that of the land; or that, if its productions could be arrived at, and their nature would suit, the sea might support all the life that *could* exist upon the land, and never feel the burden.

The storm-petrels are lighter birds, and of more rapid wing than the common petrels; but they have the bill of the same form, though weaker. They subsist chiefly upon the smaller garbage, and especially upon oil, which they collect from the water on the

feathers of their breast, and then remove with the bill. All the petrels have the nostrils enclosed in separate tubes—sometimes single, and sometimes double; but the use of these in their economy is not known.

With the storm-petrels one group of sea-birds, classed according to their habits in feeding, and the structure of their feeding organ, may be said to terminate; but there is still another, the commencement of which may again be taken from the shore, and traced to the more extended pastures of the other.

The group which has now been mentioned as extending from the gannet to the storm-petrel inclusive, may be regarded as having a relation (such a loose relation of mere analogy as can exist between preyers at sea and preyers on land) to the birds of prey—the gannets and races which have similar habits to the eagles, the petrels to the vultures, and the storm-petrels to the birds which catch insects on the wing. The analogy is, as has been said, a loose one; but it is of use in forming a relative estimate of the economy of the sea and the land.

We may, therefore, continue it with the remaining sea-birds, which are principally the *lestri* or skuas, the gulls, and the terns. These are the omnivorous birds of the ocean; but the term, as applicable to that element, does not include vegetable food, though many of these sea-birds feed on land during the breeding season, and also when the sea becomes too stormy for them.

The *lestri*, though called eagles (the real sea-eagles are land-birds), are the ravens of the deep; and in their bills, their claws, and the general *cast* of their bodies, they have a raven-like air. The following is

the bill of the common skua, the most typical and powerful of the genus.

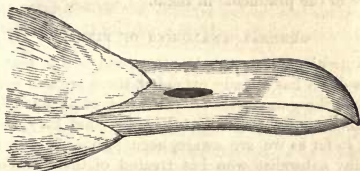


Common Skua.

This bill is very strong, coultter-shaped, hard in its texture, and considerably hooked at the tip of the upper mandible, though nearly straight for the greater part of its length. But it is not a murderous bill or a very prehensile one. It has no tooth or notch, or even the sliding motion at the point which characterises gnawing bills. Accordingly, though the skuas are strong and bold birds, they do not kill full-grown prey, neither are they very dexterous in catching their own fish. They rob the nests of other birds, and they rob the gulls of the contents of their stomachs. They are, what their systematic name expresses, *lestri*—robbers, takers of that which belongs to others. They seek not the shore-bird, they seek its eggs; they seek not the sea-bird, they seek its food; and even among mankind, it has always been reckoned more cowardly to attack the infants than the father, and baser to injure “the means” than openly attack the man.

The gulls follow, as the rocks and crows of the sea, fishing occasionally, but only for fry and the smaller fishes, and living on carrion, mollusca, worms, and “whatever they can find.” Some of them come occa-

sionally on shore and clear the ploughed land of larvæ and worms along with the rooks; and not a few breed in small lakes and marshes many miles inland, and find marsh food for themselves and their broods. Their bills correspond, as may be seen in the following figure.



Common Gull.

The terns take up the succession from the gulls; and, in the gull-billed tern, which may be considered as the commencement, there is much similarity, not only in that organ, but in the general air of the body; and as we trace them to the more typical terns, the bill does not assimilate to that of the swallows (though the terns have—not very discerningly—been called “sea-swallows”), but to that of the pratincole, which may perhaps be considered as the last of the omnivorous feeders among the land-birds, and the most powerful on the wing. And it is not a little remarkable, that when this rare but beautiful stranger makes a dash over from the Danube to the Hebrides or Zetland, by way of a morning trip, it is found in the company of gulls and *terns*.

The storm-petrels are the real swallows of the sea—the birds which feed upon the lightest and highest production of the waters just as the swallows and

swifts are the last of the land tribes which feed exclusively upon living creatures ; and, although the food is different, and requires a different form of bill, it is not a little remarkable that the general structure, air, and even colour of the storm-petrels, resemble those of the swallow tribe ; while those of the terns have more of the pratincole in them.

#### GENERAL ANALOGIES OF BIRDS.

Notwithstanding the length to which this part of the subject has already extended, there are still some very striking analogies of which it may be desirable to take notice, the more especially that they have not, so far as we are aware, been previously noticed by any naturalist who has treated of the feathered tribes, and also because we cannot with propriety introduce them into the particular account of any one group or genus. They are briefly as follows :—

In the first place, the flat-billed birds, which find their food at the bottom of the waters, have a very striking analogy to the ground-birds that feed upon land. Their flesh resembles the flesh of the grazing mammalia, the more exclusively that they are vegetable in their feeding, as in the case of the goose. The ducks, which are omnivorous, have more the flavour of poultry ; and those which feed chiefly upon mollusca, ground worms, and the spawn of fishes, partake of the racy flavour of the land "gut-birds." As they become more and more feeders upon fish, they acquire more and more of the rank flavour ; and the auks and other species which scarcely fly at all, abound very much in oil.

It is not a little singular that it is in the two corresponding divisions of the sea and land birds, where we meet with the species which are confined to one



element, and lose the grand characteristic of birds, the wings, though they retain the general structure and habits. The feathery covering is never wanting; but in the extreme of ground bird upon land it has much of the loose character of fur, while in the extreme of the divers at sea, it is so close and compact, that it has the appearance of one unbroken covering, in which the individual feathers cannot be distinguished.

In the second place, those sea-birds, from the marsh-breeding-gulls, or rather from the skuas, to the terns, which bear a resemblance to the *omnivora* among land-birds, are all, like these, good walkers, quite as much at home upon the shores as they are in the water or on the wing. This coincidence is the more worthy of being borne in mind, that the omnivorous birds are the only land ones which have the two motions of walking and flying nearly equal throughout the group; and the corresponding group of sea birds are the only ones which possess all the three in equal perfection.

Those birds which are the most general in their feeding, are thus, also, the best fitted for reaching their food in all sorts of places; and not only this, but they are the most generally distributed over the globe, and resemble each other the most in all latitudes. They are not the most numerous at particular spots, though many of them assemble in great numbers at their breeding places.

Between the air-feeding birds of the sea and the land, there is not the same perfect correspondence, because there are among sea-birds no literal preys on the wing. There cannot be, for there is no food for them, as the sea sends up into the air nothing upon which a bird can subsist. The level of the waters is

the upper level of sea-food, unless in that portion of the food of those birds which is cast up by the waves. But still there is a correspondence : they keep more to their own element, and have their motion more fitted for that, and less for the other two. Those sea-birds which seem never to tire on the wing, are all imperfect walkers ; and though they float very buoyantly, much more so indeed than those which are habitually on the water, they are by no means so expert at swimming.

The most perfect flight and the most expert action in the water are indeed incompatible with each other. Birds which float about the livelong day require to be light for their bulk and extent of feathers, though a heavier bird succeeds better on a momentary rush ; and the air birds which fly over the sea in search of their food do not require the same rapid motion as birds which fly in the air in pursuit of their food. But a bird which is to have the most perfect command of itself in the water, and be able to dive, and come up, and drive along, sometimes wholly immersed, and sometimes not, must, in order to perform its various evolutions with as little muscular exertion as possible, be of nearly the same specific gravity as sea-water.

It is absurd to say, as has sometimes been said, that if birds have not a certain specific gravity they cannot dive. The lightest substance, the lightest gas, can be forced under water by mechanical means, and it is rather too much for us to suppose that we can beat nature with our small second-hand mechanics. But still it accords with general principles that that which is the most nearly of the same specific gravity as water, should admit of motion in all directions in water with the least effort. This principle is traceable in aquatic birds ; for we find that the diving

ducks ride deeper in the water than the swimming ducks, and the divers still deeper than they.

Then there is the difference of form. The motions which a diving bird performs in the water are so varied that to determine the solid of least resistance with regard to them all would be no easy matter. But the boat which rows fastest, keeps course or turns most easily, and lives in the roughest water, is an approximation. That boat is one with the two ends nearly equal, and of an average length. If too short it "yaws like a tub," and will not keep course, and if too long it turns wide. This is the form which we find in those birds which have the most complete command of the water. If they go on long courses after fish, as is the case with the divers, they have the body elongated; and if they search about among the rocks after mollusca and crustacea, as is the case with the puffin, they have it shorter. These last, by the way, have the most powerful bruising bills of any of the sea birds, just as the parrots have among the land ones; and it is curious to notice that there is a considerable resemblance both in the appearance and in the harsh screaming voice, so much so that the puffin is sometimes called the sea-parrot.

The boat shape of those birds, and the backward position of the feet, with the weight of muscles necessary for moving them, are incompatible with that structure which answers best for powerful flight. That, in order to be performed with the least effort, requires the weight to be concentrated near the centre of motion in the wings.

From these few observations, short and imperfect as they are, it will perhaps be seen that there might be a much more natural arrangement of birds founded

upon their *principal habit* than any which can be founded on a particular part of their organisation. Air birds, ground birds, and those intermediate races which have the double motion in the case of land birds, and the triple one in the case of sea birds, might form the leading divisions.

An air bird is one which uses the wing in immediately obtaining its food ; thus an eagle which stoops to ground prey, a falcon which captures in the air but eats on the ground, a gannet which plunges in the water, and a swift or other insect feeder which feeds on the wing without stopping, are all equally air birds, arriving at their food by the action of the wings in that medium. So also a bird which immediately finds its food with the wings closed, or only with a partial use of them, subordinate to that of the feet, as in the birds which chase their prey under water, those that perch upon flexible stems and twigs, and a few others, is a ground bird. No matter whether it walks the bare earth, the vegetable surface, the boles or branches of trees, or perches, or climbs, or swims, or dives, if aerial motion does not form part of the act of capture, it is not an air bird. Many ground birds range far on the wing in search of places where they may feed or nestle ; but the distinction between that and feeding on the wing, that is, arriving directly at the prey from the air only, is obvious enough. If the bird moves anew from any support but that of the air, that element has, as it were, rendered it up ; and be the support rock, earth, plant, or water, there is an unbroken connexion with the ground.

The distinction between omnivorous birds and either of these divisions is not so clear. But this is what might be expected : the air and the ground are

the extremes, and in comparing them we have the advantage of the greatest contrast of which the class admits. There are some birds which have both habits, and they are chiefly miscellaneous feeders; and, if we had only two divisions, there are very many species which would belong equally to both; to the observer of the one habit they would be air birds, but they would be ground birds to the observer of the other habit.

With the three divisions there would still be difficulties on the confines, nor could we avoid similar difficulties though we made three hundred divisions; for in nature there are no absolute divisions but those of species, or perhaps individuals. Natural divisions are, therefore, out of the question in this or in any other department of natural history. But there is a natural gradation, and that gradation we can approximate, and approximate the more nearly the better that we understand the whole; but completely to reach it would require a degree of knowledge which man in this world never can possess.

The primary divisions in the arrangement which has been hinted at would be as unnatural, as artificial as those in any of the systems. But there would be at least one great advantage, we should have the whole bird presented to us in the general definition, and not a mere bill, foot, or wing, as we have at present. Thus we could, from a sort of general enunciation, proceed equally to all the parts by analysis, whereas, as matters stand at present, we have to collect the knowledge of all the parts, in perfect ignorance of the use which we are to make of this knowledge, till we are in possession of the whole. This is a very discouraging mode of going

to work; and if we are compelled to stop short of the whole, all the labour which we have taken is without purpose and without profit; the subject remains unknown, and the mind has not profited by the exertion.

We subjoin a figure of a bird which combines, in some respects, the characters of a ground and an air bird. It is a ground bird in its feeding, and an excellent runner; but it takes the wing on its migrations. It is a true gallinaceous bird, but it in part connects the partridge with the migrant running birds. It is itself now a migrant only in Britain, and by no means a common one.



Quail.

## CHAPTER VII.

### FEET OF BIRDS AS ILLUSTRATIVE OF THEIR HABITS AND HAUNTS.

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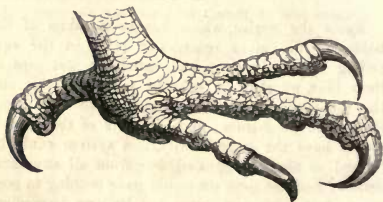
FROM the notice which has been taken of the habits of the more remarkable birds in the preceding observations on the structures and uses of their bills, we shall be enabled to reduce this and the following branch of the subject to little more than mere catalogues; and all parts of the subject would have the same brevity, if a system could be formed as above suggested, free from all structural details; because then we would have nothing to consider along with any organ but its own immediate function.

#### CLUTCHING FEET.

The feet of birds are used in the air, on the earth, on vegetable supports, and in the water. The only feet which are, strictly speaking, used in the air, are used in the capture of prey, or they are *clutching feet*, the feet of all birds of prey, diurnal and nocturnal, but the feet of no other birds. The most typical foot of these is that of the jer falcon.

The character of this foot is to have four toes, all free to their bases, and three turned to the front and one to the rear, in the general habit; but those species which fish have the exterior front toe reversible, so that the toes act two against two, and thus lift the

prey more easily out of the water than if they had the common position. When the toe is reversible it is generally the largest in the foot, and the claws upon these feet have their under sides smooth and rounded as well as the upper ones; whereas those birds which use the feet only in killing, have the under sides of the claws grooved, or with two cutting edges, by which means they inflict much more lacerated and mortal wounds.



Jer Falcon.

The claws of the more typical birds of prey (which are the only ones which get the name of talons) are used only in killing the prey, or in holding it while depluming, skinning, or tearing asunder, by the beak; but the vultures and other less typical species which eat carrion, and rarely kill living prey, use the claws more for retaining their hold, while they stand on the bodies of dead animals.

Size is not so much an indication of power in these feet as compactness and symmetry; the tarsi of the more powerful ones are all short; and in proportion as the preying of the bird becomes what is called more ignoble, the tarsi increase in length. Thus in the secretary falcon (*Serpentarius*) of Africa, which



feeds much upon reptiles, and often upon poisonous ones, the tarsi are as long as those of the wading birds. This, however, is not to answer a wading purpose, but to raise the body of the bird above the reach of the envenomed prey, as this falcon (which, by the way, is not a falcon) kills by the clutch or truss of the talons, after the general habit of the order.

The following is one of the fishing accipetres.



Osprey.

As walking is not much a habit with birds having this description of foot, the femur, or thigh bone, has not a great deal of motion or of muscle. The largest muscles are those which work the toes and claws, and they are situated upon the *tibiæ*. They are always protected by a thick feathery covering, and in the species which inhabit cold countries, the feathers are continued on the tarsi, or they hang down and shelter those parts of the feet, so that the tendons and ligaments may not be stiffened and rendered unfit for action by the cold.

There is considerable freedom of motion laterally in the toes of these clutching feet. When they are employed in violent or excited action, the four claws

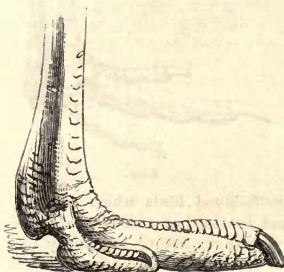
are nearly equi-distant, and all their points are directed toward the same centre, so that in whichever direction the prey writhes, it always runs itself more and more upon the point of a portion of the claws, and the trenchant edges at the same time tear and mangle its flesh. The same position of the toes enables the birds to perch on the points of rocks and other places of observation, from which they can discover their prey. But such feet are not well adapted for walking; and when the birds have to change their place even for a short distance upon the ground, they always raise or move the wings. Thus, though the foot of birds of prey is used for various purposes upon the ground, it cannot be regarded as a foot well adapted for any kind of progressive motion. The feet of ravens, and several other omnivorous birds, partake a little of this character, and hence they hop rather than walk, and partially raise the wings to balance themselves.

#### GROUND FEET.

Birds have so many and so different species of action upon the ground, and the ground itself offers so many different kinds of surface, that it is not very easy to reduce the feet to any thing like an explicit system. If the bird is a swift runner, the tarsi are long, the thigh bones articulated a little farther forward, and their action more free; but then the termination of the foot, which is usually attended to in the descriptions of the feet of birds, varies with the ground on which it is to be used, and this again causes a modification of the other parts of the leg. If the back toe is long, and articulated at the same level with the other toes, then the foot must be

placed farther forward than when the hind toe is weak, or wanting, or articulated higher on the tarsus than the other toes, in order that the axis of the body may be carried horizontal. Feet also combine other actions, such as scraping in the earth or swimming, with their action of progressive motion upon land, and this farther embarrasses us in our attempts to classify them; so that, without writing almost as many volumes as there are kinds of feet, little else can be done than simply to mention the description of surface and motion, and notice the form of the foot.

For swift motion over arid surfaces, covered with dry sand, the foot of the ostrich is best adapted.



Ostrich.

This foot has only two toes, both thick and strong, the inner short, and without any claw; the outer longer, and furnished with a broad blunt one. The tarsus is very thick as well as long, and the muscles on the tibia are large, and extend as far down as the tarsal joint. The joints have little lateral motion, but the progressive motion is extensive, and the foot

is lifted clean and high above the ground. As the ostrich is the swiftest of all running birds, we must conclude that this is the best running foot upon dry surfaces; but it cannot be considered as the normal foot of the group, for the others have three toes, and the cassowary has a long nail on the inner one, and the tarsi feathered a great way down.

The foot of the emu is intermediate between that of the ostrich and common walking feet.



Emu.

The swift-footed birds which frequent the dry shores and heaths, but which have occasionally to pass over surfaces more or less humid or soft, have three toes before, and none behind in some species, a mere rudiment in others, but not a very large toe in any. They have the middle and outer toes, more or less united by membrane at the base, according as the surface on which they generally run is more or less soft. They are all birds of flight, not having the muscles concentrated on the hind legs, like the ostriches, and their legs are in general slender; and though many of them run fast, they cannot take com-

paratively so long strides as the ostrich tribe. The foot of the common plover is nearly an average example.



Plover.

The bustards form a sort of connecting link between the "stilt" birds, which run upon dry and naked places, and the gallinidæ, which frequent richer and



Bustard.

softer ground. They can fly, and flight is their means of escape from serious danger, and also of transport on their longer journeys ; but in general they walk

or run. The preceding is the form of the foot, three toes before, with short membranes at the bases, and a sort of cartilaginous heel, but no back toe.

Birds which frequent very soft surfaces, have generally the toes longer, and bordered more or less with membrane; but unless there is another action besides walking to be performed, the difference of structure in the feet is not, in the case of winged birds, very great, whether they walk on the earth, or wade in shallow water over surfaces of the same kind.

#### FEET FOR WALKING ON GRASSY SURFACES.

These have the three front toes free to their bases, and the hind toe articulated on the same level. The claws long, the hind one especially, but not much bent. These feet extend over a large base, and the elasticity



Sky-lark.

of the grass assists the bird in jerking upwards till it can take wing. The foot of the skylark is an instance.

#### FEET FOR WALKING UPON AQUATIC PLANTS.

These have the toes very long, and the birds which have them can generally swim. The common gallinule, or water-hen, is an instance of this form of foot.

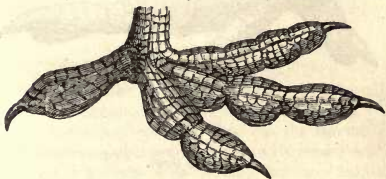
Some of the foreign birds of the same group (*Macrodactyli*) have the toes much longer in propor-

tion. The length of the toes enables these birds to walk tolerably well, though the legs are articulated so far back as to give them the position of those of a



Gallinule.

swimming bird ; and while all the species inhabit closer to the water than any other birds which have not the feet webbed, some of them have the toes lobed, and are excellent swimmers, though even these are most partial to those places of ponds and lakes



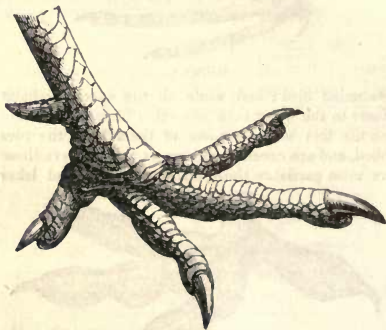
Common Coot.

in which there are aquatic plants. There is an instance of the lobed form in the foot of the common coot.

#### WALKING AND SCRAPING FEET.

These are more peculiarly the feet of the gallinaceous birds, all of which walk firmly on the ground, or stand-

ing on that reach the seeds of herbaceous plants, when they feed in a state of nature. They also scrape the ground with their feet, not only to lay bare seeds, worms, insects, and other substances upon which they feed, but to detach the small pebbles which they swallow to assist the gizzard in the process of digestion. The nails to adapt them for this operation, are rather broad and concave on their under sides.



Common Fowl.

These feet are all of the same general form, three toes before, and one behind, the front ones generally united by short membranes at their bases. The partridges have the membrane extending as far as the first articulation from the base; and in one South American genus, the hoazin, which is more aquatic than the others, the connecting membrane of the toes is altogether wanting. Some have the toes with tu-



berculated margins, and others have them smooth ; but it does not appear that there is any particular difference of habit, for the smooth and rough toed ones indiscriminately perch or "roost" during the night, though they generally nestle on the ground. Those which roost have the feet stouter and the toes longer than those which squat on the ground ; but those which squat are the swiftest runners. In general, however, their walk is slow, and in some it is stately. They always walk or run, and never hop, or raise both feet from the ground at once, unless when they are alarmed ; and then, if they do not get fairly on the wing, they flutter, and lose command of themselves. The foot of the common domestic fowl, is an average instance.

Some have the tarsi plain, some with a soft tubercle, and some with a hard and sharp horny spur. These usually appear on the males only ; but, from physiological causes, they are sometimes developed on females.

#### FEET FOR WALKING AND PERCHING.

The feet of the omnivorous birds are generally of this description, and also most of those of the granivorous—as all of them feed on the ground at some seasons, and most of them perch occasionally. The foot has three toes before, and one behind, all articulated on the same level, and divided at their bases. This is not so firm a foot upon the ground as that of the gallinaceous birds ; and the march of none of them is so stately as that of some of these. The axis of the body rolls more when they walk ; and many of them, when urged to speed, hop, and also call in the aid of their wings.

This want of firmness in walking arises from the

absence of the connecting membrane at the bases of the toes, and also from the toes themselves having more play at their articulations. But the very same circumstances render it much more efficient as a perching foot; and while the gallinaceous birds can, in general, only roost across a perch of considerable thickness, many of the free-toed birds can hang in all positions, and by one foot or both, as need may be, from a slender vibrating stem.



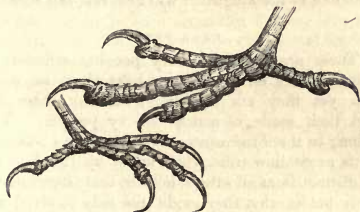
Rook and Blue Tit.

Generally speaking, the omnivorous birds are the best walkers, and those which cat small seeds from the stems of plants the best perchers; but there are exceptions. The rook is one of the best walkers; and the tits are among the most dexterous perchers: so that their feet may be taken as examples.

**FEET BETTER ADAPTED FOR PERCHING THAN  
WALKING.**

Birds with feet of this description are generally those tribes, wholly or chiefly insectivorous, which seek their food partly on the ground and partly on the leaves of trees, which are generally seen on trees and bushes, but which perch generally, and have no pecu-

liar mode of action on the trees. This foot has three toes before and one behind, but the outer front toe is more or less joined to the middle one at its base—sometimes at the base only, and sometimes as far, or nearly as far, as the first joint. This structure of foot gives the bird more firmness when perching across a twig than those birds have in whose feet all the toes are free ; but they have not so much action on their perch, and cannot swing about so much as the birds with free toes ; and they are by no means so good walkers. There are, however, considerable differences among them ; as, for instance, the song-thrush, which finds its food on the ground, is rather a good walker, while the crested wrens, which reside almost constantly in trees, have not much less command of themselves than the tits. The feet of these two species will serve as illustrations.



Song Thrush and Golden Crested Wren.

All the migrant, and some of the resident warblers, which sing from the groves and copses, and make the vernal season so lively with their music, have feet of this structure ; and they all sing on the perch, and not on the ground or the wing.

## SYNDACTYLIC FEET.

These have all the three front toes united together. They feed chiefly on the wing, use the perch only for rest, and walk little on the ground, for which the form of their feet very ill adapts them, though they usually have their nests in holes, and often in holes excavated



Kingfisher.

by themselves, for the digging of which their united and spade-like feet are by no means ill adapted. The foot of the kingfisher will illustrate this structure.

## CRAB FEET.

These are feet of a very peculiar structure, to which writers on ornithology have given no name; and yet they are distinct from any other feet, and their mode of action is very peculiar. They belong to the *Fissirostres* of Cuvier—the *Chelidonian* birds, or swallow tribe, which are so well marked, and so distinct from all others, both in their structure and their habits, that they ought not only to stand as a separate family, but as a separate order; and the three genera, of which the group is composed, are so different from each other, that each ought, in strict propriety, to form a separate group, or even sub-order.

The birds to which they have the nearest resemblance are the fly-catchers, but the resemblance is

not a very close one, except in some of the foreign species of goat-sucker ; and then, so far as the habits are known, even these are very different.

All the three leading organs,—the bills, the wings, and the feet,—are so peculiar in these birds, that almost any of them might be made the ground of classification. The wings are the most powerful part of the organisation, more especially of the diurnal ones ; but even the feet are very characteristic. They are not walking or perching feet, they are simply adhering ones ; and though both the tarsi and the toes are comparatively small and feeble, they are very beautifully adapted for retaining their hold, be the position of the body what it may.

Though the description of prey is very different, and the feet are probably never used in the capture or the killing of it, yet there is a remarkable analogy in habit between these birds and the birds of prey ; and this analogy holds even in the division into two sections. All the swallow tribe are diurnal feeders, feeding wholly upon insects, and capturing them on the wing only, and by the snap of the bill, the sound of which may be often heard when the birds are on the chase. They are thus hawks, only they are hawks in miniature ; and there is nearly the same distinction between the swifts and swallows as there is between the falcons and the short winged hawks. The habits of the nocturnal ones are not so well known, as the habits of nocturnal birds are much less open to observation than those of diurnal ones ; and, therefore, it is not ascertained in what manner they capture their prey, though probably by the bill, which is even wider in the gape than in the day-feeding species ; but as the foot of some species at least is different, they *may* use that in some instances in the capture of

their food. As they feed in the twilight, they must feed in part on moths ; but that is also the time when the larger coleopterous insects are on the wing ; and these may require preparations for the stomach different from what are requisite in the case of the naked-winged insects, which form the principal food of the swallow tribe. Still, in the form of their bodies, in the texture, and even in the colouring of their plumage, the nocturnal species differ from the diurnal ones much in the same way that the owls differ from the nocturnal birds of prey.

There is even a similar distinction in respect of habitation. The diurnal species, like the diurnal birds of prey, are all dwellers in open places, and they do not nestle in trees : the nocturnal ones are copse or woodland birds ; and though some of them are understood to nestle on the ground, the greater number certainly nestle in trees and bushes. Yet further : the diurnal ones have a harsh, sharp scream, which though not exactly like the chirrup of hawks, has some resemblance to it ; and they are in general silent : the nocturnal ones, on the other hand, have a more continued and stridulous cry ; and in the depths of the tropical forests, especially those of America, they keep not only the common night, but the sultry and otherwise silent noon, alive with their cries.

Being all chiefly insect feeders, they are most abundant in tropical climates ; and those which frequent cold and temperate regions in the summer always quit them before winter. The nocturnal feeders, being birds of less firm feather and less powerful wing, are by no means so migratory as the diurnal ones. These last, as will be more particularly shown when we come to give some account of wings,

are among the most exclusively wing-birds, and the best winged in the whole class. Their food is in smaller portions than that of any others of the class, and thus they have more labour in the procuring of it. Not only this, but many of them have much labour in the construction of their nests, whether they build them of mortar in the crevices of rocks or the apertures or angles of buildings, or excavate them in the banks; and all of them have much toil in the rearing of their broods, which, as is general with birds that have very perfect feathers, continue a long time in the nest.

Their feet more resemble the syndactylic ones than those of any other form, though these have the toes united, and consequently a narrow foot, while the birds under consideration have one remarkably broad for its length; but they both agree in this, that the tarsi and toes are short, and they use the feet only for resting or holding-on, and rarely if ever for progressive motion. It is worthy of remark, as a striking instance of agreement in two very important habits, that though the syndactylic birds build low, and the ones under consideration build high (for even the sand-martins, or bank-swallows, build in lofty banks and rarely in low ones), they should both have covered nests, and both feed their broods for a long period, as well as both capture their prey on the wing. And the height at which they build corresponds to that at which they fly. The kingfishers and bee-eaters never have their nesting-hole far above the surface of the water; and their flight, when in search of food, is invariably low. Of the swallow tribe, again, the sand-martin, which builds in holes of the banks, is the bird of lowest flight; and the flight and position of the nest rise together, till we come to the swift at the top of

the sky with the one, and the top of the rock or the tower with the other.

The feet correspond: the syndactylic foot, with its soldered toes, forms a steady base for resting by pressure upon a horizontal perch; and the foot of the swift, which is the opposite extreme, in all the birds which prey upon insects on the wing, is the best adapted for holding-on upon the slightest inequalities of an upright surface. Although, therefore, the feet of all these birds are small, apparently feeble, and not adapted for locomotion, there are no feet better adapted to the habits of their owners.

The general character in which the "crab" foot, or foot of the *Fissirostres*, differs from that of all other birds, is the equality of the three front toes, and the reversibility of the back one. In most birds the middle toe and the external front one, have each four phalanges of bone, while the inner one has only three, and in some of them, more particularly in the zygodactylic birds, the feet of which remain yet to be noticed, the outer toe is reversible backwards, so that it acts in concert with the hind one and in opposition to the other two. But in the crab foot, the back one is reversible, so that all the four points can be turned forward, or rather into the circumference of a circle, in which the articulation of the toes with the tarsus forms a fifth point.

The feet with the reversible outer toe, have the strongest action in opposite directions toward the centre of the foot, and therefore they grasp firmly any substance to which that is applied, although the tarsal joint is straight, or even the bird suspended by the leg at full length, or standing up with it in the same position. But the greatest action of the crab foot is concentrated upon the articulation of the tarsus in



one direction only, and that is the direction against which the weight of the bird pulls. The tarsal, and also the tibial joints are bent as far as they will bend, when these birds hold on upon the upright surface of a rock or wall, and the articulation of the toes is, at the same time, in contact with that surface. Therefore, if there is the least hold for the points of the claws, the strain upon them is always such as to make them retain that hold the more firmly the greater the strain.

Upon carefully examining these feet, of which the most perfect is that of the swift, a figure of which will be found in the sequel, it will be perceived that, while the spread of the toes gives great stability to the individual foot, the two are, when the bird hangs, or adheres by means of them, so placed as that the greatest resistance of each is in the direction of the centre of gravity of the whole bird, so that the weight actually draws them into closer contact with the surface on which they have hold. If in common mechanics, it were required to find an instrument consisting of hooks which should be the best for holding on against a strain, parallel or nearly parallel, to the surface on which it held on, the very best model would be the foot of the swift. The pull upon the individual toes, being toward the point of their general articulation, draws them together so that they clutch the surface upon which they have a hold; and then the strain of the bird's weight pulling upon each foot toward the centre of gravity of the whole body, acting in two lines, which, produced, pass a little outwards of the average hold of the feet, makes the whole bird hold on with the feet, as if it were grasping or embracing a substance between them.

The goat-suckers, being more woodland birds, have

the feet better adapted for perching on twigs or other horizontal supports, than the swallows. They have a short membrane, connecting all the anterior toes at their bases, and the middle front toe is longer than the others, and the claw pectinated.

There have been various speculations about the use of this pectinated claw, some of them more and some less ingenious, but none of them very much to the purpose. That it does not in any way assist the bird in perching, is proved, not only by the fact that the toe which has it does not close so completely in the terminal phalanx as the other toes, but by the general principle in nature that animals never hold on firmly by means of teeth or pectinations in one continuous inflexible member, in maintaining the stability of their own position. A single adhering point to each moveable part of the organisation, is that which makes the hold the most secure, because it is the one which allows the greatest play in all directions. Accordingly, in the articulation of animals, whenever we find a joint upon which there are to be cross motions, we always find the socket, and the head which plays in that socket, simple, while, in those which have motion in one plane only, the head and socket are often both double, and not unfrequently ridged in addition.

The speculations which have been made with regard to the use of this pectinated claw, are hardly worthy of repeating. That of White is the most sagacious, because most agreeable with the general analogy of nature. He says merely, that it appears to be to aid the bird "in taking its prey;" as the heron holds its slippery prey with a pectinated toe, and mergansers and several other birds hold theirs by serrated mandibles. But it has been also said that this toothed claw is used in trimming the vibrissæ

or hairs at the sides of the gape, and also in clearing the bird of troublesome insects.

The hint thrown out by White is that of a naturalist—of one who seeks a new use for a new form of organ ; the other conjectures hardly deserve that character, as they point at no additional use for the additional structure, inasmuch as there are birds with plain claws which live on similar food, and are more infested by nirmides than the goat-suckers. White's hint points to inquiry, the other conjectures do the reverse—they lead from nature to art.

The goat-suckers themselves, though otherwise noisy enough, are silent upon this subject ; and as the mode of their preying, from the time at which it usually takes place, is not very open to observation, it is difficult to come at the truth by that means. But, from the time, and, as far as it can be observed, the manner of their feeding, the goat-suckers must feed upon beetles and moths, insects on which there is a considerable quantity of substance not available as food ; and as, though there are *some* points of resemblance between goat-suckers and owls, no mention is made of the former returning the elytra of beetles and the wings of moths in castings, as the owls do the indigestible parts of their prey, it is not improbable, though certainly not proved, that they may use the pectinated claw in removing the indigestible parts before they swallow the rest. It avails little, however, to speculate upon the use of a structure which we have so limited means of observing ; but we may observe in passing, that though Wilson saw these birds scratching their heads with the pectinated claw, that proves nothing as to the specific use of the pectination, because birds which have not their claws pectinated, scratch themselves in a similar manner, and

this one cannot alter the form of its claws while performing this operation. It must, to use a homely phrase, scratch itself with such claws as it has ; and as no bird appears to have claws specially formed for this secondary purpose, the analogy is against such being the principal intention of this toothing of the claw of these birds.

Upon looking back at the figure of the goat-sucker's bill, it will be perceived to be very *fissirostral* ; and that, though it might be capable of transfixing a tough coated insect with the sharp points of the mandibles, it cannot bruise any thing between the tomia. The sharp points are obviously for capture ; for though there are vibrissæ along the edge of the upper mandible, there are similar hairs at the junction of the upper mandible with the front, where they cannot by any possibility assist in the capture of the prey, and there are also similar bristles at the base of the bill in many birds which do not catch insects or any thing else with the bill while they fly open-mouthed ; so that it is at least probable that while the coleopterous insect is seized and held between the hard and sharp points of the mandibles, the parts that are unfit for



Goat-sucker.

food are stripped off by the pectenated claw of the foot, which is certainly borne less bended, or in advance of the other claws. The preceding figure is an accurate representation of the foot of this bird.

The swallow-tribe all have the foot less firm as a perching foot, that is, less connected by membrane between the bases of the toes, than the goat-suckers ; and the articulations of the toes with the tarsi have more of the ball and socket form, and consequently admit of more motion. This motion increases, and the tarsus and toes become shorter, and the claws more crooked, from the lowest building swallows to the swifts, which have the most perfect crab foot, that is, the one best adapted for individually holding-on upon slight inequalities of a perpendicular surface, and at the same time the least fitted for perching on a twig, or walking upon the ground, for which last office they are not at all fitted, and the birds are consequently quite helpless there.



Swift—hind toe reversed, but closed.

The feet, admirably formed as they are, are not the only organs by means of which these birds maintain their perch upon perpendicular surfaces. The flying feathers of their wings and tails are remarkably stiff in the shafts and firm in the webs ; and though they cannot, of course, take hold with their feathers, unless when they, as it were, embrace a projection, yet the

pressure both of the wings and tail assists in tightening the hold taken with the claws; so that, even though the surface to which they cling overhangs, these birds can stick to it very firmly. The preceding figure of the swift's foot will show the structure.

#### ANISODACTYLIC FEET.

As "crab" feet, more especially in that form which they have in the swallows and swifts, are the best fitted for holding-on while the body generally of the bird is steady, upon an upright or an overhanging surface, so feet of the form now to be described are the best adapted for motion upon such surfaces. Birds which have them are all, generally speaking, tree birds, or at all events woodland birds. But, like the birds with feet of the immediately preceding form, they admit of subdivision into those which feed more exclusively upon the bark of trees, and those which feed more exclusively on the wing. They are the same, or nearly the same, as the *tenuirostres* of Cuvier.

But, although that illustrious naturalist has taken the form of the bill as their distinguishing character as a tribe, and though their wings, which are in general very powerful, might also be made both a general character of the whole and a means of dividing them into different sections, yet the foot is unquestionably their most prominent and remarkable character. Their feet are entitled to the preeminence, not because they are, as in those birds which cannot fly, the only active organs except the bill, and not because they are efficient organs of locomotion upon the ground; for, generally speaking, these birds are not only very bad walkers, but they are seldom, if ever, found upon horizontal surfaces. Indeed they

are not at all adapted for such surfaces, and those of them which have their own peculiar feet in the greatest perfection, are as helpless upon the ground as the swifts.

But their feet can adhere to, and, with the assistance of the wings, move along any surface, be its form or position what it may. Those which are bark birds can run along the boles of trees, upwards, downwards, or round by a circular motion; and others, again, can hang by the feet to the petals of flowers, while the bill reaches the bottom of the nectary, and sips the sweet juice which accumulates there, as is well exemplified in the humming-birds and the nectar-suckers.

The structure of foot, by means of which this singular command of all manner of surfaces is obtained, is apparently a very simple one; and if we had not so many instances in nature of the cleverest action performed by organs apparently the most simple, we should never imagine that the apparently small difference of structure that there is between the feet of these birds, and the feet of birds which cannot climb at all, could be sufficient to effect so great a difference of action. The ordinary appearance of the foot, when in a state of repose, is three toes to the front, and one behind, the same as in an ordinary walking foot, only the middle and external toe have a union at their bases which appears to be something more than a merely membranous connexion, like that of many of the insectivorous birds. It is, however, in these two toes, their union and the peculiar mode of their articulation, that the whole peculiarity of the foot, that to which it owes its wonderful climbing power, consists. These two toes form a sort of second foot, which can act upon its own articulation in

opposition to the two remaining ones, that is, to the interior front one and the back; and the joint by which the two are articulated on the tarsus admits of so much and such varied motion, that the one part of the foot can act in any direction against the other. Owing to this, the action of the foot is universal as to direction, parallel to the axis of the body, or almost at any angle to it. Thus the birds can run upon the bark of trees in any direction, holding on upon the irregularities of the bark with each foot, and at the same time embracing the convexity with both. This can be easily understood, when it is considered that both the recurved toes of each foot press inward towards the centre of the body; and this action of the two feet in opposition to each other converts them into a sort of one clutching foot, which acts without any direct exertion of muscles, and therefore holds on for a long time without being in the least fatigued.

Anisodactylic feet are thus formed for concentrating their action upon the centre of the body, without any reference to the direction in which the weight presses, just in the same way as the crab feet of swifts concentrate their action so as to support the centre of gravity in the most effective manner.

The best native example which we have of a bird with this clever species of foot is the creeper, or the common tree creeper (*Certhia familiaris*). It is a very small bird, the smallest that we have in these islands, with the exception of the crested wrens, which, like it, are tree birds, and very clever on their feet, although they are perchers and not climbers. It is a resident bird in Britain, and by no means a rare one, and its motions upon the trees are well worthy of observation. The direction in which it runs (for its



motions, though aided by the wings, have more the appearance of running than of any thing else) appears to be of little consequence. Upwards or downwards upon the bole of the tree, outwards or inwards upon the branches, with the back or the belly uppermost, appear to be all the same to it; but, from the celerity of its motion, and its diminutive size, it is not easily seen. The nuthatch, of whose foot a figure is annexed, is the only other species resident in Britain, though the hoopoe, which is a very handsome bird, with feet nearly of the same character, appears not unfrequently as a summer visitant.



Nuthatch.

The hoopoe differs, however, in many of its habits, for it is more of a water bird than a frequenter of trees, and its bill is incapable of performing labours so severe as those of the nuthatch, or even of the creeper; for though the last is an insectivorous bird, and not able to hew the shells of nuts to pieces like the nuthatch, it has to dig its food out of the crevices of trees.

The different substances upon which birds with feet of this structure feed, is strong evidence against the classification of them by the form of the bill; because, if such a classification is to mean any thing, it should mean similarity both of food and of manner of feeding. But though most, if not all, of the birds which

have feet of the structure under consideration have slender bills, their food is very varied, and the only habit in which they all agree is that of being able not only to adhere by the feet, but to move about upon almost any form of surface, or in almost any position.

Considered as mechanical structures, acting in concert with the whole organisation of the birds, these are, perhaps, the most extraordinary of all the varied forms which birds possess. They act in concert with the whole structure of the birds; and thus, though the mechanical contrivance that appears in them, taken singly, is not very striking, yet it becomes remarkably so when we consider bird and foot jointly, and notice how the varying pressures which the weight of the body gives in all the numerous positions which it can assume, contribute almost equally to render more firm and sure the hold taken by the feet. One of the greatest beauties in those displays of the mechanics of nature, and one of the greatest superiorities which they evince over all that human ingenuity can contrive, is the wonderful simplicity with which what, to us, seems the most difficult of all purposes, is accomplished. When we have a mechanical difficulty to overcome, we complicate part upon part, and often defeat our object, because the artificial clogs and hinderances which we thus produce, are greater than the difficulty which we sought to overcome; and thus we produce a negative effect instead of a positive one, and are further from our object at the end of our labour than at the beginning; but when we examine nature, we find that the very difficulty itself becomes one of the most effective means by which it is overcome,—as in the case of these singularly footed birds, the weight which the feet have to sustain is actually converted into a means of sustaining it.

## SCANSORIAL OR CLIMBING FEET.

The principal object to be accomplished by these feet, is not simple adherence to an upright overhanging surface, as in the case of the swallows and swifts, or progressive motion along the boles and branches of trees, as in that of the *anisodactyli*. It is, in the more perfect specimens, motion from branch to branch, and in the others stability on the boles of trees, with the body in an upright position. Feet which accomplish these purposes are all *zygodactylic*, or yoke-toed, that is, they have the outer toe very readily reversible, so that the foot presents two toes to the front and two to the rear, both nearly of equal power; and where there is a different function to be performed, that is done chiefly by modified articulations of the other parts of the foot and leg.



Aracari.

The extremes of this kind of foot are perhaps those which are found in the woodpeckers and the parrots. The woodpeckers are trunk birds, and when upon trees, they are insectivorous; the parrots, on the other hand, find no food upon boles or large branches, but subsist chiefly upon fruits, and ramble about among the smaller twigs and sprays in quest of them.

Thus, though both are climbers, they climb so very

differently, that when they are described as birds of the same habit, a person who knew only one of them would be apt to form a very inaccurate notion of the other. The woodpecker cannot climb as the parrot climbs, neither can the parrot climb as the woodpecker. The woodpecker is a bark bird; and though it can adhere to the bark of a tree, so as to leave its bill, neck, and head free for other action, it cannot adhere in an inverted position; and unless the crevices of the bark are particularly favourable for its claws, it must use the stiff feathers of the tail as a prop. Whether it requires to do this or not, it must always bend the joints of the leg so as to make the claws hold with the requisite firmness. Its foot is in fact a sort of double crab foot, the two parts of which hold on in opposite directions. It is by the claws which are turned to the front that the weight is suspended; and those which are turned to the rear, have their principal action in tightening the hold of these. Then the line of the body and tail acts in the same manner as a diagonal strut under a beam; and every one knows how small a hold in the wall will support a beam if such a strut is applied to it. The painter's scaffold, used in cleaning or repairing windows high above the ground, which one sees every day in the streets, acts upon a principle nearly similar to that of the woodpecker.



Woodpecker.

The above is the position of the foot when in the act of holding on.

The foot of this bird has other functions to perform besides keeping its hold on the bark of trees. It is an insect-feeder, and at certain seasons these are much more abundant on the ground between the trees, than in the trees themselves. The seasons when the larvæ are in the bark or the decaying wood, and when the mature insects resort thither to deposit their eggs, are those at which the woodpecker is most active upon the bark ; but there is an intermediate time during which the bird is on the ground picking up beetles, and especially ants, which last are gregarious or social insects, and great frequenters of forests. In temperate countries, woodpeckers answer, at those times, nearly the same purpose which ant-eaters answer in more tropical climates.

This habit in the woodpecker requires a command of itself upon the ground for which the parrot has no necessity; and which, indeed, would be incompatible with perfection in that peculiar structure of foot which the parrot requires. Accordingly, although the woodpecker does not require to be a runner, inasmuch as food for it is very abundant at those times when it is on the ground, yet it stands well on its legs, and is a tolerable walker; while, on a level surface, the parrot makes sadly shambling work of it—much like that of a climbing ape, and it very soon gets fatigued, which the woodpecker does not.

Though three toes before and one behind, all free at their bases, be the normal foot for a continued slow pace on the ground, yet the form of the toes is not that which constitutes a walking foot. The relative lengths of the bones, and more especially the articulations of the foot and leg, are the chief points which render the foot either a good walking one or not. If these joints have their motions only in the

vertical plane and parallel to the mesial plane of the body, without any lateral flexure, then the bird will walk firmly; and whether its march shall be quick or slow upon one kind of surface or another is made out by the details, the relative length of the member, and the form and magnitude of the toes and claws. If a man has his knees or his ankle-joints with lateral play, or with a twist inward at the knees, or more especially with a twist either way at the ankles, he walks never a bit the better though his feet may happen to be, as is often the case with inward-twisted ankles, as broad as shovels. It is also impossible even to imagine members more finely organised for their proper use than the toes of long-armed apes and spider monkeys; and yet, from the twist of the ankle, which is an outward twist, or one which turns the sole of the foot inwards, they walk not only with great awkwardness but with great pain.

The articulation of the toes of a bird, answers in anatomical arrangement to the metatarsal joints of the toes in man; but in walking it answers to the ankle-joint. If this joint is firm, and the joints above it so articulated as that the weight of the bird comes perpendicularly upon its centre, then the step of the bird will be firm; but if this joint is loose, or even if the strain takes it in an oblique direction, the bird will wriggle or waddle, and waste in rolling from side to side great part of that muscular exertion which would carry a better set bird straight forward on its way. The woodpecker is straight and firm on these articulations; and even its capacity of holding-on upon the trees, requires that it should be so. It is not, as we have seen, a clutching climber, which holds on by grasping with the foot,—for even when the woodpecker perches upon a branch for repose, it does

not perch across, as most perching birds do, but lengthways, or with the axis of its body parallel to that of the branch,—it holds on by a combination of mechanical resistances, acting all in the same plane, though in different directions; and therefore any lateral motion in the joints of the foot or leg would turn that foot into an instrument of positive instability—a crow-bar to wrench the bird from the tree.

But when we consider the style in which the parrot climbs, we can easily perceive that the looseness and twist, of the articulation of the toes especially, which make it so bad a walker, are the very best for its proper habit. It is the same with the twisted-limbed mammalia, to which allusion has been made for illustration; they could not have performed their part in the system of nature, unless they had had that very formation which makes them appear so awkward when out of their proper sphere. When we come to notice the feet of the water-birds, we shall find instances of structures differing from each other to the same extent, and nearly in the same manner as these differ; and if it lay within our province, we could easily show the very same differences of adaptation and use, and the same perfect accordance of the one with the other, in all animals endowed with locomotion, whether vertebrated or invertebrated, and whether of the magnitude of whales or the minuteness of animalculi. Throughout the whole there is the most complete evidence of mechanical perfection, always competent to effect its purpose without supplemental aid. And among most of those cases, probably indeed in every case of an articulated animal, whether articulated internally in the skeleton, or externally in the crust, where it has been supposed that suckers and cements, and other clumsy contrivances have been

resorted to, in order to enable the animal to keep its hold, a very few simple claws, or elastic pads, applied with nature's mechanical skill, are not only all that exist, but all that is necessary, and that more would be an absolute incumbrance.

Those attempts at explanation by such supplemental aids as have been alluded to, are found in numbers in very many of the books (even those of no measured pretence) which profess to treat of the mechanics of the living world. But the accounts of such structures always point out the origin of the structure : it is a bungle ; therefore it is the work of man : were it the work of God, it would be perfect in its single and simple organisation, and more, even could it be added, would overload and weaken it, just as a machine of human invention is overloaded and weakened when it consists of too many parts. That joiner is a bungler in his art who must upon all occasions use the glue-pot ; and that is the most perfect piece of carpentry which stands firm without glue or nail, or any other supplemental fastening ; and when we come to nature we find no such fastenings ; the parts themselves have the requisite form, the requisite adherence to each other, and the whole, by means of its own organisation, has the necessary adhesion to whatever kind of surface is to support the animal in its ordinary motions.

And here, as the subject presents itself naturally in consequence of the explanations which have been given of these feet, we cannot resist calling the attention of such readers as may not generally be in the habit of attending to such subjects, to the very wide and wonderful field for mechanical study which the animal creation presents. Yet ample and apparently exhaustless as it is, it is all acquirable knowledge, as



far as the telescope can survey in the one direction, and the microscope in the other.

The organisations of animals do not partake of the unseen and, therefore, the mysterious nature of that energy of life by which they are evolved and put in motion. They are, in all their parts, wholly material, and every motion, and every position of rest, of which they are capable, admits of as certain explanation—an explanation as simple, if we would go the right way to it, as the putting of a common balance in equilibrio, by placing equal weights in both scales. A leech may proceed by suckers, but no animal proceeds thus, unless its principal action in motion is a lengthening and shortening of the body; and when we say of a swift-footed animal, that it must pause at every step, and either fasten its foot by glue, or by pumping out the air from under it, we afford a very certain proof, not only that we are imperfect in the knowledge of nature's mechanics, but that we do not understand the meaning and application of those common laws of mechanics, which are set down in the books, although we may be able to parrot the enunciations. When we do not understand by what means, or in what manner, an animal, or a particular organ of an animal, which is new to us, and, philosophically speaking, everything which we do not understand is new to us, though we should have been in the habit of seeing it daily for the longest life—when we do not thus understand, the most candid, and by far the wisest plan, is to say so, because all mankind like candour in others, and thus we win the applause of the whole world, without any admixture of that envy or jealousy, which is just as apt to follow a false discovery as a true one; and besides, we leave uncloyed, and in full vigour, that appetite by which

alone we may come at the true knowledge. But to return to the scandent feet.

The foot of the parrot is a foot which climbs by clutching—a “tying” foot, as one would say—and not one which holds on by a combination of “counter-strains,” like that of the woodpecker ; and it is so, in order that the owner may find its food in situations where a woodpecker, or, indeed, any bird differently organised to a parrot, could not subsist. The pasture of the parrot is among the sprays or smaller twigs of large spreading trees, and not exactly at the extremities of them, because the fruit which is fit for the parrot’s eating is rather farther in, there being a new shoot beyond the fruit before it is ripe, in most fruit trees, and a new shoot with green fruit, and often another with blossoms beyond it, in many of the fruit trees in parrots’ countries. Besides, many of those trees bear their fruit at the axillæ of the twigs or leaves ; and as the same point of a vegetable never blooms or fruits twice (so that the most perennial trees in duration are really annuals in their most important functions), the successive fruits or flowers are, even in these, without the place where the parrot feeds. Some of the allied genera alight on the tops of the trees, but these are the long-tailed ones, which are better winged, more in the habit of flying, and less expert climbers than the true parrots ; and even they do not penetrate so far into the sprays as where the parrot feeds, and they feed upon fruits of a different character—fruit of which the pips, not the pulp, is eaten.

Now, any one who examines a tree, when so cleared of leaves as that the twigs can be seen, must perceive, that at about the situation of the previous year’s shoots, the twigs, even when leafless, are so tangled, that no

bird half the size of a parrot could use its wings among them, unless to pass through at some opening; but the parrot has to range the tree in all directions at the very part of it where wings cannot be used; and it has to range minutely, because there are always leaves upon those trees, and the leaves of tropical trees are often broad and close. Thus, though the parrot is a tree bird, it seeks its food much in the same manner as a partridge seeks among the corn, or a grouse among the heather; that is, by comparatively slow motion, and prying about on all sides as it goes along. Consequently, the organisation most essential to this habit is the one which enables it to get most readily from twig to twig without the use of its wings in any other way than partially opened to assist in keeping its balance.

The foot, to possess this property, must have the whole of its prehensile action in the toes; and the leg, instead of maintaining one invariable position in assisting the foot in holding on, must be free to move to its utmost stretch in all directions. It is also evident, that unless the parrot could hold on by one foot, and hold on with that foot in any direction, above it, below it, or laterally, it could not make its way; and even in addition to this, the bill of the parrot is prehensile, and affords the same assistance to the feet, as the prehensile tails of those climbing mammalia and reptiles which have that character.

To accomplish these purposes, the joints in the leg and foot of the parrot must have rolling or oblique motions, in order that, while it holds on with the one foot, it may extend the other as far as its length will permit in any direction; and it is especially necessary that the joint at the articulation of the toes should

turn the foot outwards, because that is the best position for its readily laying hold. When the necessity that there is for its action is known, the action



Parrot.

itself may be easily inferred from inspection of the annexed figure.

#### SWIMMING FEET.

There are not so many diversities of form in the feet of aquatic birds as in those which inhabit the land, whether they seek their food on the earth itself, or upon vegetable substances. The element is the same, or nearly the same, in all water birds, so that the only thing which remains to which the feet have to be adapted is the difference in habit among the birds themselves. There is, however, one difference of element which requires a corresponding modification of the foot : there are some birds which are very exclusively in the water, and, as such, water birds, in the form of their bodies and the manner in which their feet are articulated ; but they frequent those waters which are full of the stems of reeds and other aquatic plants, among which the structure of foot which is best for action in the clear or open

water, would, of course, not be the most convenient. The foot for action in the open water is a continuous web of membrane between the toes, which varies with the habit of the bird; but among stems this web could not be so conveniently used, as it would be liable to get entangled or interrupted, if not torn. Accordingly, these birds have the toes only lobed, so that they can be drawn through between the stems with the less opposition. Some of the birds which have these partake of the character of shore or bank birds, and can walk upon the land as well as swim upon the water. These are the coots and phalaropes, which continue the succession from the gallinules, which, through the landrails, have some relation to certain species of the gallinaceous birds. They, when on land, carry the axis of the body in nearly a horizontal position; and the lobes on their toes are divided into segments answering to the phalanges. Of these the foot of the common coot is an instance.

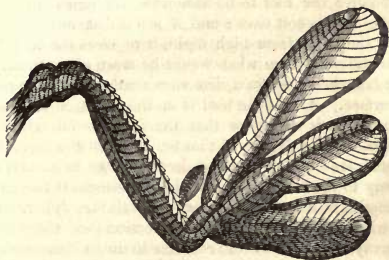
Grebes, though chiefly frequenters of fresh water lakes, have much more aquatic habits. They have the body of the true canoe shape, and the legs articulated so far backwards, that they cannot support the axis of the body in a horizontal position upon land. They accordingly walk with the spine nearly erect; they walk with difficulty, and are never found far from the water. Their feet have complete lobes to all the toes, and even the tarsus is flattened, and has a membranous margin, so that the foot is a swimming foot all over, though one adapted to peculiar places. The articulations of the tarsi have a rolling motion, and those of the tibia also work outwards when the feet act in swimming. The looseness of these two joints renders the bird incapable of moving along the ground with the legs steady; and this, more

than the mere form of the lobed toes, is the reason of its being so bad a walker.

But the feet are admirably fitted for aquatic motion. They turn their thin edges nearly in the direction of the resistance when they are drawn forward, but they strike back with the full breadth of their webs, and they can turn on the joints so as to give the stroke in a variety of directions, and thus impel the body upon any course which may be necessary to the bird in following its prey in the water. The wings also come into action in swimming, though more as points of support, against which the legs act, than as propelling organs. But the birds are altogether excellent swimmers, or rather coursers through the water with great speed. They do not dabble like ducks, but plunge freely into the water, and dash along, not by alternate strokes of the feet, as in a common walking motion, but by striking with both at once, as a frog does. It is to enable them to perform this motion that the wings are brought into action as well as the feet; and the same kind of motion could not be performed, and the intended course kept, without the wings. This is, in part at least, the reason why those aquatic birds, which are incapable of flight, have the wings, though destitute of flying feathers, much more produced and capable of motion than those of the running birds upon land. The different styles of motion through the water, whether on the surface or below it, can, however, be more briefly, as well as clearly explained, when we come to consider the habits of those birds which have entire webs on the feet, and range the water in places where they are not liable to interruption from the stems of plants.

What may be considered as the normal swimming foot consists of three toes directed to the front, and

one small one to the rear. There are always webs of membrane between the front toes; but in the



Grebe.

species which swim only and do not dive, there is no web to the hind one. Divers have it margined with a small web; those birds which Cuvier styles *totipalms*, or entire feet, have the hind toe much longer and stronger, and included in the same web with the anterior ones, and they have the whole foot turned in a particular direction, the purpose of which will be explained afterwards; and there are some genera which are in the habit of tipping the surface of the water with their feet, while their bodies are nearly or altogether supported by the wings in the air, and these have the hind toe merely rudimental, and the foot narrower in proportion than any of the others.

In order clearly to understand the uses of the different forms of web feet, it is necessary to consider the other actions of the bird to which the foot must be subservient, or at least with which it must be in accordance. These actions are of course either walk-

ing or flight; though they also admit of modification. Thus, if the sea-bird alights only on solid surfaces, it requires the feet to be somewhat different than if it alighted on soft ones; and if it dash at once down on the water from high flight, it requires the feet to be different from what would be more convenient if it launched itself in a direction nearly parallel to the surface. Also if the bird is in the habit of walking much, it is necessary that the feet should retain a considerable degree of that action of all the joints in one plane, which we have already shown to be necessary to the stability of a walking motion. If the bird combines the three motions of walking, flying, and swimming, in nearly equal perfection (and there are many birds which do so combine them), it is necessary that the feet should have a different structure; and if the motion is in the water only, the structure of the feet requires still to be modified according as it is more of a straight forward motion, or of an ascending and descending one.



Wigeon.

There is, however, no bird with webbed feet which can have that perfect adaptation of the feet for walking, which is possessed by ground birds upon land; because every bird with webbed feet is a swimmer;

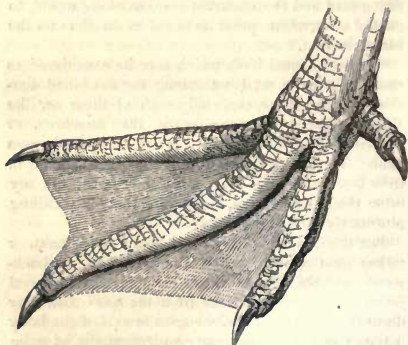


and though the swimming motion should be merely a modification of the walking one, that is, by alternate strokes of the two feet and never by both at once, yet the articulation necessary for swimming is somewhat different from that which answers best for walking; because the swimming feet must throw out a little in order to clear the body, and this very throwing out, which does not cause the body of the bird to vibrate when it is supported by the water, does make it vibrate when it is in the air. Sea birds as well as sailors, may thus be known by the style of their walking; and though the causes be different, and the one habit and the other structure, there is such a resemblance between the rolling motion of the seafaring bird and the seafaring man, as alone would, to careful observation, point them out as dwellers on the same element.

The web-footed birds which may be considered as the least aquatic, at least among the flat-billed division, are the geese, especially such of them as, like the domesticated goose, graze the meadows, or otherwise find the greatest part of their food upon land. These have most of the walking character in their feet; and when they swim they never use any other than the walking motion, or that of paddling alternately with the feet.

But the body of the goose has a sort of boat, or rather punt shape; the sternum extends far backwards, and the tibiæ are so articulated that the tarsal joints project much farther from the sides than they do in land birds. Thus, though the axis of the body is borne in a position nearly horizontal, the advance of the foot, wide apart as the feet are from each other, does not carry the centre of gravity directly forward, but swings it round; so that, unless when

the motion is very slow and the bill in contact with the ground, as is the case in feeding, the goose swings along with not a very graceful motion. Besides, though geese in their domesticated state are not much in the habit of flying, they are birds of long-continued and moderately rapid flight when in a state of nature. From this combination of feet and wings, and adaptation of the feet both to walking and to swimming, these birds have their muscles distributed over the body much in the same way as common poultry, and thus neither their feet nor their wings are very remarkably characteristic. The foot is a swimming foot of the simplest kind, and may be understood from the annexed figure.



Common Goose.

All merely swimming birds, which float along with part of the body above water, have the motion of the

feet more nearly in the vertical plane than the divers. But there is, even in them, a very beautiful action of the foot, brought about by the mere bending of the leg, without any additional exertion of muscular power. The moment that they begin to draw it forward, after it has made the stroke, it begins to contract, by the bending of the tarsal joint pulling the tendon. The surface which the foot presents to the water in the direction toward which it is pulled, is thus not only constantly diminishing, but it is convex in its form, and yielding as the joints are relaxed, so that it "comes home" through the water with very little effort on the part of the bird. When, however, it begins to act in the taking of the stroke, it presents the concave side, and that side keeps enlarging till, at the time when the stroke is given, it has attained its greatest breadth. It then comes to nearly a horizontal position of the feet, and from this it is drawn forwards with not much more breadth than the edge to the water.

This foot is exactly a paddle, only it acts better both on the stroke and the return than any paddle which man can construct. No doubt the paddle which man uses is recovered through the air, and thus the resistance of the water is wholly avoided during that part of the operation. But still the exertion which has to be made in raising the paddle is much greater in proportion to the effect produced than that made by the foot.

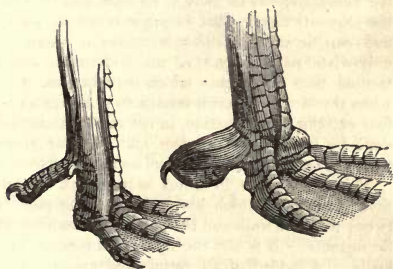
The swan, though nearly or altogether equal to the goose in flight, is much less upon land in its ordinary habit, and it is accordingly better adapted for swimming, and, as a necessary consequence, a worse walker. Swans, indeed, stand in much the same relation to geese (taking them on the average) as the diving

ducks do to the swimming ones. Their tarsi are shorter, the webs of their feet larger in proportion, and the joints have rather more oblique motion. As neither dive, the comparison of them is of course made as surface swimmers ; and the attitude of the swan upon the water has been a favourite theme with poets and picturesque describers in all ages : and the bird is stately as well as graceful, both when it moves with closed wings and smooth plumage against the breeze, and when it hoists sail, and takes the wind in its raised wings, to aid or relieve the labour of its feet. From its beauty, its size, and its tameness, the swan is the best subject in which to study or observe the action of surface swimming. All its evolutions upon the water are worthy of notice, and its style of doubling and of backing is particularly so.

All those surface swimmings in which there is smooth motion, are, of course, made with the alternate foot ; for, as the feet are considerably in the rear of the centre of gravity, if the bird was to attempt leaping on both without something to hold on, the hinder part would be jerked out of the water, and the fore part plunged into it, by which means the progress would become both unseemly and fatiguing. When alarm, or any other cause, impels these birds to more rapid motion along the water than they can accomplish with the ordinary swimming motion, at its full stretch, they take to the wing, and if they do not get so high as merely to tip the water with their feet, as the skimming birds do, they make the same flutter, and generally utter painful cries, as barn-door fowls do when forced to the wing.

The swimming ducks are less upon the water than swans, as a considerable part of their food is found on land, and they are incapable of reaching the

bottom in so deep water. Their bodies are also not quite so well trimmed to the action of the swimming feet, and they labour and wriggle more, both laterally and vertically, so that, though they can float about for a considerable time, they are much sooner tired when they attempt to swim upon a stretch. These ducks have the tarsi longer, the toes shorter, and the action of the foot in swimming not so much to the rear. The sheldrake is the most landward ; but the foot of the common duck is perhaps very nearly the average.



Feet of the swimming and the diving Ducks.

The diving ducks are bad walkers, and seldom upon land ; but they are more compact in the build of their bodies than the swimmers. When, however, we speak of swimmers and divers, as contrasted with each other, we must bear in mind that there is no definite species with which the one ends or the other begins ; for there are species in the middle of the group, partaking in nearly an equal degree of the habits of those at both extremities. The divers have

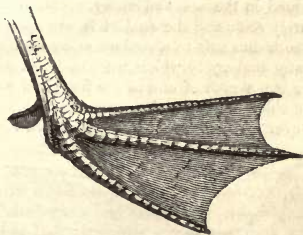
the tarsi short, the tibiæ rather lengthened, which throws the joint of the tarsus backward ; the toes and webs larger, and the hind toe with a little web. They do not dive habitually ; for though they are less fitted for dabbling than the others, they do practise it a little, and they also feed along the strands ; but they often appear to get down for change of motion, as well as for food ; and on such occasions they move more quickly below the water than they can on the surface.

Of course when they are once down, and the water has closed over them, there is no more paddling with the alternate feet. That is properly a land motion, and can be used as the sole means of progression only when part, at least, of the body is in a rarer medium than that against which the foot acts. Thus, when the bird is under, it immediately brings all the four extremities into action, in the same manner as is done by frogs, water-tortoises, and all other animals which have four extremities and swim immersed.

This is the style in which man swims, and also those mammalia which have not a trotting pace between the slow walk and the gallop, the common pig for instance. It is also the style of all aquatic mammalia, and indeed of all vertebrated animals which inhabit the waters ; for those which have no fins of any sort cannot advance with one flexure of the body, but must twine in two or more, eel-fashion, according to their length. The golden-eye is the duck, visiting the British shores, which has this action in greatest perfection ; and the following is the figure of its foot.

But even in the birds last mentioned, progressive motion under water is only an occasional action, and therefore they have it not in the finest style. The grebes which, notwithstanding their merely lobed

feet, and their inhabiting ponds rank with vegetation rather than the ocean or even the larger lakes, are much more aquatic than the golden-eye; and the rate at which they get on under water would not be



Golden Eye.

believed by those who have not actually seen it. It is frog-like, to be sure, from the way in which the feet are worked, and the nearness to which the plane of their action approaches to that of the body, but it more resembles the rush of a bird through the air than the swimming of any ordinary air-inhabitant in the water. Among all the diving birds, from the merganser to the penguin, which, although not the swiftest, perhaps, in the water, is the one which depends most exclusively upon aquatic motion, there is not much difference in the feet, so far as can be shown by a figure. The chief distinctions consist in the legs being placed further backward, and the tarsi being shorter and stouter, the more exclusively that the bird is restricted to the motions of swimming and diving. The joints have also more oblique motion, and there appear to be some peculiar muscles upon

the tarsus, which assist in the curious twisting motions of the feet, which of course increase as the wings become less efficient as organs of support and balance. But the most curious motions of these birds are all performed in the sea, and under water, so that they are rarely seen, and the subject is one upon which it is by no means safe to speculate, as we have not upon land any analogy to which we can trust. The following is a sketch of one of the feet; but we should not be able to illustrate the mode of action, even if we gave ever so accurate a figure of the bird itself.



Diver.

The feet which have been now described, or rather simply noticed, carry their owners down into the depths of the ocean as far as winged creatures can descend; and as the knowledge of them is nearly as dark and downward as the places of their resort, it is rather pleasant to escape from them, and once more visit the sun and the sky, the cheerer and the abode of the more typical birds.

#### ENTIRE WEBBED FEET.

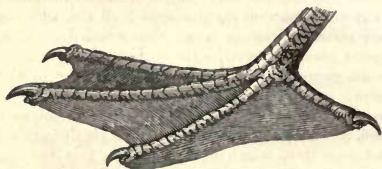
We have, next in order, to notice those feet which are entirely webbed, that is, which have the hind toe included in the web as well as the three front ones. At first, one would be apt to conclude that these, as



being the most webbed, are the most aquatic, or the best swimming feet of the whole. But such is not the case in fact; and when we come to consider the matter a little more closely, we find that such ought not to be the case, according to the structural analogy. The back toe of a bird, whether its path be upon the land or the water, is never an auxiliary to the foot in merely progressive motion; it is always rather the reverse, and placed there in accordance with something else; and thus the produced hind toe, which is rudimental or wanting in all birds which have their motion confined either to the surface of the earth or to the water, indicates an aerial character in this group. Accordingly, the pelicans, cormorants, darters, and several others which have feet of this description, often migrate inland, and perch and also build in trees; and even those which never or rarely quit the sea, build high upon the cliffs, and take their repose upon the land, while some of the swimmers fold their head under their wing and sleep in safety upon the water.

These birds have the feet differently articulated in the different genera; as, for instance, the cormorant has them much farther back than the gannet, and is not able to carry the axis of its body in so horizontal a position. But they all "stand well" on their legs, only the feet, in consequence of that form which is required to answer the habit of the bird in feeding, come rather into contact with each other, and render the walk awkward and swinging. The tarsi are perpendicular, or nearly so; but they are thrown wide of each other by the position of the tibiae; and it is to this wide setting of the tarsi, and not to any want of firmness in the articulation of the toes, that the birds owe their rolling gait when they walk. The foot is nearly a semicircle, or rather a semioctagon of un-

equal sides, of which the outer toe (which is generally very long) and the back one form the largest diameter. This is articulated upon the tarsus, intermediate between the directions of inward and forward, as may be seen in the annexed cut of the foot of the gannet, which, as one of the most active and best known birds of the group, may be taken as the type, in as far as the foot is concerned.



Gannet.

The birds which have this structure of foot are all fishers, and most of them (the gannets especially) dash down almost perpendicularly from great heights upon their prey, and seize it with the bill. The gannet is curiously provided against any injurious effect from these headlong plunges. On the breast and throat of this bird there are three great air-cells between the integuments and the muscles, the two largest divided (but not shut out) from each other by a perforated septum along the keel of the sternum, and tied to the enveloping membrane of the muscles by a number of small straps of membrane; and the smaller one anterior of the furcal bone, and not communicating with the other two, though all the three have communications with the air-cells in the interior of the bird. When the bird dashes down at a fish,

the air in those cells breaks its fall ; acts like a parachute in preventing it from going too deep ; probably invigorates its vital system by the application of a portion of air, condensed by the resistance and cooling effect of the water, to the coats of the arteries ; and, what is more to our present purpose, assists it in recovering its position, in order that it may remount the sky, after it has either caught its prey or failed in doing so. This quantity of air is of course condensed by the collision ; but when that is over it expands and raises the anterior part of the body, and at the same time throws the centre of gravity further backwards, or more in a line with the feet. These at the same time press downward with their curious webs, both brought under the body by the position in which the toes are articulated on the tarsi, and so heave the body upward in the same manner, or at least upon the same principle, that ordinary swimming feet impel the body of a bird forward. Thus, what with the action of the air, and what with that of the feet, the bird is able to regain the wing without any difficulty.

When the proper action of the foot is connected with some action of the wings of the bird, as adapting the foot for some particular kind of surface, or to accomplish some other object in the general economy of the creature, it always lessens the perfection of the organ as a foot, whether for swimming or for walking.

Concentration upon one single part, or upon the smallest number of parts possible, is always the structure of maximum action in nature. We find it in the wing of the swift, in the foot of the ostrich, in the feet of all the swifter running birds, and in the more perfect swimmers ; for though these have the back toe with a marginal lobe, which appears to

answer some purpose in the oblique motions of the foot, just as the bastard wing appears to assist in the oblique motions of the main one, though what the specific motion or assistance which this partially developed part gives in the performance of it, can be found only by a more nice and thorough analysis than has hitherto been applied to the mechanics of animals.

This delightful study is, indeed, as humbling to the pride of human learning as it is gratifying to the spirit of more lowly but more reverential inquiry; and the man who comes to it mailed and cuirassed all over with the forms and the formulæ of the schools, is much in the same predicament as the young Israelite when he put on the armour of the king to combat with the giant Philistine—he is encumbered and oppressed; and if he would hope to conquer, he finds that “the smooth stone from the brook”—that which nature affords to observation, must be the true weapon of his warfare, and all his learning only “the sling,” by means of which it is sent to its destination with the requisite force.

And if they who weary their days under the load of the armour, had not their eyes dimmed and dazzled by its glitter, they would see that such must be the case: that natural action—the action of that which has life—must have a way of its own, according to which, and only according to which, it can be studied. In a machine of human contrivance, not only all the parts, and the precise degree in which each part contributes to the compound effect of the whole, can be determined, but the *motive* power can also be estimated with the greatest accuracy, and the whole can be planned, and what it could or could not accomplish known, before there is one peg of it in existence, and though it never should exist.

In the animal structure we can also examine all the parts, and, comparing them with what they do in one case, we can form an appropriate judgment of what they can do in another. We can say, for instance, of the action of a foot in swimming, that it is a "function" of certain bones, muscles, tendons, and membranes, and other parts, all of which may be *eliminated* by the knife of the dissector. But we do not thus arrive at the specific action of the foot, either in power or in mode, for that is also a "function" of the energy of life in the animal; and so far from being able to express this energy in terms of any known or measurable quantities, we have no expression at all involving it, but that very compound action, the principles of which we seek thus in vain to analyse.

But even this, mortifying as it is to those who labour to appear wise, is fraught with the same advantages and pleasure which are found everywhere in nature. The animal cannot be wholly brought into the closet, so as that the scientific recluse can become fully acquainted with it there, at the sacrifice of much of his health, usefulness, and pleasure. He must go to field and flood, and see the creatures, otherwise he may dream out the years of Methuselah (if the canker of his seclusion shall not eat him up in the twentieth part of that long period), without one moment of awakening to reality and knowledge. Thus, as it were, the coyness of nature is one of her principal fascinations, and he who would secure her favour must woo her as a bride, which, both in the fact and the figure, is the only path in which pleasure and profit are inseparable.

#### FEET OF THE LONGIPENNES.

As birds of this group all depend more on the wing

than the feet for the aquatic part of their food, and as many of them alight on the water chiefly, or exclusively, for the purposes of rest, and not of feeding, they have less of positive character in their feet than the swimming or the diving birds, and less even than those birds which, like the gannet, use the feet in working upward to take the wing. These feet are accordingly less stout in the tarsi, and less produced in the toes and webs, and they are without the oblique motions, and have the toes and webs turned nearly in the direction of the front: the outer and inner of nearly the same length, and the middle one little different. The webs, too, are much narrower in proportion to the length of the toes than in the swimming birds, and the hind toe always very short, sometimes a mere tubercle, or a rudimental nail, but differently placed according to the habit.

These birds can all swim, and most of them ride very buoyant on the water, and they sometimes feed as well as rest there; but as their neck is short, and they do not dive, they command a very limited range of the water when they are on its surface. One principal use of their feet is in alighting and rising from the water, which they do more readily than any other birds. They come down with a twitch, half on the surface, and are on the wing again almost in an instant. In alighting, they advance the feet flat under the body, with the anterior edge of the webs in advance of the centre of gravity; and as the principal joints act parallel to the mesial plane, the least exertion in pushing down the webbed feet, reacting on the centre of gravity, and raising it a little backward as well as upward, throws the bird so clear of the water, that its open wings take the air and it is instantly in the sky. All this is accomplished with-

out occasioning the least splash or disturbance of the water ; whereas those birds which feed on or in that element, and use the wing only in journeying from place to place, always make a splash when they alight, and have some trouble before they get on the wing. The length of the tarsus is the principal character of the foot, by which those of different habits may be distinguished. It is, of course, longest in those which walk most on the ground, whether inland or along the beaches, and gradually shorter in proportion as they are more exclusively occupied in skimming over the surface of the sea.

The gulls have it the longest, but it is slender, and a portion above the tarsal joint is bare of feathers. Their front toes and webs are of moderate length ; but the hind toe is very short, without any web, and articulated higher up than the front ones. The feet are placed considerably forward ; and although there is an obliquity of the tibiæ which throws the tarsal joints a little outwards, the birds walk with less of a rolling motion than any of the swimming birds.

The skuas have the feet nearly of the same form ; but the hinder toe is a mere tubercle, articulated on the same plane with the front toes. They also have the claws considerably hooked, which agrees with the raven-like habit of the birds, which displays itself in eating carrion, and plundering the nests of birds which build in the banks ; and which they have in addition to their peculiar and more characteristic habit of attacking other birds (gulls chiefly) and making them deliver up the contents of their stomachs. The length and crookedness of the claws might lead to the supposition that the skuas, which are very bold birds, use these instruments as hawks do ; but such is not the case, though they may assist the birds in holding-on

upon oily carcasses which they find floating in the sea, or on land carrion, to which they have no objection, if it comes in their way. Some of them also eat crustaceous animals and shelled mollusca; and they may very naturally be supposed to hold these with the claws while they break or divide them with the strong bill. The annexed is the foot of the common species.



Common Skua.

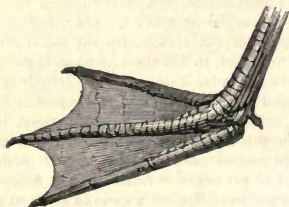
The terns, which have very much the form of the swallow tribe in the body, the wings, and the tail, and also in style of flight, though the bill and the food are different, have the tarsi shorter, and the feet altogether smaller than any others of the group. They at the same time, however, preserve a certain degree of likeness to the gulls, and, like these, many of them are discovered inland upon the fresh waters.

Terns are the birds most peculiarly adapted for twitching small prey out of the water, which they do with wonderful celerity; and their feet, with very short tarsi, and articulated forwards upon the body, enable them to alight and arise in the swift and easy manner formerly alluded to. Their front toes are all nearly of equal length, their hind toe very small, free, and pointing downwards.



The petrels have the feet with the tarsi considerably longer than those of the terns, and generally compressed in the direction of their action. They have three toes to the front, webbed like those of the terns, and a small claw in place of the hind toe. These feet are, like those of the others, only auxiliary to the principal natural action which is performed by the wings, and they are adapted to a different sort of flight. The terns, though not birds of lofty flight, fly moderately high, and catch those substances upon which they feed by twitching down, snapping with the bill, and instantly rising again. The petrels skim along the surface, and pick up the lighter substances without altering their motion. On these occasions they often, but not always, tip the water with the webs of their feet, to aid the motion of the wings, or sometimes to render it unnecessary. The length and compressed form of the tarsi fit them well for this purpose, while their lightness of structure, in proportion to the strength of the muscles by which they are put in motion, enables them to move with great celerity, and yet occasion little fatigue. At the same time, the action of tipping is done in so clean a style, that the water is not disturbed, and the motion of the legs is not seen unless when the observer is very close to the bird. Some of the larger species, which are found on the Antarctic ocean, are nearly of the same dimensions as a wild goose, and yet they will let themselves down, with the wings fully expanded, till the points of their webs touch the surface of the water, and then they will glide along without a movement of the wing till they are lost in the distance. The cut represents the foot of the fulmar petrel, which is very common on the seas to the northward of the British islands.

Such are a few of the leading distinctions in the feet of birds, whether those feet are in themselves the principal organs of motion, or whether they are made use of as auxiliary to other organs; but the parts of a bird act so much in concert, that no one of them can be fully understood without a knowledge of the others.



Fulmar Petrel.

## CHAPTER VIII.

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WINGS AND STERNAL APPARATUS OF BIRDS, AS  
ILLUSTRATIVE OF THEIR HABITS, MORE ESPECIALLY  
THEIR POWER AND STYLE OF FLIGHT.

As wings are the grand characteristic of birds, which especially distinguishes them from all other vertebrated animals, one might naturally suppose that in these organs would be found not only the best means of subdividing them into orders, groups, and genera, but also the best indications of the habits of even particular species. De Blainville was, we believe, the first to suggest such an arrangement ; and an outline was subsequently given by Dr. Lherminier, in the Transactions of the Linnæan Society of Paris, and afterwards in a separate pamphlet, in the year 1828.

There is a great deal of merit in M. Lherminier's little work, the size and science of which are well worthy the attention of all writers upon similar subjects. But still, though a system could unquestionably be founded upon the wings of birds, or even, as the Doctor's is, founded upon the sternal apparatus in the skeleton, as giving insertion and stability to those muscles which perform the grand motions of the wing ; yet that, after all, would be a system of flying, and not a system of birds, because all birds must eat ; and there are no birds so absolutely destitute of feet as some birds are of wings. Notwithstanding, the wings, and especially this part of them, and not

merely the numbers, lengths, and arrangements of the flying feathers, which are almost the only characters usually noticed even by those who profess to write scientifically upon this class of animals, are highly important toward the formation of such a systematic arrangement as shall be of use—that is, which shall direct and shorten the labour of the student who seeks for a knowledge of the characters and uses of these highly interesting creatures.

The mass of the body in birds is, from the inflexibility of the spine, what may be called passive, or rather consenting, in those actions wherein the characters of birds are displayed, as it does not directly perform any of those external operations which are open to observation, though there is no doubt that it is always of that form which gives greatest facility to the more active part of the animal, whether that part be bill, or foot, or wing. To enter minutely into the anatomical structure of a wing, so as to make all its parts intelligible to common readers, would require far more space, and more illustration, than are compatible with the nature and design of this work ; and without a perfect knowledge of the parts, it would of course be impossible to give any idea of their individual action. Then, as to the joint-action of the whole, that is a matter which cannot be expressed. There are twelve distinct moving forces all acting, in one way or other, upon the first, or shoulder-joint of the wing. Those forces are all different in what may be called their structural energy—in the power they derive from their manner of application—in their effect in different positions of the wing—and in their energy from different degrees of excitement in the bird ; so that, when we take those causes of difference, and consider them in all the combinations and changes

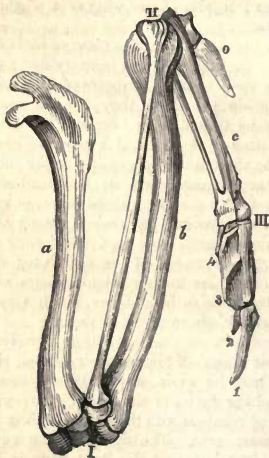
of which they are susceptible, we are within the truth when we say, that, counting from morning to night every day for a thousand years, would be insufficient simply to enumerate all the motions and positions, of which even this joint of one wing of a single bird is susceptible.

Still, in order to be able to observe birds with advantage, as they appear to us in every-day nature, so as to turn them to those purposes of instruction and companionship to which they can so easily and pleasantly be turned, it is necessary to have some general notion of the parts of a wing. These parts, considering them simply according to the substances of which they are composed, are, first, feathers, which being palpable to the eye without much, or even any separation of parts, may be ranked among the mere external appearances, as noticed in a former section; secondly, the substance of the solid wing which is made up: these are the bones and muscles, of which some notice has also been taken, but it may be necessary very briefly to revert to them.

The jer-falcon, to which we have already alluded as the most typical of birds in their general character as flyers, may be again advantageously used as a model, and the figure of the bones of its wing examined in comparison with the corresponding portions of the human arm. The figure on the next page represents the bones of the right wing in half the lineal dimensions of nature.

The position is nearly that of the closed wing; and it can be understood by bringing the elbow against the side, the wrist to the shoulder, and bending down the hand on the fore-arm. The portion marked *a* answers to the humeral part of the human arm, that is, from the shoulder to the elbow, and consists of a

single bone, the humerus. The portion marked *b* answers to the fore-arm or cubit, the part of the arm from the elbow to the wrist. This part consists of two bones, a larger and curved one, the radius, and a



Jer-falcon's wing.

more slender and straighter one, the ulna. The portion marked *c* answers to the hand in man; *o* is the thumb, which in the bird carries the bastard wing; in this wing it is tolerably developed, and consists of two phalanges of bone soldered together, the union of which may be seen at *o*. The metacarpal bones,

answering to the palm of the hand, extend from II, the wrist joint, to III, the knuckle joint; and this also consists of two portions, extending the whole length, and united at both extremities. From the knuckle joint at III to the point at 1, answers to the fingers in the human hand. The fore-finger, from III to 1, consists of two phalanges soldered together. The distal phalanx forms the tip of the wing, and terminates at 1. This phalanx consists of only a single bone. This bone consists of a longer thickened portion, the fore-finger ending at 1, and a shorter, the second finger, ending at 2, with a thinner portion of bone between them. The second phalanx, which is broad and flat, is marked by oblique thickened portions ending at 3 and 4, and answering to the third and fourth fingers, only the whole is one plate of bone, thickened and strengthened by the oblique ridges terminating at 3 and 4, which proceed from a thickened portion continued along the other side.

It will be seen that all the bones in this wing which have moveable joints are very much enlarged at their extremities; and that, with the exception of the joint at the head of the humerus, one part only of which is seen, as the socket in which the shoulder joint moves is not shown in the figure, have their motions chiefly in one direction or plane only.

When the wing is extended, the upper process of the head of the humerus is brought considerably within the centre of motion of the shoulder-joint. To it the tendons of the muscles which raise the wing are attached, and its projection, increased beyond the centre of motion, gives the lever power, by means of which these muscles act. The muscle which depresses the wing, or gives the stroke in flying, has its tendon attached to the under side of the flattened portion of

the head of the humeral bone, farther without the centre of motion than the others are within it, and therefore it acts upon a longer lever of power, and has a shorter lever of resistance to overcome than the muscles which elevate the wing.

All the round bones of the wing are hollow, or tubular, which makes them much lighter than if they had been solid and of the same dimensions, and much stronger and stiffer than if they were solid with the same quantity of bone. But at all places where there is either a muscle or a tendon inserted, the action of which would be upon one side only of the tube, there is a tie, or septum of bone extending from the one side to the other, so that it may throw the strain equally upon both sides of the tube. If this strain is great, these ties are branched, so that they throw it upon a considerable portion of the bone, and as they are ties in the one direction and struts in the cross one, and all gradually run into the bone by heads enlarging in curves, they give the same strength as if the bone were entirely solid throughout. Indeed, for maximum of strength and stiffness, with minimum of weight, these bones are quite a study.

The elbow joint, I, is very beautifully constructed. It is a sort of triple hinge; and when the humerus and radius are brought into the same line in the stretching of the wing, the processes, as may be seen from their form, stop it from having the least flexure in the other direction, while the head of the ulna comes over the centre, between the double processes of the two principal bones, and wedges it against all bending upwards, something in the same manner as the keystone of an arch.

The wrist-joint at II, is also both very peculiar



and very firm. It admits of extension till the metacarpal bones (the whole hand in fact) be nearly in the same line with the fore-arm, but beyond this it cannot be stretched without breaking the wing ; and here the other end of the ulna, together with the bones of the thumb, offer the same resistance against bending in the wrong direction that is offered by the elbow-joint.

The knuckle-joint, III, has little or no motion in any direction ; and it rather gives a little elasticity to the bone, which is very hard and firm in its texture, than answers any other purpose ; but, though very light, this portion of the wing is, from the way in which the thickened parts are placed, actually stronger in rapid motion than if it were all as thick as these.

The form of all the bones, indeed, is such as to give them the maximum both of stiffness and of strength. The humerus, which is the only single bone, is very strong, both from its shape and from the cross pieces inside the tube opposite to the insertions of the muscles and tendons ; and even these are additional means of support. This bone, too, is so near the centre of motion, that the resistance of the air acts much less powerfully upon it than upon the others. The fore-arm, having to sustain the broadest part of the wing, is very strong : indeed it is the strongest form which, combined with the same lightness, could be given ; and lightness is as essential as firmness in all the parts of a wing, because weight would be a source both of weakness and fatigue. The radius, or larger bone, has the form of a bow, and the smaller one, the ulna, that of a bow-string ; and any one who places the tips or horns of a bent bow on the ground, and tries to crush it by pressing down the middle of the bend, will find it

much stiffer and stronger than a straight stick of twice the thickness. A very portable bridge is often made upon this principle, of a thin plank, bent into the form of a bow by a cord tied to the two ends; and when tied in this manner, a plank which a man can carry without fatigue, will enable him to cross with safety a chasm ten or twelve feet wide.

But the bow and the bridge are very imperfect pieces of mechanism, as compared with this portion of the wing. They are strong in one direction only; that is, when the strain or pressure is upon the outside of the bend, and this is in them the position of least stability. If its position is reversed, the bow bridge is weaker than a straight plank by the whole extent to which it is bent, as the string offers no resistance to further bending. But it will be seen, on looking back at the figure, that the radius, which answers to the bow, is one of very curious curvature. Though less in diameter at the middle than toward the ends, it has its stiffness there greatly increased by being not only straight, but a very little bent the other way. This against a single strain would give it the same strength as a bow has by being thicker, and consequently bending less toward the middle than toward the ends. But the bone has to bear strains and twists in all directions; and therefore, though the double curvature cannot be shown in a figure, it will be found, upon examination of the bone itself, that some part of it is a bow in what direction soever it is turned. The ulna is also both a tie and a strut, and resists equally the drawing asunder and the pressing together of the ends of the larger bone. It is nearly straight, which is the form of greatest strength against both of these; and it is spindle-shaped, or thickened toward the middle of its length, which is the form of greatest

stiffness. But we must not proceed much farther in the consideration of this exquisite piece of mechanism :—it would not only afford study for years, but remain in great part an unexplained wonder after we had exercised the longest life upon it.

But, admirable as is the structure of this moving part of the wing, it would fail in producing its office if the point to which it is attached, and the organs by which it is moved, did not partake of the same character : for without this it would be like a well-made tool or a powerful weapon placed in an unskilful hand.

The sternum is the grand bone upon which the articulation of the wing at the shoulder-joint, and the muscles which move that joint, are founded; and therefore, the general power of every wing may be judged of more from that bone than from any other single part.

But, in order to have a clear understanding of the relative power of wings, it is necessary to examine carefully all the bones which support the point to which the wing is articulated, or which afford insertion to the muscles by which it is moved. It has been already mentioned, in the general notice of the structure of birds, that the three bones which support that point are the coracoid, the scapula, and the branch of the furcal. The articulation is more immediately upon the coracoid, though the shallow socket in which the head of the humerus plays, is often in part formed by the scapula, with the arm of the furcal bones against the other two on the inside, beyond the socket, and as far as their extremities ; and immediately behind the head of the coracoid, to the outside of which the scapula is applied, there is a foramen or hole, which serves as a pulley, through which the tendons of the muscles that raise the wing pass. The

firmness with which these three bones are united to each other is always in proportion to the power of flight in the bird. In no bird of powerful wing can any of them be dislocated from the other two without fracture; and in old eagles and hawks, the portion of cartilaginous matter by which they are united passes so completely into bone, though bone which remains a little flexible, that they cannot be detached from each other by maceration in water.

It is worthy of remark, as affording a beautiful instance of that provision of nature by means of which the vital parts of animals are always protected from injury even in their most violent actions, if those actions are natural, or essential to the accomplishment of those purposes which their Creator has ordained them to accomplish, that the anterior extremities of no vertebrated animal are articulated upon the spinal column. This is very remarkably the case in birds of powerful wing.

In mammalia, the articulation of the humerus is always upon the scapula only; they want the coracoid bones entirely, and in those species which use the fore legs only in walking, the clavicles are wanting. Even in those species, as in the quadrumana, which have the clavicles most perfectly developed, the office of these bones is secondary, chiefly that of keeping the shoulder-joints apart from each other, so that the animals may stretch their fore-legs, or arms, at right angles to the mesial plane of the body, and not use them parallel to that plane only, as is the case with those mammalia which employ the fore legs only in walking.

In the mammalia, the scapular bone is flattened and extended to the shape of a triangular plate, and it is furnished with a spine, or elevated keel of bone,

to each side of which there are muscles attached, which move the bone backwards or forwards, according as is necessary to the action of the other parts of the limb. But in birds the scapula is never furnished with a ridge or keel of this description ; and it is most developed and enlarged at the end farthest from the joint in those birds which make the nearest approach to the quadruped action of the mammalia,—as for instance, in the penguins, which use the wings and the feet, with nearly equal energy, as they make their way under water. In those land-birds, such as the ostrich, which cannot raise the wings, but use them only for balancing the body as they run, the scapulæ are less developed ; but even in them, they are more so than in the birds of the most powerful flight. These birds have not the clavicles united in front into a regular arch, as in powerfully-winged birds, or even into a fork with the branches nearly straight, as in the gallinidæ and other bad fliers ; and in some of the species they are little else than mere processes on the anterior edges of the coracoid bones.

In no case, however, of these short-winged birds are the coracoid bones, which connect the scapulars with the anterior part of the sternum, wanting : and in no case, even of those of most vigorous flight, in which the furcal bone is the most developed, are the humeral bones of the wings articulated directly upon that bone.

It is here, that we find one of those strikingly distinctive characters from which we can at once pronounce a bird to be a bird, whether it has or has not the power of flight ; and here, that we are enabled to see which is the characteristic bone in this part of the skeleton which is possessed by birds and never by mammalia. On this point it would be unjust not to

acknowledge the merit due to the science and the sagacity of Cuvier. Before his time, those who treated of the structures of animals, and of the structural differences of the several classes of vertebrated ones, were somewhat at a loss which to consider as the additional bone in birds, and which as the true clavicle; and the furcal bone, as being the most anterior one, and the least connected with the sternum, was generally considered as the additional one, and the coracoid bones, which have nearly the same relative position with regard to the sternum, as the clavicles of mammalia, as the true clavicles of birds.

But when we examine, with due attention, the skeletons of all birds, whether capable or not capable of flight, and if capable, whether they fly with more or less power, we find that the coracoid is the true distinguishing bone of the winged race—the bone which connects the anterior extremities with the sternum as their grand support; and that the furcal bone is more or less perfect, or present, or wanting, according to the difference of habit, as in the mammalia—we must admit, with the illustrious author of the *Regne Animal*, that that bone is really the clavicle; and that the coracoid bone is just as essential to the existence of a bird as the scapular bone is to that of the mammalia. The humerus of the wing in birds is as constantly articulated (that is, *chiefly* articulated) upon the coracoid as the fore leg of the mammalia is articulated upon the shoulder-bone, or blade-bone; and the furcal bone is entire in the one class when the joints of the shoulders require to be kept asunder, and imperfect when they do not, just as it is in the other.

Thus, in birds, we have the wing as uniformly referred to the sternum, by means of the coracoid, as

we have the fore-leg referred to the muscles of the shoulder and the spinous processes by which they are supported in the mammalia ; and though both are so placed that neither the one nor the other directly disturbs the vertebral column, so as to derange its important contents, yet they are very beautifully arranged so as to suit the different systematic habits of the animals. In the mammalia, an action of the thorax in heaving and falling is required, in order to carry on the process of breathing by means of lungs and a moveable diaphragm exclusively; and therefore neither the weight of the anterior part of the body, nor the motion of the fore-legs, could be, in them, supported from the sternum, without confining and disturbing that action. Thus the mammalia, when they bear the weight on the fore-legs, have the thorax free as it were, and suspended upon these fore-legs as props, the muscles and other soft parts, which attach the scapular bone to the body, affording an elastic support, similar but superior to that of the springs upon which the body of a carriage is hung.

Birds, on the contrary, never have any support, except by the feet, upon substances which are not in themselves elastic, as the air or the water, and thus the anterior part of their bodies is carried on the sternum, as a basket or boat, that bone being always more produced and developed in proportion as the weight of the body is borne more upon it. If the bearing is chiefly upon the wing, then the strength of the sternum is concentrated forwards ; but if upon the under surface of the body, as in the swimming birds, then the sternum is produced backwards, or has more of a boat shape. In birds that fly little, the sternum is weak ; and in those which cannot fly it is short, that it may be out of the way of the more

vigorous action of the legs which is required in them. In both, and more especially in the latter, it serves more as a breast-plate or buckler for supporting the anterior part of the body, by reference to the spinal column, and by means of that to the legs, than as the ultimate fulcrum of any sort of motion ; and in these birds the scapular bones, by means of which the anterior part of the sternum is supported, or rather by means of which it is suspended, are more produced, and have their forms better adapted for a firm imbedment among the muscles of the back, than in habitual flyers. So marked does this character become, that in the ostrich tribe, which, as they do not require the furcal bone to keep the heads of the scapulars asunder, have it only in two rudimental processes, the coracoids and scapulars have much the character and office of two hooks, which, taking hold by means of their imbedment in the flesh, bear up the anterior part of the sternum.

This enlarged and basket or boat-shaped sternum, together with the coracoid bones, are therefore to be regarded as the most typical part not only of the skeleton of birds, but of their whole organisation. The form of the sternum varies much with the habits of the different species ; but it is, in all cases, the characteristic sternum of a bird, and in no species, which has been examined, has it been found without coracoids, though in those species where these do little else than suspend the sternum they are united into nearly one continued flat piece with the scapulars.

It is to be regretted that, hitherto, there has been no opportunity of completing this part of the series by examining the sternal apparatus of the apteryx, which, as the most wingless of the class, and as being, from the structure of its feet, a bird of slow motion,



must be the one which has the sternal apparatus most exclusively formed for the support of the anterior part of the body only. Thus in it we should have a real analysis of this most characteristic part of the structure of birds, not by mere dissection, where we are left to guess at the use of the organ from its form and its connexion with other organs, but actually in the living bird. By this means we should be able to separate the two functions of the sternal apparatus—the simple and more general, which supports the body of the animal, and the more complicated and variable, which relates to the operation of flying.

## STERNA OF WINGLESS BIRDS.

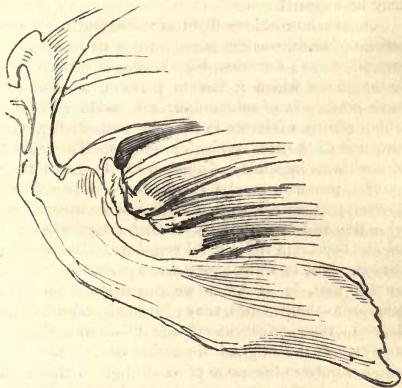
Wingless, though the epithet commonly given to those birds that are incapable of flight, is not accurate. There is no bird absolutely wingless, even though it should have the bones of the wing wholly within the integuments. When we reflect a little on the matter, we find that such might be expected. A wing is an organ of flight, and the performing of that operation is the chief apparent use of the wing. But the wing is also, independently of its action in flying, an integrant part of the structure of a bird—a part which the bird has, whether it be in motion or at rest. Now, it should always be borne in mind, that an animal is a perfect structure, and that all its parts are in concert, whether it be in a state of action or in a state of repose. One part does not, therefore, merely bear up, or move the other, as in the case of our structures and machines. In our moving structures we have to apply some *external power* to put the structure in motion, after all its parts are completed; but the motive force of the animal is *internal*, and we cannot locate it to one part of the

organisation. The animal has, therefore, the whole of its structure *consenting*, and not merely consenting, but *co-operating* in all its actions and all its positions of repose; and it should seem that the posterior extremities of a bird are incapable of supporting the body, so as to make it stable when borne forward in rapid progressive motion, and especially in turning, without the addition of rudimental wings. Thus there is, at least, a harmony and reciprocal action in the parts of the bird, so that while the one assists the other in its operations, it receives assistance in return: as in this instance, the shoulder-joint supports the wing, and the articulation of the wing is necessary to the perfection of the shoulder-joint. This mutual or reciprocal assistance of the parts of an animal to each other is one of the most remarkable points of difference between the mechanics of the living body and of dead matter, and it is one of which we should never lose sight, when we speculate about the former.

We have no practical knowledge of a bird with a perfectly immoveable wing, but we have a very near approximation in the emu, which, although a long-legged and swift-footed bird, has its covering, and probably also its food, much more analogous to that of the apteryx than the true ostriches have; and it is curious also that the two, the one in Australia and the other in New Zealand, are more nearly neighbours, and inhabit climates which are much more nearly similar than those inhabited by the others. On this account we shall, before proceeding to take a very short glance at the comparative structures of the sterna of some of the more remarkable flying birds with reference to their powers of flight, notice that of the emu, as being nearly confined to the supporting of the anterior part of the body.

This sternum is oval, without any keel, and bears some resemblance to the breast-plate of a tortoise ; and the coracoids, whose principal use is to support the bone, and preserve the form of the anterior part of the chest against the weight of the bird, the presence of the atmosphere, and casualties, without having any direct strain to bear when the bird is in motion, are short, broad, and flat.

The following figure is a side view of this sternal apparatus.



The outline of the sternum of this bird is, it will be seen, very convex, with merely a trace of a keel at the anterior part, near the junction of the coracoids. The ribs are articulated far forward, and they are

much thicker and stronger than in flying birds. There is not, upon this bony structure, any place where muscles capable of giving motion to a wing could be inserted. The strong articulation by the coracoids and the ribs, and the length of the scapulars which suspend the former, enable this form of bone, however, to give the most efficient support to the body, as a basket in which the thoracic viscera are carried ; and its convex form renders it a most efficient breast-plate against any external injury to which the bird may be exposed.

Those who consider flight as the essential characteristic of birds, sometimes regard this structure as an imperfect one ; but when we examine it with regard to the offices which it has to perform, we find the same perfection of adaptation in it as in that form which affords a fulcrum to the most active wing, and insertion to the most powerful muscles. The species of land birds incapable of flight are so few, and their natural pastures on the earth so peculiar and so limited, that we can with difficulty so connect them with the rest of nature as to understand the part which they act in the general economy. But though they are thus, in a great measure, a sealed book to us, we find that, in as far as we can study them with relation to their haunts, they afford as irresistible evidence of that perfect knowledge of all the circumstances, at the original formation of the creature, which inscribes the name of God upon all that God has made, in characters so plain that he who runs may read, as any other race that can be named. The ostrich on the African karoo, the crested cassouary in India, the hea among the tall herbage of the American pampas, the emu on the "hummocky" plains of Australia, and (as we have reason to suppose) the apteryx

by the shingly bases of the New Zealand cliffs, are all as much in harmony with the scenes in which we find them, as the parrot is with the perennial bloom of the tropical forest, or the albatross or the petrel is with the expanse of the world of waters. Wings are not wanted upon extended flats of firm surface ; they are for the "ups and downs" of feeding grounds ; and, therefore, those birds to which wings would be an incumbrance have them not, but in their stead organisations better suited to their haunts.

## STERNA OF WINGED BIRDS.

In considering the sterna of birds as indices to their different powers of flight, the elevated crest or keel is certainly the most important ; while of the other bones which form part of the sternal apparatus, the most important is the clavicle, for as we have seen, the coracoid bones are constant, not very much dependent on the rate or style of flight, and the scapulars, though of weaker structure, and less fitted for bearing cross strains, are often more developed in birds which fly heavily than in those which fly well.

But still the form and consistency of the sternal bone itself, independently of its ridge or its appendages, vary considerably in birds of different powers of wing. The firmer the sternum is, that is, the more completely that it consists of one plate of bone, without apertures, and with the different pieces in which ossification begins in the young birds, united by bone, the bird flies the better and the more powerfully ; and of course, in proportion as the sternum is deficient in those qualities, the flight of the bird is less elevated and less capable of being continued. If the sternum, besides being of solid bone, is of

considerable breadth, and curved in its section as well as in the principal line of its crest, the bird is one of the most powerful wing, and whether its chief exercise be in long flight, or very rapid flight of shorter continuance, depends a good deal on the number, form, and arrangement of the feathers. Generally speaking, however, birds which do not require the violent rush of the accipitres, have the sternum straighter and narrower, though a little longer in proportion. Sterna which are very broad, with the crest low, always indicate bad fliers. Here, however, the adaptation of the sternum for flight, begins to be combined with that for swimming; and, as those two habits occur in many proportions with regard to each other, it is not very easy to frame such a general description of the bone as will apply to all or even half the varieties. When birds of this description come to have the two motions of the wings, the flying one in the air, and the swimming one under water, the form of the external part of the wing is adapted to the one or the other, according to the habit, while the form of the sternum itself remains nearly the same.

#### STERNAL MUSCLES.

In order that the action of the wings of birds and the influence which the different modifications of the sternal bones have in that action, may be more clearly understood, it is necessary to say a little more respecting the muscles by which the wings are moved than the mere enumeration which was given in a former chapter. This may have somewhat the appearance of repetition; but, in treating of complex structures, so much of repetition as shall keep the several parts constantly in the reader's view is not only

excusable but necessary ; and when the object is to communicate information, that is not the very best taste which sacrifices perspicuity to mere nicety, and plainness of expression to what is (often very falsely) considered elegance of style.

The first set of muscles are those which have their insertion in the sternum, the coracoid bone, and the clavicle, and their tendons attached to the humerus ; and these are the muscles which perform the grand operation of working the wing. They are four in number.

The first, the great pectoral muscle, is situated externally toward the anterior part of the sternum, where it has the freest action. It is inserted on the keel and body of the sternum, on the side of the coracoid, and also on that of the clavicle ; and its tendon, which is particularly strong and firmly united by a large extent of surface, is attached to the extended crest of the humerus on the lower side. When this muscle contracts, it bends down the humerus on the shoulder-joint ; but as it is inserted in all the bones by which that joint is supported, the very same action which bends down the humerus on the joint, tends to push the joint upwards, which not only renders the effect of the pulling of the tendon more steady, but actually increases its force. This is the grand muscle in flying, and it is impossible to imagine an organ better situated or altogether better adapted for its purpose than it is in birds of powerful flight.

Immediately under this there is situated the middle pectoral muscle, which is the antagonist of the former. This muscle lies in the angle formed by the keel and body of the sternum, and is attached also to the coracoid, and partly to the clavicle on the angle of its inner side. It passes under the coracoid, and the tendon in which it terminates, passes through a hole

which is formed by the uniting of the coracoid, the clavicle, and the scapular, and returning outwards, is attached, by an extended termination, on the upper side of the crest of the humerus, rather inward of the centre of motion of the shoulder-joint. This is the principal muscle employed in raising the wing; and the mode of its action is a little curious. Its insertion is nearly the same as that of its antagonist, the great pectoral muscle; and when it acts, it tends to raise and keep steady the centre of motion in the shoulder-joint, just as that does; but as its tendon passes through the pulley, or foramen, above-mentioned, its power to produce motion is reversed, and though similarly inserted, and as a muscle acting in the very same way, it produces exactly the opposite effect upon the humerus. The tendon which passes through the pulley is such that, besides having additional firmness from its structure, the upper part of it acts as a more powerful lever in the raising of the wing.

The action of these two muscles, which are the most important ones in the operation of flying, is one of the most beautiful in the whole range of animal mechanics, wide and varied as it is. The great pectoral which, by depressing the wing, gives the stroke, and therefore performs the most essential operation in flying, is the most free in its action, as it is pressed by the integuments only. It also pulls the wing downwards with the greatest advantage, as its tendon goes directly to the lower part of the humerus without the joint. Its antagonist, which raises the wing, does it by the reversed action of the tendon passing through the pulley; but it acts more rapidly, and it has the same tendency to support the centre of motion as the other: and though there must be some



of the power lost by the reversing of the tendon, that is more than compensated by the steadiness given to the joint, and the increased rapidity of the upward motion. That motion is also greatly facilitated by the structure of the feathered part of the wing, which is so formed that while it takes the greatest hold possible on the air when striking downwards, it takes the least possible in rising upwards.

Immediately above the mean pectoral muscle, there is a third and much smaller one, which is most conspicuous in those birds which get suddenly on the wing from the ground. Its tendon also passes through the pulley, and is attached to the upper part of the head of the humerus. Its office is to assist the middle pectoral in raising the wing.

The fourth and last of this group is the small pectoral muscle, which is inserted on the sternum to the rear of the others, and also partially to the upper and exterior edge of the coracoid. Its tendon is attached to a tubercle on the lower part of the head of the humerus, and its office is two-fold,—when the muscles which are more immediately employed in moving the wing during flight, are not in action, this muscle draws the humeral part of the wing toward the body by a peculiar twist of the shoulder-joint; and when they are in action, it exerts a sort of twisting influence, by means of which the posterior edge of the wing is prevented from turning upwards, and a sort of rotatory motion is produced, which has considerable influence in the ascent or descent of the bird, and also in the altering of its course while on the wing.

The articulation of the wing with the coracoid is a very peculiar kind of joint. It is not a hinge joint, neither is it a ball and socket, but something interme-

diate between the two, and partaking of the properties of both. The average line, or axis, of its motion is oblique, elevated to the front, and depressed to the rear, but both the principal head of the humerus and the socket have their outlines curved, so that the wing may be advanced or drawn backward at the same time that it is elevated or depressed, and by some of the muscles acting more and some less, all the motions of the shoulder-joint, which are requisite both for the action of flight and the direction of that action, are performed. The double head of the humerus, which may be understood by looking back to the wing of the jer-falcon, or forward to the sternal portion of the skeleton of the golden eagle, assists very materially in both the direct and the oblique motions of this joint. In proportion as the action of the wing is more powerful, the crest of the humerus, that is, the process or portion of the head which is toward the convex side of the bone, or that which is most in advance when the bone is in its natural position, is more produced. It is more so in the humerus of the jer-falcon than perhaps in that of any other bird, and more so in the falcons which prey on the wing than in any other genus of birds.

The second set of muscles in the wing are those which are inserted on the coracoid, and attached to the humerus and the radius. There are two of them attached by a common tendon to the external part of the extremity of the coracoid, near the glenoid cavity, but below it. The coraco-brachial is attached to the crest of the humerus, and acts as the antagonist of the third pectoral, and extends the humerus from the body. The biceps is attached to the radius, and extends the fore-arm or great medial portion of the wing.

There is only one single muscle inserted in both the shoulder-bone and the coracoid. It has its insertion in the lower side of the shoulder-bone and the upper edge of the coracoid, and its tendon is inserted in the head of the humerus, on the lower side, by the edge of the insertion of the smaller pectoral muscle. Its office is to close the wing toward the body, but it of course acts only on the humeral portion.

The next set of muscles are those which are attached to the scapula or shoulder-bone only, and act between that bone and either the humeral or the radial portion of the wing. They are three in number. The first is attached to a greater or smaller portion of the external edge of the scapular bone, sometimes in two separate fasciculi of fibres, and sometimes with the two fasciculi united by a tendinous septum. When the latter is the case, it is inserted by one tendon in the posterior edge of the humerus, below the cavity; and in the former, by a tendon and a fasciculus of muscular fibres to nearly the same point. The use of this muscle is to draw the humerus toward the body of the bird, and at the same time to raise it upwards. The second of these muscles is inserted by a very strong tendon to the glenoid cavity, and it is attached to the humerus. Its office is to draw the wing toward the body, and raise it, and also to extend the fore-arm, or radial joint of the wing. The third of these muscles is a long and slender fasciculus, which, originating in the lower and exterior part of the scapular bone, behind the last-mentioned one, is attached to the scapula, and appears chiefly an auxiliary to the former.

There are two muscles originating in the scapula, the clavicle and the coracoid, which chiefly assist in

elevating the wing, or in advancing it, or bending it to the rear, when the bird is in flight. But the actions of these secondary muscles, which are efficient chiefly in altering the direction of the birds in flight, upward, downward, or laterally, cannot be fully explained without more space, and more illustrative figures, than are compatible with the nature, and indeed the purpose, of this brief sketch. The whole of the muscular actions of a wing form a very extensive as well as a very nice subject for study, and one which can be very imperfectly comprehended even by those who devote their whole time and their best attention to it. The reason is obvious: the actions of the numerous muscles of the wing are so combined with each other, and the action of the one modifies that of the other so much, that the most minute definition, and the most careful study, are incapable of informing us how the wing acts in all its varied motions; so that the utmost which, in the present state of science, we can expect to obtain, is a very rude and imperfect estimate of the relative powers of wings, derived fully as much from what we see them performing in the living bird, as from any thing apparently more scientific (and it is mere appearance rather than reality) which we find in dissecting the dead one.

In giving a few examples of the form of the sternum, and its apparatus, the coracoids, the clavicle, and the scapulars, as illustrative of the power of flight in birds, we shall not attempt to follow even the outline of a system proposed by M. Lherminier, because that is incomplete, as treating of the sternal apparatus with reference to flight only, and not combining the general character of the class, the support which the body receives from the sternal bones, altogether independent of power of flight; and also because, though

very ingenious and scientific so far as it goes, the sketch which he gives is not perfectly satisfactory, even in so far as the mere action of flying is concerned. The sternum and the sternal apparatus, whether of bones or of muscles, are not the whole organs of flight, we have still to take into account the bones and muscles of the wing, and the character of the feathers with which that wing is furnished; and even if we were put fully in possession of these, there still remains the accordance of the other structures of the bird with the entire wing, as relates to the style of flight, and also to those other actions of the bird with which the flight is always in accordance. In consequence of these difficulties, which volumes of writing would not explain away, we must content ourselves with a few short notices of the sternal apparatus of the leading division of birds, as formed on the usual mixed characters.

## STERNA OF THE ACCIPITRES.

In this class, the sternum is firm, though the thicker parts of it are full of air-cells, more especially the enlarged base of the keel, which passes, by a gradual curvature, into the surface of the sides of the sternum, without any corresponding cavity on the upper side, or side toward the interior of the bird. Its form is nearly that of a parallelogram, with the length exceeding the breadth, concave on the upper side, and convex on the under. The keel generally large and elevated, but always lower the broader the sternum is in proportion to its length. The anterior margin of the keel is concave, and the under one convex: the anterior angle sometimes even with the anterior part of the bone, and sometimes in advance of it, with the edge thickened, as if it con-

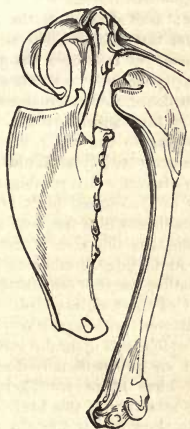
sisted of two pieces united together; the keel much higher in the anterior and middle parts than at the posterior extremities. The sides are a little concave, and the ribs vary from five to seven; the posterior edge generally nearly straight, with a lateral hole in each angle, but these are often nearly, and sometimes wholly, obliterated by bone. There is not, even in young stages of the more typical birds, any appearance of distinct bones forming the sternum, as there are in birds of some other orders, though the process of ossification begins at several points, and proceeds regularly till completed.

The coracoids are shorter than the sternum, but very strongly formed, and their internal angles, where they are attached to the sternum, often meet each other. The clavicle forms a complete arch, more or less depressed toward the centre, having its depth placed in the direction of the strain; of nearly equal strength throughout its length in the falcons, which are the birds of most rapid and continuous flight, but diminished toward the middle in most of the others; and firmly united at both extremities to the scapulars and the coracoids.

The scapulars are a little longer than the sides of the sternum, oval in their section, slightly curved, pointed at their extremities, and firmly united with the coracoids and clavicle at the angle of the shoulder, a little above the articulation of the humerus, to which they afford a very firm point of support, and to the tendon of whose elevating muscle they furnish a very perfect pulley.

We have given in the following cut a profile of the sternum of the golden eagle, as about the average of the order, and we add the humerus, to show the relative size of that bone, as well as the enlarged pro-

cesses on both ends, which serve as levers upon which the tendons act in a very powerful wing.



Golden Eagle.

From what has been already said, the different parts of this as well as of the other sterna which are to follow, will it is hoped be understood without the somewhat clumsy expedient of letters of reference.

This is the average type of the sternal apparatus of the diurnal birds of prey, to which some are superior and some inferior. The most perfectly formed are the noble hawks or falcons, of which some notion

may be obtained by looking back at the sketch of the most perfect of the whole, the jer-falcon, at page 98. The short-winged hawks, eagles, buzzards, kites, and harriers follow; and after them the fishing eagles, the vultures, and the skuas, which last, though they do not kill game, yet rush upon the gulls and other birds, which they plunder, with strong and rapid wing. They have, no doubt, their sternal apparatus somewhat modified so as to accord with their webbed feet when they do take to the water, but still they are chiefly and characteristically air-birds.

The secretary falcon, which combines with some of the characters of the diurnal birds of prey some of those of the grallidæ, which frequent not the waters or their margins, has the keel of the sternum less perfect, the posterior edge terminating in a point, and the general outline curved something in the same manner as that of the wingless birds. The clavicle has also an enlarged process at the junction of the two branches, which rests upon the sternum; and the coracoid bones are proportionally much longer than in the typical birds of prey. There is, in short, enough in the structure of this bird (and the habit corresponds) to show that it ought not to be classed with the accipitres; but not enough to bring it properly into any other order or family.

In the nocturnal birds of prey there are also considerable differences in the formation of the sternal apparatus. The snowy and eagle owls, which are more bold and daring than the rest, have the furcal bone more powerfully formed, and the keel of the sternum better developed than in the common owls, which are birds of weak flight, feeding on reptiles and small mammalia, and chiefly in the twilight. But the whole of this division have the skeleton so much



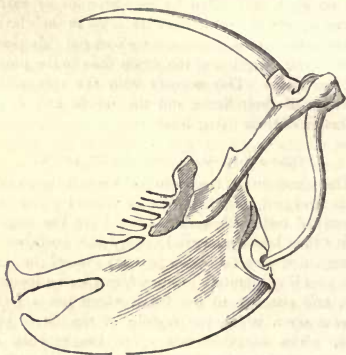
more feeble in all its parts than the diurnal preys that, in a strictly natural system, they ought perhaps to be wholly separated. The common owls have the posterior edge of the sternum with notches, generally two on each side, filled by membranous or cartilaginous matter, and they have the arms of the clavicle or furcal bone straighter, and with its flat side placed more in the direction of the strain than in the diurnal birds of prey. This accords with the comparative slowness of their flight, and the feeble and downy character of their flying feathers.

#### STERNA OF THE OMNIVOROUS BIRDS.

The character of the sternum is much the same in the greater part of those birds which form the otherwise diversified order *Passeres*. They have the sternum longer than broad, enlarged toward the posterior extremity, and with two deep notches toward the sides. The keel is moderately produced, convex on its under side, and concave to the front, which has a forked process upon which the middle of the furcal bone rests. The coracoid bones are longer than the sternum, slightly bent, or couller-shaped, with an enlargement near the shoulder-joints, and narrowed toward the extremities. The clavicle is long and bent downwards at the middle, generally rather narrow, and united to the forked process of the sternum. The scapular bones are long, bent downwards, pointed at the extremities, but with an enlarged process on the under sides near the middle of their length. The following figure of the sternal apparatus of the jackdaw may be taken as nearly the average of birds of this character.

None of the birds which have the sternum formed in this manner capture their prey on the wing, or are

very rapid fliers, though they are all birds of considerable power of flight. They are, however, all, at the same time, birds which are tolerably active on their feet; and the large notches in the sternum,



Jackdaw.

posteriorly towards the sides, enable them to make use of their feet, by the flexure of this part of the sternum, while the average production of the sternal crest or keel admits of tolerably powerful muscles for putting the wings in motion. They are so numerous and so diversified in their habits, that no one type can be properly expressive of them all, but their general character is that of uniting habits on the wing and on the ground in nearly equal proportions; and upon comparing their sternal apparatus with those of the birds of powerful wing and the ground birds, it will

be found to partake of the characters of both. The different powers of wing in these birds are in a great measure dependent upon the form and distribution of the feathers.

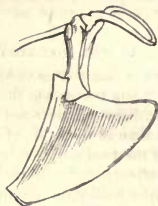
#### STERNA OF THE FISSIROSTRES.

The birds which belong to this order are all feeders on the wing; but upon comparing their sternal apparatus we find more difference between the diurnal and nocturnal feeders than in the birds of prey.

Day-feeders, or the swallow tribe, have the sternum much elongated, often broader toward the rear than the front, and a little hollow on the upper side. The sternal crest or keel very much developed, concave in its front edge, and convex in its under one, with the angle where these meet very pointed. Front edge of the sternum very narrow, with two grooves separated by a ridge of bone. The outlines of the sides concave, generally with five ribs attached to each, but with six in the white-throated swift (*Cypselus collaris*). Posterior edge slightly rounded, concave on the upper side, and entire, or without any holes or notches toward the angles. The figure on next page shows the sternal apparatus of the common swift of the natural size.

This may, among birds which naturally resort to Britain, if not among all birds whatever, be considered as the typical sternum for continued flight, though not for a powerful but more momentary rush. The sternum of the jer-falcon is the typical or most perfect one for the latter purpose, and the difference between it and the one now given may in part be observed by comparing this figure with the sternum in that of the jer-falcon formerly given; and, if the sternum of the golden eagle is also referred to, the

means of judging will be still more complete and satisfactory.



Swift.

The sternum of the falcon is firmer and more developed in the anterior part than either of the other two, but it is shorter, narrower at its posterior edge, not so hollow, and weaker from the holes at the angles. That of the eagle is larger backwards, more concave, and the holes are nearly obliterated, but still the anterior part of it is broadest. That of the swift has the posterior part broadest, and the angles have no holes. Thus in the falcon the whole strength of the sternum is concentrated upon that part on which the grand flying muscles are inserted; and the more perfect arch and uniform strength of the fureal bone harmonise, and render the whole sternal apparatus the most efficient for powerful flight. There is accordingly no bird which has the same desperate rush as the falcon, and that rush is performed almost exclusively by the effort of the wings, and with comparatively little momentum from gravitation. Indeed a force or momentum produced by gravitation would

be a disadvantage to the falcon. She gives chase, and such a momentum would throw her out when her quarry doubles. Thus, though she always attempts to gain and to keep the sky, she never rises to any great height above her prey.

The more produced sternum, and less perfectly formed furcal bone of the eagle, show that her sternal apparatus is not so exclusively, and therefore not so powerfully, of a flying character. The enlargement of the sternum backwards, and the greater strength of the posterior angles, make it more of a carrying basket, though it retains no small portion of the rapid flight character. But strength rather than swiftness is the character of the eagle's wing. The ordinary flight is floating and hovering, and the wings are more employed in bearing her up than in making progressive motion. When she stoops it is always from a height, and no inconsiderable portion of the force with which she strikes arises from the momentum of gravity acquired during the descent. This is further proved by the fact that when the eagle misses her stoop (which, from the goodness of her eye, and the firmness of her body and wing, is not often) she abandons, and takes the sky anew for fresh game; whereas when the falcon misses, she can continue her flight and strike again. The falcon thus more resembles the lightning from the cloud, which produces its effect by its own proper and inherent motion, and the eagle more resembles the ball from a piece of ordnance, which is urged onward by a force not its own.

In the sternum of the swift we have the maximum development of that bone as a carrying basket in the air, but still accompanied with considerable power of wing, though the swift never

rushes, either by its power of flight like the falcon, or by a momentum of gravitation like the eagle. Its sternum bears up the whole under-part of the body, and thus it can remain longer on the wing without fatigue than any other bird with which we are familiar. The rest of the tribe are inferior in this respect to the swift; but they all have the same general character of sternum and the same style of flight.

The coracoids in these birds are short and strong; the clavicle open, but an elliptic arch more than a circular one; the scapulars are shorter than the sternum, nearly straight, rather slender, but enlarged a little toward their terminations, which however are pointed.

Night-feeders, or those which feed only in the dusk or twilight, and rest during the day, have their sternal apparatus considerably different. They have the sternum short, widened in front, concave at the sides, and the general outline to the rear convex, but divided into three processes by two large notches. The keel well developed, concave in front, convex in the lower line anteriorly, but becoming straight or even concave toward the rear. The lateral processes with elevated points. The coracoids round in the middle of the bone, but enlarged at the heads, and with a pointed process on their posterior sides, near their junction with the sternum. The furcal bone open, but slender, and the sides not so much arched as in the swift. Subjoined there is a representation of these bones in the common goat-sucker of the size of nature.

The cuckoo is the bird whose sternal apparatus most resembles that of the goat-sucker; and though the one is a day feeder and the other a night or twilight one, there is a very considerable resemblance in

their styles of flight. They are both tree or copse birds, and they never take very long flights when they are in search of their food; and the sternum, from the deep notches in its posterior edge, is not nearly so well adapted for bearing up the body upon



Goat-sucker.

long flight as that of the swifts and swallows. Here we may remark, by the way, though the assumption which suggests the remark is now exploded, that there is nothing in the sternum of the cuckoo to prevent that bird from setting upon and hatching eggs in the same manner as other birds do. In their ordinary habit these birds neither fly fast nor take long flights; but the ordinary habit of a bird while resident in one locality is not a certain proof to the full extent of what it can do. The cuckoo flies only from copse to copse, or from one tree in the hedge-row to another; and when feeding its motions are even more limited. But both are very light birds in proportion to their size, and their plumage is soft and loose, so that they float in the air with very easy though not rapid wing.

Thus they are able to change their habitat by migration, and appear with us only as summer visitants. In their sterna they bear some resemblance to the owls, with which they also agree in some of their other characters and habits.

#### STERNA OF THE SYNDACTYLI.

The birds belonging to this order are also chiefly dependent on the wing in the finding of their food; but their flight is in general lower than that of the swallows, the prey on which they feed larger, and though not water-birds, or at all capable of swimming, their habits are more aquatic. It is rather a remarkable coincidence with this aquatic habit that the sternum is elongated, and deeply notched in its posterior edge, as in many of the swimming-birds. There is, however, considerable difference between the sternal apparatus of the bee-eater and that of the kingfisher.

That of the kingfisher is more indicative of a power of resisting pressure on the anterior part of the body than of rapidity or even duration of flight; but still it indicates a wing of considerable flying power: the sternum is rather short, and much broader toward the rear than in the anterior part. The keel pretty large, nearly straight in its under edge, and a little concave in front, with the angle advanced a considerable way forward between the coracoid bones. The lateral processes are pointed and produced in front of the junctions of the coracoids. The coracoids are long and strong; and their unions with the sternum are rendered very firm by the projection of the central part of that bone and the lateral processes, which receive and sustain each coracoid as in a fork. The furcal bone is long, open, bent downwards, and much



enlarged at the heads of the branches, which are divided into two processes, one in contact with the coracoid and the blade-bone ; and the other, which is much larger, passing under and bearing up the head of the coracoid. The blade-bones are also large, flattened, sithe-shaped, and pointed at their terminations.

Thus the greatest strength of this sternum is concentrated upon the coracoids, the furcal, and the blade bones ; but when we come to examine the posterior part of it we find it proportionally weaker, so that the keel or origin of the muscles of flight is not so well supported as the shoulder-joint ; and that therefore there is, in the sternum of this bird, an indication of some other action of the fore-part of the body besides that of simple flight.

This agrees well with the habit of the bird, great part of whose food consists of small fishes captured when on the wing ; and thus the bird has not only to resist the contact of the water with the fore-part of its body, but also to regain the sky with little or no assistance from the feet, while the line of the wings is nearly touching the surface. This is a position from which hardly any bird besides the kingfisher has to recover its flight ; for other fishing birds, if we except the eagles and hawks which have that habit, derive assistance either from the bottom, as in the case of the wading birds ; or from the water, as in the case of the gannets, darters, and other birds of that tribe. Even the fishing eagles derive advantage from the water in regaining the sky after their stoop. The points of their wings, and especially their broad and firm tail feathers, assist them in working themselves so far out of the water as that they have it under their wings, and thus are able to use these for flight. The

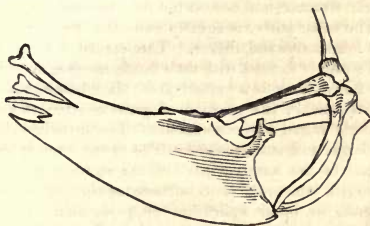
twitch which the common kingfisher makes downward upon its prey is performed so rapidly as not to be easily seen ; but it is probable that not only the long bill, but also the head and neck, are plunged into the water, and they are again recovered with equal swiftness, and without materially disturbing the surface ; so that this bird requires a very peculiar action of the wing, though it is an action very difficult of explanation. The following figure represents the sternum of the common kingfisher of the natural size.



Kingfisher.

It is found, by examining it in plan, that this sternum is much wider posteriorly than toward the front ; but that it is much weakened there, in consequence of the two notches upon each side, the external ones of which divide it to nearly a third part of its length. The difference between this sternum and that of a bird of nearly similar haunt and some similarity of habit, will appear by contrasting the preceding figure with the following one, which re-

presents, of the size of nature, the sternum of the common bee-eater.



Bee-eater.

This sternum, as will be seen, has some resemblance in shape to that of the swift, only the posterior part of it is rendered much weaker than in that bird by the two very deep notches on each side; the processes that separate which are, with the exception of the middle one which is strengthened by the keel, thin and flexible, though they are widened at their terminations so as to make the posterior line of the sternum nearly a continued curve. The keel is very large, extending the whole length of the sternum, long as it is, and very much curved, both on its ridge, and at its junction to the rest of the sternum. It is indeed, an exceedingly strong bone, and at the same time a very light one; and if the profile is examined, it will be found that the power of supporting muscles of flight is not diminished by the notches in the sides; for if a straight line is drawn from the anterior process at the insertion of the coracoid to the posterior termination of the keel, it will be seen that this line passes entirely over the solid bone, and that the two

processes formed laterally by the notches are not very dissimilar in their situation to false ribs only inserted on the sternum, and not on the spinal column.

The other parts are equally well fitted for powerful and long-continued flights. The coracoids are long and strongly formed, with their heads much enlarged ; the furcal bone is a perfect arch, placed, like that of the falcons, in the position of greatest strength and strongly united to the coracoids. The scapulars also are large and sithe-shaped. The furcal bone is not united to the anterior part of the sternum, though there is a bifurcated process there, neither has it any tubercle or other indication of a junction of two branches at the middle, but consists of one unbroken curve of nearly uniform strength throughout.

This sternum is very beautifully adapted to the habits of its owner. It combines great flying power : length for the support of a body habitually on the wing, and flexibility in the posterior angles, by means of which the bird can better thread its way among obstacles. And the birds of this and the analogous genera are all powerful and long-continued in their flight, although none of them are lofty fliers. Feeding chiefly upon winged insects, by the banks of rivers or over other humid surfaces in warm climates where vegetation is luxuriant, they have to pursue their prey among twigs and branches, the pendent festoons of climbing plants, and the tall stems and large leaves of aquatic ones, so that while they pursue on a swift and smooth forward flight, it is also necessary that they should be able to glide and turn in all directions with the utmost freedom. This facility in turning is very necessary to birds which feed upon insects, many of which are themselves carnivorous, and hawk for their prey in the bushes or on the

leaves, and others are to be sought for in the corollas of plants, into which they have plunged for the sake of the sweet juices which accumulate there.

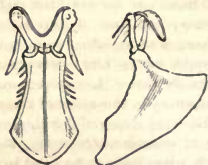
Birds of this family bring us to the margin and surface of the waters, with those races whose habit it is to prey on the wing; but there are still those tribes which feed chiefly by perching on the stems or the twigs of trees, or walking on the ground; and we shall find that, though there are great differences in the sternal apparatus, both of those which have the one habit and those which have the other, according as they combine it more or less with the action of the wings, yet there are characters descriptive of each, that run through the whole.

#### STERNA OF THE ANISODACTYLI.

Some birds included in this order use the wings more and some less, but as they are all more or less walkers on the boles of trees, and other surfaces, on which, from their form, and especially from their position, there can be but little stability arising from the ordinary pressure of gravitation, which is the principal means of stability upon horizontal surfaces, they require to be birds of very ready wing, which can instantly throw themselves upon that part of their organisation, in the event of their claws missing hold. The wing required for this purpose must have muscles of considerable power, and also firm feathers. Such wings have to be used in all positions of the body; sometimes both, and at other times only one of them can act, and they often strike against trees, branches, and other hard substances, so that they require more strength in their whole structure, than wings which are used only in the free air.

Some of these birds also feed on the wing, and

feed on the sweet juice of blossoms, to acquire which there must be much use of the wing before even a little bird can procure a meal. Thus, though the wings of these birds cannot be considered as the most general or immediate of their organs in feeding, they are very essential in some, and in all they are auxiliaries which need to be constantly in readiness. As the wings, even of those species which use them the most in feeding, are not used for long stretches, but merely for flitting about from flower to flower, they all have the character of twitching wings, which take the air by sudden jerks more than of wings of forward flight; but notwithstanding this undulating style of flight, some of them get through the air with much rapidity. We shall select as specimens for illustrating the sternal apparatus of the tribe, one of the humming-birds of the tropical parts of America, which is a feeder on the wing, and the common hoopoe, which is a summer migrant in the warmer parts of Europe, and feeds on the ground or on trees.



Humming Bird.

The sternal apparatus of these very small birds is, as may be seen by the figure, remarkably well developed, though, like that of the swallow tribe, it combines not a little of the character of a carrying basket

with that of an organ upon which to establish the means of powerful flight. It has a considerable resemblance to the sternum of the swift, being long in proportion to its breadth, and considerably broader in the rear than toward the front. In general it is without notches or holes at the posterior angles. The keel is perhaps more developed in proportion to the size of the whole bone than in any other bird; the coracoids are also short and strong; and the scapulars, from the particular way in which they are bent, take a firm hold in their embedment. The form of the furcal bone is also good, though not a perfect arch; but it is proportionally weaker than the other parts of the arrangement.

We may glean something respecting the highly interesting but exceedingly obscure subject of muscular action, from the study of this sternum. It is higher in the keel in proportion than any other, and the height is continued farther backward than in most birds; but the anterior part, where the great muscles of flight are attached, is narrow, narrower in proportion to the height of the keel than in any other known species. Hence, though the muscles admit of a greater number of fasciculi of fibres than if the relative breadths of the side of the sternum and the keel had been different, yet these fibres must be proportionally shorter.

Now, though muscular action is not capable of being estimated with mathematical accuracy, because we have no measure of any action of the living principle, and the very same muscle is capable of many different degrees of action, arising from health, excitement, and various other circumstances which cannot be reduced to a numerical scale; yet as the action is mechanical in its effects, whatever it may be in its

principle, it must follow that the shorter the fibre is the sooner must it be wholly brought into action, and the sooner also must its individual effort be over. All muscular action (as the reader must of course be aware) consists in a contracting or shortening of the fibres, and a proportional increase in thickness. How the shortening takes place is a part of the subject upon which it would not be very wise to offer any conjecture, as it is one upon which we possess no knowledge; but the action itself can be observed, and we may rationally conclude that the times in which equal degrees of excitement are communicated to muscles are in proportion to the lengths of their fibres: that one-half of the length will be brought into action in half the time, and so of all other proportions. This will hold true, whatever may be the absolute length of the time, even though it should be, as it no doubt is in the case of very minute muscles, too short for our being able to measure, or in any way estimate its length in terms of any other motion. But as the shorter muscle must act in the shortest time, so the action of the longer one must be greater, if the requisite time is allowed it—it must contract more, or be capable of moving the same weight over a greater space.

From the indeterminate quantities, which we have no means of separating, or even of expressing, that, as already noticed, enter into the very complex operation of muscular action, what has been now stated can be regarded only as a glimmer in the dark, yet it is far from being without its use, especially in the comparison of structures so varied in their actions, yet all formed on the same general principle, as the wings of birds.

A short muscle will, from what has been said, per-



form its extent of motion more rapidly than a long one ; but it will not move so heavy a member, or move it over the same effective extent at one contraction. Hence we find that birds which rush upon their prey on the wing, have the sternum broader at those parts to which the grand and middle pectoral, which depress and raise the wing in flight, are applied ; that (though its tendon is longer, from passing through the pulley) the body of the middle pectoral is shorter than that of the grand, having a lighter labour to perform, but having to perform it more quickly ; and that birds which have this habit have the wings, and indeed the whole frame, more solid and heavy than other birds. But we find that in those birds which make no rush, but capture their food in the air at the speed of ordinary flight, as in the swallows and bee-eaters, or which flit about, not in chace of their food, but simply in quest of it, as the humming-birds, the sternum is narrowed in these parts so as to adapt it to the action of shorter muscles, without the load of an additional portion of tendon ; and that, in proportion as the habit of these birds requires the action of the wing to be more powerful, the keel is deepened to admit the insertion of a greater number of muscular fibres, or fasciculi.

In birds which fly with equal speed on a level, or an ascent or a descent, the raising of the wing with great rapidity and considerable force is much more necessary than in those which get their most rapid motions upon a descent ; and it is especially necessary in the group of birds under consideration, which always have to hold the wings in readiness for being expanded, while they are adhering by the feet to upright or sloping surfaces. Accordingly, they have the middle pectoral larger in its volume, and also in

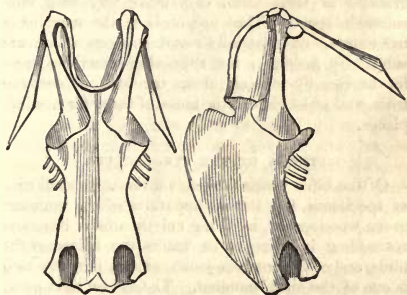
the surface to which its origin is attached, in proportion to the grand pectoral, than birds which have a descent in their rushing motions.

The different style and direction of the flight are not, however, the only circumstances to which the muscles have to be accommodated. The bird requires to be able to make its way through the air the more easily the greater length of time that it spends on the wing, and this easiness of the motion has reference to the respiratory and circulating systems of the bird, as well as to the fatiguing or not fatiguing of the muscles. Now, if we may judge from the analogies, which, as far as we can trace them in all living nature, agree, we must conclude, that, up to a certain rate of speed, the short muscle, moving the comparatively light member, is that which can continue longest in action without fatigue to the muscles, or derangement to any part of the system ; but that, beyond a certain rate of motion, the long muscle is the best for speed, though the continuation of its action is shorter than that of the other. We find this in the limbs of the mammalia, and in the feet of birds, whether used in walking or in swimming, as well as the wing, and the principle is one of considerable importance in the economical use of animal power.

The hoopoe, which we shall select as a specimen of anisodactylic feet, with the habit differing the most from that of the swimming birds, has the tarsi much longer and stronger, and instead of walking with difficulty on the ground, it walks with a sort of strut, as if it had more power there than what is absolutely necessary for moving it along. The following figures represent the sternal apparatus of the natural size.

It will be seen that the general form of the sternum is nearly the same as that of the humming-bird, but

that there are very marked differences in particular places; the keel is lower, but the anterior part of the sternum is better developed; the lateral processes are much larger, and there is a process in front which approaches the furcal bone. The posterior angles are weakened or rendered flexible by two deep notches, and there are only four ribs on each side.



Hoopoe.

Thus the body of the bird is much more yielding than that of the humming-bird, and bears nearly the same relation to it as that of the swift bears to that of the goat-sucker. The anterior part of the keel is much rounded, and the furcal bone is much bent toward the coracoids, though it does not proceed so straight backward as in the parrot tribe. There is, however, a considerable resemblance in the anterior part of the sternum to that of the parrots, while in the posterior part there is a slight approach to the character of the ground birds. The style of their

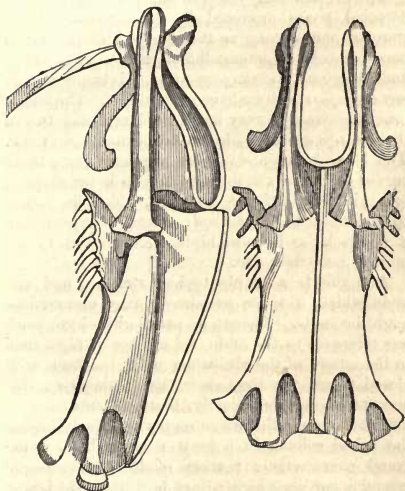
flight corresponds. It is unequal and jerking, performed with much flutter of the wings, as if the down stroke of these were not very effective, which might be inferred from the rounding away of the anterior part of the keel and the feebleness of the furcal bone. But they can raise the wing with great quickness; and, though their flight is far from being so graceful as their form, they make way with considerable speed. They are birds of the margins of the waters, and especially resort to rivers which are subject to flooding; but they also sometimes hunt for beetles by running along the bark of decayed trees, and often choose the holes of these for nestling places.

#### STERNA OF THE ZYGODACTYLLI.

Of the birds which form this division we shall give as specimens, the sternal apparatus of the common green woodpecker, as being chiefly a bank bird, and resembling in some of its habits the anisodactylic birds, and of the common jacko, or grey parrot, which is one of the most scandent. The cut on next page, that of the woodpecker, is of the natural size.

This is a very peculiar sternum; and upon looking back to what is said of the foot, or, far better, by watching the habits of the bird itself, it will be found to be one of very peculiar action. The bird, while it seeks its food in the holes of trees, or excavates them in making a resting hole for its young, rests chiefly with the sternum pressed against the tree; and it will be seen, upon examining the profile, that the bones are fully as much suited for answering this purpose as they are for flight, though the great length of the sternum, and the production of the keel for the whole of that length, though not very high at

any point, still enable the bird to use its wings with considerable effect.



Woodpecker.

The posterior angles of the sternum are divided by two deep notches on each side, the processes between which are enlarged at their extremities, and, except the middle one, padded with cartilaginous discs; they thus protect the flanks of the bird far backward with a strong cuirass, though flexible or elastic at the sides. The continuation of the keel, however, renders

the central part stiff and firm throughout its length, so that it admits of flexure in the flank angles only.

Upon examining the anterior part we find the coracoid bones produced in the direction of the sternum, and as long as that bone ; while the furcal bone is nearly a continuation of the line of the keel, and, though not wide in proportion, it is longer than in any example which we have yet adduced. The lateral processes are also very much produced, and two of the five ribs on each side are articulated upon them. The blade bones are of very peculiar shape, being curved downwards at the terminations in the shape of blunt hooks, as if the coracoids, which lie nearly parallel to the axis of the body, instead of approaching it obliquely, as in most birds, were hooked to the muscles near the spine.

And this is a highly typical sternum, and one upon which, if space permitted, many observations might be made. Though its peculiarities have much less reference to the style and manner of flight than to the action of the bird when upon the bark, with closed wings, yet they show, and perhaps on that account show more clearly, that the sternum of a bird, that organisation which supports the body, having the spinal column in a great measure bare, is the grand characteristic portion of its structure—the essential part by which a bird is distinguished from every other animal—and the basis, as it were, upon which all the rest of its organisation is built, and in accordance with which the whole of the minor parts are formed.

The main office for which the structure of a woodpecker has to be adapted, is that of maintaining with the under part of the body a vertical position on the bark of a tree, in such a manner as to have

the head, the neck, and the spine as far as the lumbar vertebræ (which have a little more motion in this bird than in some others), perfectly free, so that the point of the bill may command the largest possible surface which is compatible with the length of the neck, or move with that force and velocity which are necessary for hewing holes in the wood with the greatest certainty and expedition. For this purpose, the long sternum and coracoids, with the keel and furcal bone on the exterior side of them, form a flat arc with its chord,— the former applied to the tree, so that the fixed point upon which the head and neck move in pecking may be brought nearer to the surface, or moved farther from it, according as may be necessary. If this part (which may be called the base of the bird when in action) had been straight, there would have been more stability in one position, but it would have been only in one, and in that one only when the vertical line of the bark happened to be straight, which is not often the case in those gnarly and decaying trees which afford the fattest pastures for woodpeckers. This, however, would have made the bird work at a disadvantage in excavating a hole to any considerable depth; because, if the position of the centre of action, had been immoveably adjusted to any one distance, the action of the bird would have been less effective at every other. But the arched form of the keel enables the bird to keep the centre of action always adjusted for the maximum effect, and that with so slight a motion of the steady or pectoral part of its body that it can hardly be perceived.

A very little extension of the tarsal joints brings the centre of action more to the tree, and a very little bending of the same joints removes it farther

away. Nor is this ready adaptation of the centre to the greatest effect of the stroke the only result of that action of the tarsal joints by which it is produced ; for there is the same nice adjustment of the degree of hold taken on the bark to the varying stability of the position. When the centre of action is removed to the greatest distance, the centre of gravity is thrown farthest out, in proportion to the line of the axis, and therefore the weight tends more to pull the bird from the bark ; but the very same action of the tarsal joints which produces this, causes the claws to take a firmer hold of the bark, and also the stiff feathers of the tail to bear more against it as a strut. So also, when the centre of action is brought nearer to the tree, and the hold by the foot not so much required, the same extension of the tarsal joint which brings the axis more parallel to the tree eases the clutch of the foot in exactly the same proportion.

Thus, by one of the most beautiful instances of the harmony of parts with each other, the woodpecker is enabled to work with equal stability and effect, while the axis of the body is at all possible angles to the line of the tree, within the range that is necessary for its habit ; and yet the different parts of this very curious and apparently complicated organisation are so flexible to other purposes that the woodpecker can at once become a wing bird or a ground bird, when such a habit is necessary.

When on the tree, the woodpecker may be regarded as consisting of three parts, all differently employed ; the first of these is the sternum and its apparatus, which acts as the basal or pectoral part, and has no motion except in bringing the centre of action to the tree, or removing it to a greater distance ; the second or prehensile part which consists of the posterior

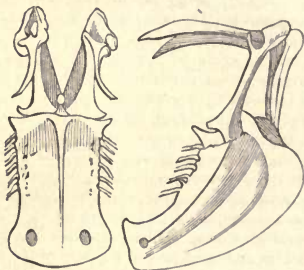


part of the spine and its apparatus, the legs and feet, and the tail; the former of which act as double hooks in holding on, and the latter as a prop or strut; and the third, or immediately acting part, consists of the head and neck, which move with great rapidity without in the least disturbing the other parts. The wings do not come into play, unless when the bird shifts its position laterally, or rises from the tree; but they are, as in the case of all climbing and perching birds, which have much action of the bill when holding on with the feet, always held in readiness, so as to come into action whenever any sudden jerk may require it.

The wryneck, which adheres to the bark of trees something in the same manner as the woodpecker, though its action upon them is different, has the sternum very much of the same structure; only as the wryneck does not hew into the wood of trees, but merely searches the crevices for bark insects, it has a different motion of the head, and the furcal bone differently formed to suit this motion. It cannot strike so forcibly with the bill, or so repeatedly in one place, as the woodpecker; but the wryneck has the joints of that organ remarkably quick and free in their motions, so that when it is searching the crevices, now on the one side now on the other, the well defined mesial line of rich deep brown, which marks the neck and shoulders, appears to be twining up the tree like a little snake.

Zygodactylic birds, which are a very numerous tribe, and the characteristic tree or forest birds of the warmer parts of the world, have many differences of habit, according as they depend more upon flying, walking, or climbing, and according to the nature of their food, and the parts of the trees, or the places

between them, where they seek it. The sternum is of course modified to suit these differences; and thus no one bird can in that respect be considered as typical of the whole order. That of the woodpecker, which we have given, may be perhaps considered as the one extreme, while the following, which is half the lineal dimensions of nature, may be regarded as the other.



Jacko Parrot.

The posterior part of this sternum bears some resemblance to that of the diurnal birds of prey, but the anterior portion and the attached bones are very different. Its relative length is also nearly the same. But all this similarity of the hinder parts of the two sterna merely shows, that parrots and diurnal birds of prey have both a very powerful and firm action in those muscles which move their tarsi or toes, while the different actions depend on the structure of the toes themselves. It is, however, of no inconsiderable importance in facilitating our knowledge of the rela-

tion between structure and use in those parts of birds, even those parts which are not immediately connected with each other, to find that the same quantity and power of motion (however different the object) are accompanied by the same general form of the posterior portion of the sternum; and there is still this other relation between the action of the feet in these otherwise dissimilar tribes of birds, that, though they are both powerful clutchers, the one in killing game, and the other in climbing among twigs, they are both very imperfect walkers on the ground.

When we come to examine the anterior part of the sternum—that on which the character of the flight more immediately depends, we find that, though the wing of the parrot must, from both the depth of the keel and the breadth of the sternum, be a ready wing, yet it must be comparatively feeble and unsteady.

The lower ends of the coracoids do not form an angle of about sixty degrees, with these edges attached to the sternum, as is the case in all the falconidæ of powerful wing; neither are their axes directed toward the strongest part of the keel of the sternum, either when viewed in front or on the side, as those of the falcons are when viewed both ways. Their union with the sternum, though not quite a straight line, is upon the whole at right angles to the axis of the body when seen in front, and they are nearly parallel to each other; and though enlarged at the heads, not nearly so robust as those of the falcons, although rather longer in proportion. In their articulation on the sternum, and their position with regard to each other, they have thus very little stiffness in resisting the approach of the shoulder joints toward each other; thus in this respect they are to a great extent the very opposite of those of the falcons.

And this flexibility which the coracoids have for bringing the shoulder joints together, is not counteracted by any great strength of the furcal bone ; for, though the two extremities of that bone are enlarged, the branches are slender and straight, which renders them as feeble as the coracoids. Even the blade bones are not formed for taking a very firm hold in their embedment.

Thus when we examine the point of articulation to which the wing of the parrot is attached, we find it a very feeble one, and one which could not be used in long flight, without great fatigue to the bird. The coracoids and branches of the furcal bone are placed in that position in which they are the least fitted for resisting that strain on the shoulder joint which is necessarily given when a bird flies rapidly ; and they even appear to be loaded with an additional quantity of bone at the joint, for no other apparent purpose than that the joint may be the more unsteady, and the flight of the bird the more feeble and laborious. We would thence, if we reasoned only from the relative structures of the sternal apparatus, be apt to conclude that nature has given to the parrot tribe similar power of foot with the birds of prey, but shorn and crippled them in those characteristic organs of birds, the wings.

When, however, we take the haunts and the habits of each into consideration, we find that not the jerr-falcon herself, in the pride of her finest flight in the free air over the bleak and bushless wild, affords us a better specimen of exquisite mechanical skill, both in the design and the accomplishment, than the parrot among the tangled sprays of a tropical forest. The fine wing of the falcon would avail her nothing in such a place : for it is as unbending as the spirit

of the bird ; and one stroke of it taking effect on the branches, which in the habitation of the parrots she could not avoid, would fracture the wing, firm as it is, or at all events throw her off her poise, and tumble her to the earth, defeated, helpless, and fit only for food to the snake or the vulture, if even they did not scorn her as a meal.

But the wings of the parrot are, from the looseness of their articulation, proof against any such casualty ; so that, though the bird move and flutter them ever so much among the thick sprays, or have to use them in the most awkward situations, in making way from perch to perch, when the distance is too great for the reach of the foot or the bill, they do not sustain the slightest injury. From the flexibility of the wings of these birds in the joints of their bones, the bones are not only saved from danger of fracture to which more firmly-jointed ones would be constantly exposed, but the feathers are also less liable to be ruffled or injured by striking against the twigs and branches than the feathers of those stiff wings which are adapted for more forward and rapid flight are by the contact of the air, when they deliver their strokes from their comparatively immoveable points of articulation on the firmly-knit shoulders.

All forest birds, which have to make their way among twigs and leaves, and all birds generally which are liable to come in contact with obstacles in the stretching out or in the subsequent use of their wings, have them more or less of this yielding structure, according to the necessity which they have for it, so that, whatever may be the difference of the place of resort, or of the hazards to which any creature may be exposed on account of these, the creature which is native, or in its natural and accustomed element, in

them, is just as much at home and as safe in the one as in the other.

It is this universal perfection of adaptation which renders the study of nature, the more extended and liberal the scale on which it is conducted, the more gratifying to the best feelings, and the more cheering to the best hopes, of man. When we study the different parts of the world, in their climatal differences and in their productions, we find that they are dependent upon the structure and form of the earth's surface, the motions of the earth around the sun, and the reciprocal actions of earth, water, and air, with those of the relative positions of the sun and moon upon both ; but that, in all the varieties of climate, and all the differences of surface and vegetation which are produced by those numerous and complicated causes, the animal, to what class soever of animated nature it may belong, is so true to all the rest of the system, that they must be all parts of one design—the workmanship of One Almighty and All-seeing Architect, who required to proceed by no such experience of steps or induction of particulars as that which hems in the widest flights of our invention ; and that, ere one particle of the whole system was in existence, every possible part of the complicated whole, and every variety of which any one is susceptible (even those which, to our confined perception of the matter, appear anomalies or imperfections) must have been far more clear and simple than is to us the simplest work which we can perform, after we have performed it the greatest possible number of times. If we attend only to the single organ, we cannot but admire the perfection of workmanship which it displays ; but when we, to so humble an extent as our limited powers enable us, endeavour to think of the

whole, our admiration changes to the most complete astonishment, because the utmost effort of our powers can no more fathom the depth of design, which is apparent in whatsoever portion of nature we study, than the span of our fingers can measure the extension of the universe.

## STERNA OF THE COLUMBADÆ.

Though the birds belonging to this group are not climbers, and the greater number of them seek their food upon the ground, chiefly vegetable, though some of them also eat insects, yet they retain in the sternal apparatus some of the characters of the climbing birds; and there are, among the species found in warm countries, some which have the colours of the plumage as brilliant as any of the climbing or zygodactylic birds. They in general perch in trees, or in the holes and on the ledges of rocks; but there are some species which reside chiefly on the ground. There are also some which, in their general appearance, and partially also in the form of the sternum and its apparatus, have some resemblance to the gallinaceous or poultry birds; and of these, as is the case in that order, there are some which nestle in trees and some on the ground. The race are indeed considerably diversified; but still the more typical ones, in many particulars of their sterna, preserve a resemblance to the climbing birds. The sternum of the rock-dove, which is usually considered as the parent stock out of which the numerous varieties of domestic pigeons have been bred, may be selected as about the average.

In the development of its keel, this sternum bears some resemblance to that of the parrot; but it is better formed for flight, as the keel is more advanced

in front, and the angle, though rounded off, is not so much so as in the other. The central portion backwards is much more produced, and it is rendered stiff by the continuation of the keel; but the angles are cut off, which gives the entire bone a sort of lozenge form; and the sides are weakened by the two holes



Rock-dove, half the lineal dimensions.

and two notches which appear in the figure. The coracoids, though not very strong, are much better set at their junction with the sternum than those of the parrot. They have not that direct bearing toward the centre of the sternum which we find in the more typical wing birds; but their axes do form an angle with each other as seen in front, and the position of the lines of their union tends also to throw the pressure on their heads toward the middle of the sternum. The clavicle, though by no means of the strongest form, is much firmer, in comparison with the quantity of matter that it contains, than the clavicle of the parrot. It is an arch, though an elongated elliptical



one, and therefore comparatively weak against lateral pressure on the extremities, though not so much so as a fir with the branches nearly straight, and its process at the middle bearing on the head of the sternum. Thus the sternal apparatus of this order, though far from being so firm as that of those birds of which the air is the principal element, is not so flexible as that of those birds whose chief action is walking upon legs so articulated as to support the axis of the body in a horizontal posture. The pigeons are thus, in their structure, intermediate between air and ground birds; and they are, on the average, the same in their habits, though, according to this habit, they might perhaps admit of division into four groups. First, those which feed, habitually or occasionally, upon seeds and berries, while these are yet on the plant, the tree, or the bush. Of these the migrant pigeons of the south-east, which are gay in their plumage, and which, though they have perching rather than climbing feet, yet have some resemblance to the parroquets, are the most typical. Secondly, those which, though they feed more on the ground, yet perch and nestle habitually on trees, of which we have British examples in the common ringdove, and in the rarer stock-dove and turtle. Thirdly, those which feed on the ground, and roost and nestle in rocks, of which the rock-dove may be regarded as the type, and all the varieties of pigeon-house and domesticated pigeons as instances. Fourthly, those which bear so much resemblance to the gallinidæ that they are popularly called gallinaceous pigeons. Of these one species is as large as the common turkey, or larger. Some of them nestle in trees, and some on the ground, but they are all lower fliers and less discursive in their range than the true pigeon; they

are also much more omnivorous, and on this, as well as on other accounts, they ought in a perfectly natural system to stand as a separate family, if not as a distinct sub-order.

Before proceeding to notice the sternal apparatus of the gallinaceous tribe, it may not be improper to remark that the flexibility of the lateral parts of sterna produced by notches of the bone, or cartilaginous continuations, are intimately connected with the power of walking straight forward upon two legs, in birds which have the use of their wings in flight, and which consequently have furcal or clavicular bones, though the form and strength of these vary with the powers of flight.

It will be readily understood that the clavicle ties the shoulder-joints together, and the coracoids at the same time keep them both at equal distances from the anterior angles of the sternum, so that the line joining the shoulder-joints is immoveable in position with reference to the sternum, except in so far as the different articulations are loose and admit of play, and the change of position produced in this way is very limited. Consequently, if the sternum were inflexible (as it is in birds of powerful wing) in claviced birds which walk by striding with the alternate foot, and not by hopping with both feet at once, the line of the bird's body would twine about like a corkscrew as it marched along, as the advance of each foot would necessarily throw the anterior part of the axis to the opposite side, and give the bird a swinging motion upon its centre of gravity, which would considerably increase the fatigue of walking, and thus be a violation of that general law according to which all the natural actions of animals are performed with the smallest possible waste of their energy. We see

instances of this swinging of the axis in several flying birds when they walk by steps; and it is more conspicuous in proportion as the tarsi are longer, and the tibiæ more moved in performing the step. But such birds have generally the tarsi rather short, so that on their quick marches upon the ground they take short trundling steps, or they hop, as is the case with most of those *passeres* which are habitually or occasionally ground feeders. In order that the progress may be by steps of considerable length, it becomes necessary that, if the shoulders require a stiffening clavicle to fit them for flight, the posterior part of the sternum and also the ribs, but especially the former, should be flexible, in order that the one side may contract and the other expand on the advance of the leg, as much as shall keep the axis of the body steady to the line of motion. We have a perfect confirmation of this in the sterna of gallinaeous birds, all of which are straight-forward runners, and runners without hopping. Many of the long-legged birds also run fast and steadily forward, and never use any action of the feet for that purpose, except the alternate one; but the particular structure of the bones, by which this is accomplished in them, can be more advantageously explained afterwards.

## STERNA OF THE GALLINIDÆ.

The sternum of these birds has the lozenge form which characterises that of the pigeon tribe, only it is more elongated in proportion to its breadth. As in these, the anterior part of it is the firmer, but the posterior part is much more flexible, consisting of five processes of bone, all narrow and slender, with the notches next the middle by far the deepest,

extending, in fact, fully more than three-fourths of the entire length of the sternum; and the two lateral processes, though united by cartilaginous membranes to each other and to the central bone, having more the appearance of a forked sternal rib than of portions of the sternum as a continuous bone. The keel is considerably developed, especially in the anterior part, but lower toward the rear, though there it still affords some stiffness to the middle portion of the sternum. The anterior part of the sternum terminates in a triangular process, which is notched at the edges to receive the coracoid bones, and the lateral processes extend forwards nearly as far as the triangular one in the centre. The coracoids are rather strong, flattened on their anterior edges, and with an angular ridge backwards. The clavicle is a semi-ellipse, more elongated, and with the branches much more straight, feeble, and flexible, than in the pigeons. It has always a process at the union of the two branches, often of considerable size, and directed toward the anterior part of the keel to which it is united. The shoulder bones are rather large, broader in the middle than toward the extremities, and a little bent.

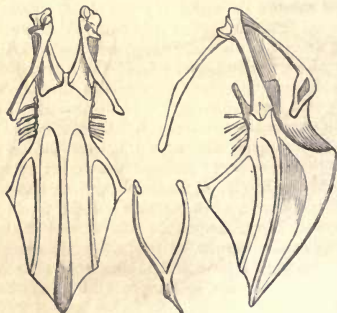
The whole structure of this sternal apparatus shows that its strength lies much more in the vertical plane than in the horizontal, and consequently that it is better adapted for supporting the body of the bird, while walking or running, than for giving steadiness to the wing in flight. The coracoid and the clavicle stand upon the sternum like two sides of a triangle, of which the anterior parts of that bone and its keel form the third side or base, and thus the shoulder-joint is kept at the same vertical distance from the sternum. The enlargement of the blade-bone, too,

gives that joint a firm suspension in the muscles of the back, and this, with the other structure of the bones which have been mentioned, causes the sternum, and the viscera which it supports, to hang, in a great measure, upon the upper part of the back, from which the support is continued through the bones, and furnishing a larger supply of muscles for the support of the legs than in air birds. But this very arrangement, which makes these bones steady, or comparatively stiff, in the vertical direction, and connects them with the legs as the grand organs of motion, renders them more flexible, or less able to resist a strain in the cross direction. This is a general principle in mechanics, that when any arrangement of pieces, framed by carpentry, as one would say, have the greatest possible strength in any one plane, they have always the least possible in the plane at right angles to that one. A truss which supports the most extensive roof, as, for instance, one of those beautifully scientific ones which support the roof of Westminster Hall, would break in pieces by its own weight, if an attempt were made to support it horizontally by the ends of the rafters; and even if it were laid on its side, with the ends of these and the vertex on two walls of equal height, all the framing, which makes it so stiff and strong, when it stands upright, would be just so much of a load upon the rafters, by which they would be weakened to its full weight, from the strength which they would have if laid single at their full length upon two walls, to the general lines at which they were at right angles.

This structure, which throws the strength of the sternal apparatus into the plane in which the legs are moved in walking, is the grand characteristic of a ground bird, and the very opposite of that of a bird

of powerful wing, which has the plane of greatest strength in its sternal apparatus nearly at right angles to the plane of walking; and therefore the power of walking in the latter bird is the smallest possible in proportion to the articulation and muscles of its legs, just as the flying power of the gallinaceous, or ground birds, is the smallest possible in proportion to the articulation and muscles of their wings.

Birds of this order are numerous; and, though there is perhaps fully as much similarity of habit among them as among the different species of any other order equally numerous, yet there are slight differences. The common partridge, as one which is among the fleetest runners, runs almost the instant it is out of the shell, always rests or squats as well as nestles on



Common Partridge.

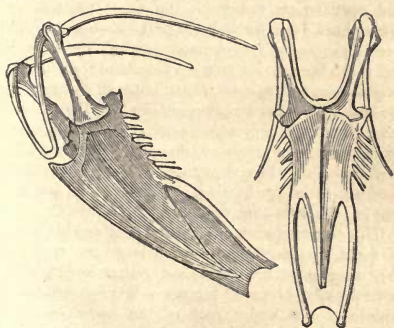
the ground, and seldom takes the wing, may be considered as one of the most typical; and it has the

farther advantage of being almost the only one which, in a state of nature, may be seen and studied alive in every habitable district of the British islands. The following figures represent its sternal apparatus, half the lineal dimensions of nature.

## STERNA OF THE GALLINULES.

Birds of this tribe may be considered as in their habits forming a connecting link between the gallinidæ and those swimming or diving birds which have the feet lobed or webbed, and they may be taken as an average type of the *Long-toed birds* of Cuvier's arrangement.

The following figures represent the sternal apparatus of the common gallinule, half the lineal dimensions of nature.



Gallinule.

This sternum, as may be seen from the figures, is very long and narrow, broader toward the ends than

at the middle, divided posteriorly into three processes, by means of two deep and wide notches, which are filled by cartilaginous membrane. The middle process is rather longer than the solid portion of the sternum, and terminates in a blunt point. The lateral ones are more than one and a half times as long, and are a little broadened at the points, and the edge of the membrane between them is concave. These lateral processes are flexible, and may be regarded as oblique sternal ribs for supporting the flanks of the bird, rather than as portions of the sternum in supporting the organs of flight. The middle process is rendered stiffer by the keel, which, although not high as compared with that of many other birds, is high in proportion to the width of the sternum. This keel is convex on the under side and concave on the front, the angle pointed, and surmounted by a small bony process outside. The lateral processes are inclined forward and upward, and there are six ribs between them and the posterior lateral ones. Coracoids short, but well formed, and moderately well set for giving firmness to the shoulder joint. The clavicle is a long semi-oval, rather slender, but without any process on the under side at the union of the two branches; but there is a small tubercular process on the upper side. The scapulars are very long, and a little bent downwards, and thin.

This sternal apparatus indicates considerable power of flight, though, from its narrowness, the stroke of the wing must be quick and rather feeble. The central posterior process gives a firm support to the middle of the under part of the body; and the lateral ones, from their great length and flexibility, support the flanks, and at the same time enable the body to accommodate itself to those obstacles among



which, from their habits, the birds have to find their way. The narrowness of the sternum in proportion to its length, and the accordant general shape of the bird, also conduce to the same purpose, and the straightness of the sternum enables it better to resist pressure in the direction of its length than the curved sterna of other birds, though these support much more powerfully the flying motion of the wing.

Many of the birds which have the sternum of this form are swift and smooth runners, and all, or at least most of them, run with the head advanced nearly in a line with the axis of the body, which is carried horizontally. The head, too, is small and pointed, and the shoulders are narrow and tapering. This form of the body enables the birds to make their way among the tall herbage of humid places, and especially the banks of brooks and streams, and the reedy margins of pools and shallow lakes in rich and flat countries, where they seek the greater part of their food. Many, if not all of them, can at times enter the water, and, when they are immersed to a sufficient depth, they use their wings for motion in that element. The narrow sternum, and the consequently short and rapid motion of the wings, are much better adapted for action in the water than wings which take longer strokes, and are more powerful and efficient in the air. This can be readily understood when it is borne in mind that the raising or recovering of the wing is a much more laborious operation in water than in air, and that the power requisite for working long wings, almost to the full circle, as is done by air birds, would in water be greater than any ordinary structure of a bird could be supposed to possess. Besides, when wings are used under water, they must keep time with the feet, and hence they are never moved far

from the horizontal plane of the body, but strike short and quick, and move most forcibly downwards or upwards, according as the course is ascending or descending.

The natural transition here is not to the running and wading birds, which resort, at least in most of the species, to the banks, shores, and other humid places, which are not so tangled and rank with vegetation as the haunts of the tribe now considered. These carry the type in the general form of the body and the sternal apparatus, though modified by the habit and haunt, from the grebes, which unite considerable powers of flight with swimming and diving, through the divers properly so called, to the penguins, which are incapable of flight; but those species which use the wings chiefly in the water as a sort of fins have the sternal apparatus, of course, different from those that use them in the air.

#### STERNA OF THE DIVERS.

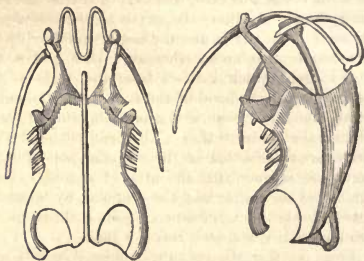
There is so much diversity of habit, as well as of sternal structure, among these, that it is impossible to select any single species as an average type. We shall, therefore, give three instances which correspond in some measure to the two extremes and the mean—the grebes, the true divers, and the penguins.

1. *Sterna of the Grebes.* The sternum of these birds is intermediate, in its general form, between that of the coots, as the aquatic extreme of the preceding group, and that of some of the diving ducks, or rather those of the eiders and scoters, which are intermediate between the swimmers and divers of the duck tribe. The sternum is short and broad, and much broader in the rear than the front; but the breadth in that part does not consist so much of

continuous bone as of two posterior lateral processes, which are divided from the central part of the bone by notches of considerable depth. These processes are much stronger, as well as shorter, than those of the birds in the preceding family. They are arched, rising upward at their divisions, and recurving again toward the middle portion, though not joining it. The keel is well developed, though its height is not equal to the breadth of one side of the sternum. It is convex on the under side, and concave in front, with the angle sharp, but without any production of bone. The margin is triangular and cartilaginous. The coracoids are of moderate length, rounded on their anterior sides, and flattened and much enlarged in the rear. They are strong, and well set for giving firmness to the shoulder-joint, as they form a considerable angle with each other, and also with the general line of the sternum; so that the strain which they exert when the wings are moved is directed toward the point of greatest resistance in that bone, which is, of course, also the mean centre of the surfaces to which the muscles which move the wings are attached. The clavicle is long, forming a regular semi-ellipse, attached by a small tubercle at the middle to the angle of the keel, flattened laterally, and forming, from the head of the coracoid to the keel, a perfect arch, with its convex side to the front, and the terminations of its branches bear against the heads of the scapulars, the greater part of which is slender, and slightly bent downwards. The general shape may be seen in the following two figures of the sternal apparatus of the eared grebe half the size of nature.

The breadth of this sternum, the convexity of its under side, the form and size of its keel, the strength and setting of the coracoids, and the opening and

curved form of the clavicle, all indicate considerable action of the wings. Its stoutness and firmness in the posterior part also indicate considerable action of the legs, not of the tarsi merely, but also of the tibiæ,



Eared Grebe.

and not in the vertical plane, as in the common operation of walking, but in a direction contrary, or at all events oblique, to that plane. A sternum which best suits for a walking motion is that which has the posterior angles taken off, so that the whole has a lozenge shape, as in poultry and pigeons; and one which answers best for the alternate foot motion of swimming on the surface of the water is of a punt or boat shape, which bears up the body equally. But the sternum of the grebe does not answer to any of these characters: it is shortened, as in the birds of prey, to admit a free motion of the legs, and the lateral processes backward are formed into a sort of strong, yet partially flexible arches, for defending the sides of the bird.

The structure of the shoulder is also well worthy of attention. The form of the clavicle resembles that of birds of prey, both in its curvature of opening and its curvature downwards. The strength arising from these curves is, however, reversed to that of the predatory birds. In them the curve of the opening is the more perfect arch, and the bone is flattened in the direction of that arch; whereas, in the grebes, the lateral arch, which extends from the angle of the sternal keel to the head of the scapular, is the better formed, and the bone is flattened laterally to give additional stiffness to that. The head of the clavicle also bears against that of the scapular something in the same manner that the arch of a bridge bears against its abutment; and the scapular, by becoming narrow toward its termination, resists a thrust on the head much better than it resists a pull.

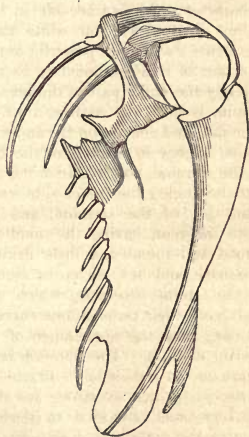
From this formation of the shoulder, it will be seen that though it forms not an unsteady fulcrum for the action of the wing in flight, it is also well calculated for resisting a strain or pressure from the front; and from the posterior portion it may be seen that provision is made there for a peculiar action of the feet. The sternal apparatus of the grebe is thus a very typical one; and when the small and elongated head and neck, and the lobed toes, with the flattened tarsi, turned outwards on their articulations, are taken into consideration, one might almost arrive at a knowledge of the habit of the bird without further investigation. No air-bird, not even the most typical of the falcons, presents the most powerful arch of its clavicle to the air against which it flies, neither has it the extremities of this arch resting on the angle of the keel and the head of the scapula as abutments, as is the case in this bird. Thus it is evident, from the structure of

the shoulder alone, and independently of that of the foot, that the grebe is formed for making its way through the water, and not merely along the surface, though the resemblance of the sternum to that of some of the ducks shows that it is also in part a surface swimmer; and this inference is rendered the more certain by that resemblance being to the ducks of the intermediate division, which have the swimming habit and the diving one in nearly equal perfection.

2. *Sterna of the true Divers.* In these birds, the duck-like character which is traceable in the sterna of the grebes disappears; and while the sternal apparatus presents a still more powerful arch in front, the posterior part of it is continued so as to support more completely the under part of the bird.

The sternum is long and narrow, a little concave on the upper side, and convex on the under; the keel well developed, higher in front than the breadth of the side of the sternum, concave in front, and much advanced at the angle; the under side convex, but less so than that of the sternum, and gradually diminished to the rear, having the middle process, which is broad and rounded, a little flexible. The sides are concave, and have seven or eight ribs on each; and the lateral processes, which are rather slender, and have their terminations curved toward the central one, have the appearance of two short sternal ribs in addition. The anterior lateral processes are large, and have their points directed upwards; and the coracoids, which are strong and short, have their bases very much enlarged to the rear, and with large processes projecting in the same direction as the lateral ones. The clavicle is very much curved downwards, with a tubercle at the middle, bearing on the angle of the keel (which is more rounded than in

the grebes), but not articulated to it. The branches of the clavicle are flattened laterally, rather slender at the middle point, but much enlarged at their union with the coracoids and the scapulars. They abut against the latter bones by a head consisting of two processes, and the coracoid has its enlarged head applied over the junction of the two, and a process underneath, which bears up the head of the clavicle. The scapulars are rather slender, bent into a regular curve, and tapering a little toward their points. The



Diver.

annexed figure of the sternal apparatus of the red-throated diver (*Colymbus septentrionalis*), in the propor-

tion of half the lineal dimensions of nature, and shown obliquely, half on the under side, half on the profile, will afford a better idea of these energetic careerers through the water than could be obtained from two separate views.

On examining this figure, it will be seen that the keel of the sternum, the clavicle, and the scapular of this apparatus, form nearly one continued curve, which does not bear so much on the angle of the keel, and therefore does not press so much upon the sternum, and the viscera which it supports, as in the grebes ; while the sternum, from its greater length, gives more firmness to the under part of the body. The great strain of the shoulder, as the bird moves through the water, is upon the coracoid, chiefly to turn that bone backwards ; and this is resisted by the great enlargement backward at the base, and the embedment of the process of the coracoid and that of the anterior angle of the sternum among the flesh of the shoulder. So that, while the resistance is very powerful, it is at the same time elastic, and not a direct thrust of bone against bone, which would occasion a direct prolongation of the strain through all the bony connexion, instead of an extinguishment of it among the neighbouring parts, as is the case in the mode of articulation here presented. Those direct or jarring strains, propagated all in one direction, are never found in the mechanical structure of animals ; but, on the contrary, the greater the strain upon any one part, the more speedily and widely is it distributed over a number of other parts.

The form of the clavicle is also a very beautiful part of this structure: the enlargement at the shoulder-joint, the gradual diminution in width as the bone becomes more curved in approaching the keel, and



the way in which the head of the clavicle is united to that of the scapular, so as to bend that bone more firmly against the ribs near the inflexible part of the spine, when the pressure of the water tends to bend the clavicle itself toward the angle of the sternal keel, are all well worthy of close observation : the more so that the natural action of the bird in the water cannot be so easily seen as that of a land bird in the air. Even the point of articulation of the wing is worthy of notice, as having the line of its principal action more in the direction of the general axis of the body than that of wings which are used exclusively in flying. Taken altogether, the divers afford one of the finest and most instructive instances of mechanical perfection which is to be met with in the whole feathered race. Not that their structure is better adapted to their habits than that of any other tribe, for in this all birds, and indeed all animals, may be said to be alike ; but their action is particularly energetic ; and the energetic action strikes us with admiration, while in the case of that which is less conspicuous we must examine before we can admire. Those striking cases are of course the ones which it is best to present to those entering upon the study ; whether the object be to produce love for the productions of nature, or the inseparable adjunct of that love when grounded aright—veneration for nature's Almighty Author.

3. *Sterna of the penguins.* In these birds the wings,—which in the divers, and also in some of the intermediate genera of auks, are capable of tolerably rapid and prolonged flight, so that the birds can not only range over the surfaces of the bays and landward parts of the sea, but migrate from one latitude to another as circumstances may require,—are

incapable of every thing which can with propriety be called flight, though they assist some of the species in a peculiar kind of leaping motion by which they can clear any obstacle with which they meet, by leaping three or four feet clear of the water. English sailors call those which have this habit by the not very inappropriate name of "Jumping Jacks."

These have the sternum elongated, with the keel well developed, pointed at its angle, and extending considerably in advance of the sternum. The anterior edge of the sternum with two large furrows, terminating in a depression in some of the species, and in a perforation in others. The sides of the sternum concave in the anterior part, and convex in the



Cape Penguin.

posterior. The concave portion having six ribs attached, the last one double; and the convex consisting of a slender process, extending backward to a

considerable distance beyond the termination of the middle portion of the sternum, bearing in this respect a very considerable resemblance to that of the gallinidæ.

The coracoids are long, strong, flattened, having the inner edge formed into a lamina, which is perforated, and bears at its upper extremity a process of the clavicle. The clavicle has a very peculiar shape, which will be better understood from the preceding half-size plan of the sternum of the Cape penguin than from any verbal description.

The scapulars are very large, much broader than in any other species of bird, and bearing a trace of resemblance to the same bones in the mammalia. Their form will be better seen in the following profile



Profile of the Cape Penguin.

of the sternal apparatus of the same bird, represented on the same scale.

It will be perceived that, in those birds, there is a considerable deviation from the usual means of supporting the shoulder. The coracoids are strong, they are well set as far as direction is concerned; but the smallness of the bases by which they are articulated gives them little stability in the vertical plane. They are, however, strongly tied to the shoulders by means of the large blade bones; and thus the support of the wing, or rather of the swimming flap, is thrown as much upon the muscles of the back, and through these as an elastic medium upon the spine, as upon the sternum.

As these birds use their imperfectly produced wings only in swimming, or in the leaping motion, in which there is no second effort of the wings in the air, and indeed little or no effort of them there at all, the body is never borne up by those appendages, and thus the organisation of greatest ease to the bird is that in which the upper and the under sides contribute equally to its support. In its ordinary habit of being in the water, indeed, it is pressed pretty equally by that fluid upon all sides; and therefore the greatest stability of the clavicle, which is the bone which resists the compressing force in the motion forward, is more stable by having its hold on the back by means of the large scapular. The clavicle is flattened, and placed with the edge forward, so that it presents to the water through which the bird moves the greatest stiffness which could be obtained from the same portion of bone; and its articulation at the shoulder is such that, when there is a strain on the middle part of it, it tends to pull the scapular forwards. This the broad scapular resists, and it is aided in its resistance by the anterior lateral processes of the sternum, while the equal supports, which the flap

of wing has from above and from below, enable it to act with equal force in its upward and its downward stroke, and thus perform with more efficiency its fin-like function. The birds of this group are slow and unwieldy, with little capacity of motion either in the air or upon land; but their organisation is as admirably fitted to their habit as that of any other birds; and they are curious, as forming the last link between the



Patagonian Penguin.

birds which, as a class, are more typically inhabitants of the air, and those vertebrated animals which are permanently dwellers in the waters, and cannot carry on the process of respiration in the free air.

#### STERNA OF LONG-LEGGED AND LONG-WINGED BIRDS.

Among the long-legged or long-winged birds which find their food near the waters, in fresh water or in the sea, there is a resemblance in the sternum, but there is also a gradation which may be traced, from the agami, which may be considered as among the least aquatic of the whole, to the cormorants and gannets, and perhaps even to the gulls and terns. This sternal structure does not of course, in birds of such varied forms and habits, accord with the classification which is usually made of them on the structure of their bills and feet;

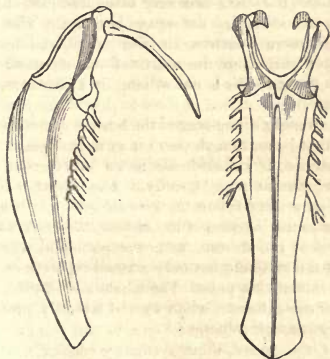
but they all agree in being, to a very considerable extent, air-birds ; though none of them, the genus *lestris* excepted, find their food in the air on the wing ; and these do not find their own prey in that element, but live upon the food of other birds, which they make these disgorge from their stomachs, and catch it ere it falls. Gulls and terns are the races which are chiefly robbed in this manner, and so prone are they to offer this sort of boon or bribe to real or supposed enemies, that, even in a state of confinement, they will disgorge the contents of their stomachs at the sight of an eagle, or any other formidable rapacious bird. Even the petrels, whose habits are too much seaward for encountering predatory or even plundering birds, have this disposition ; for when they are compelled, as they often are during severe weather, to alight on the decks or rigging of ships, they instantly make a votive offering of the quantity of oil with which their stomachs are loaded.

The habits of long-legged birds are so diversified—they are so much on the land in certain cases, and on the waters or by the sides of them in others—that it is not easy to select any species as a fair average of the whole ; but they follow the general law in having the sternum short in proportion as they are more on the wing, having that bone more elongated, and narrower in proportion, as they are more of walking birds in open places which have not water, and in having the posterior part more divided by notches, in proportion as they are more aquatic.

#### STERNUM OF THE AGAMI.

These birds are certainly not a little anomalous ; and though they are usually classed with the cranes, to which they have scarcely any other point of resem-

blance than a long neck, which after all is not a crane neck, but one fully as like those of the ostrich family, they partake of the characters and some of the habits of gallinaceous birds,—or rather they partake so equally of the characters of many races, and so little of those of any one, that in nature they stand alone and distinct, whatever may be the place assigned to them in any system. It is also not a little remarkable, that the sternum of these birds is as unique as their character; and this very clearly shows that no classification of birds can be either natural or valuable as an index to their history, of which the sternal apparatus does not form a considerable and even the leading part.



Agami.

This is what we might expect; because when we carry our analysis as far as it can rationally be carried,

that is to the bones which give the entire structure its form and its leading characters, we find that it is by the sternum, and those attached bones the coracoids, which are never wanting in a bird, be its habit what it may, and never present in any other animal, that we determine a bird to be a bird and nothing else. The preceding figures represent the sternal apparatus of the agami.

Upon examining these representations, it will be found that the bird to which they have the greatest resemblance is the gallinule ; that the general form of the sternum is nearly the same ; but that as the gallinule is a much more aquatic bird than the agami, its sternum possesses two very elongated lateral processes, while that of the agami is entire. The ribs are also more numerous in the agami, and occupy a greater portion of the length of the sternum, and though the scapular is not so long, it is broader, has a slight approximation in form to that of the penguin, and is strongly articulated to the head of the coracoid, while that bone, though well set as to the resisting of cross-strains, is rather loose in its articulation with the sternum as seen laterally. The furcal bone is much more slender than in the gallinule, and it has a process at the junction of its branches directed toward the keel of the sternum as in the gallinidæ, whereas that of the gallinule has only a small tubercle on the upper side at that point. The whole line of the furcal bone of the gallinule, when viewed laterally, presents an arch, though a flattened one, to the front ; while that of the agami, though slightly convex near the articulation with the other bones at the shoulder, is concave to the front in the part next the sternum. Throughout its whole length, this bone is remarkably slender and feeble as compared with the sternum,



the coracoids, and the scapulars ; and on this account the agami may perhaps be regarded as the feeblest winged of birds which have the clavicles united and can use the wings in flight. The great elongation backwards of the sternum makes a very marked difference between this bird and the ostriches, in which this bone, instead of being long, narrow, and but little curved, as it is in this case, is short, broad, and very convex on the under or external surface. The habit of the bird corresponds ; for while the ostrich family, in whatever part of the world they reside, are found on dry if not parched and naked pastures, the agami is found native in richer places, near the perennial waters, but on the verge of the tall aquatic herbage rather than in the middle of it. The agami is thus intermediate in its locality between the ostrich and the gallinules, and other macrodactylic birds ; and it is not a little remarkable that its sternal bone partakes of the undivided character of that of the one race, and the elongated one of the other.

#### STERNA OF THE CRANE FAMILY.

The cranes and the herons are not only found in places bearing considerable resemblance to each other, but some of the species are externally so much alike that they have been very generally considered as forming one tribe and sometimes only one genus.

The grand distinction between the cranes and the herons, whether we consider them as distinct groups or merely as genera (and the distinction is perhaps broad enough to amount to the former), is that the cranes have much more of a landward character than the herons, and they are also much more discursive and migratory, though from their habit of fishing or otherwise feeding in the shallows of the waters, herons

are also necessarily migrant in those parts of the world which are alternately flooded by water and parched by drought.

The sternum of the cranes is of moderate length, rather narrow, very little hollowed on the upper surface, and of nearly equal breadth throughout its whole extent. The sternal crest is large in proportion to the whole extent of the bone; arched on the under side for the greater part of its length, but slightly concave toward the posterior extremity; and in some of the species it contains a large cavity in which a flexure of the windpipe is lodged, as is also the case in some of those long-necked swimming birds which seek their food with the head immersed in water.

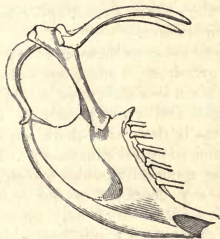


White Stork.

The angle of the crest advances considerably in front, is rounded, and, in the true cranes, and some other species, united to the central part of the clavicle. Seen in profile, the sides of the sternum appear concave; and in the rear it is divided by two triangular notches, which form the posterior angles into two processes which extend a little, but not much, beyond

the central part. The coracoids are short, strong, and much enlarged on their posterior sides. The clavicle is open, though but slightly arched in the plane of the opening. It is much enlarged toward the shoulder-joints, and much more arched toward the front than laterally. The blade bones are long, flat, and slightly bent, but not so large in proportion as in the agami. The preceding figure of the sternum of the white stork, on a scale of half the natural size, may be considered as an average specimen.

Profile of the same bone on the same scale.



White Stork.

On examining this sternal apparatus it will be seen that though the keel is well developed, and the shoulder also moderately firm for flight, yet that the extent of the scapular, the arching toward the front of the clavicle, and the union of that bone with the angle of the sternal keel, throw a portion of the support upon the back and thence to the legs, which in all the species are well adapted for walking. Still, though these birds cannot be considered as possessing

either very swift or very ready wings, they have all considerable power of continuance on their flight. They are also light birds in proportion to the extent of their wings, and therefore they fly high on their long flights ; and, as is the case with the true *grallidæ* or wading birds, they fly with the feet backwards, and use these in steering their course, in supplement to the tail, which is, generally speaking, short.

The example above given must be considered not as an average of the crane family, as the storks do not strictly belong either to the cranes or to the herons, though they resemble both ; but it is a tolerable average of the sternal apparatus of Cuvier's sub-order *cultrirostres*.

Intermediate between these and the *grallidæ*, which include the *pressirostres* and *longirostres* of Cuvier, which have much less difference in their haunts and style of flight, and consequently in their sternal apparatus, than in their bills, there are some species or genera, which require distinct notice. These are the ibises and the spoon-bills, which are more discursive than almost any members of the crane or heron families. The birds which may be considered as forming this group do not suit well with the genera with which they are usually classed according to the bill. That of the spoon-bills is not in the coultter or knife-shape, as may be seen by looking back at a sketch of it given on a former page ; while that of the ibis, though it resembles in shape the bill of the curlew, and certainly deserves the epithet "long," is not of the same texture with the generality of those bills of which length has been taken as the distinguishing character. The genus *tantalus*, which resembles ibis in many particulars, has the bill straight ; and there are various other genera included in the *cultrirostres*

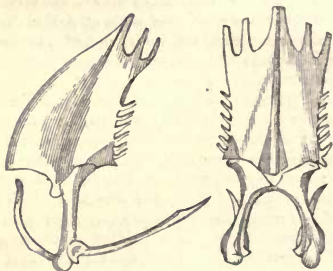
of Cuvier which have bills so totally different from each other that they cannot properly be brought into one group from the structure of that organ.

With regard to the habits of these birds, and more especially those of the genus ibis, it may not be irrelevant to mention that they have long got credit for being destroyers of poisonous serpents, and according to the story were, on this account, deified by the Egyptians; but this habit is very doubtful, beetles are more likely food for them, and poisonous serpents are not numerous in their haunts.

The general habits of the ibis, tantalus, and spoon-bill so much resemble each other, and they are all so perfectly similar in their sternal apparatus, that they belong perhaps more naturally to the same group than almost any other genera of birds. Their sternum is short, broad, and deep, with the keel much produced, and altogether indicating a capacity of powerful and continued flight. It is pointed anteriorly so as to afford firm basis to the coracoids. The keel is a little concave anteriorly, but convex on its under side. It is nearly of the same breadth throughout; bears six ribs on each side, the sides being concave when viewed laterally, and the posterior portion is divided by two notches of moderate depth towards each angle, the central process being longer and much stiffer than the lateral ones. The coracoids are short, strong, well-set, much enlarged both at their bases and at their heads; and the clavicle forms a perfect semi-ellipse, thickened at the shoulder-joints, and generally united to the angle of the sternum. The scapular is small-pointed at its extremity, and very slight and curved. The strength of this apparatus is obviously directed towards, or concentrated on, the shoulder-joint; while the comparative shortness of

the sternum, and the flexibility of its posterior angles in consequence of the notches, give free scope for the motion of the legs, which are in all the species long and well adapted for walking.

The following half-sized figures of the sternal apparatus of the glossy ibis (*falcinellus*), which some-



Glossy Ibis.

times, though rarely, makes a dash into this country on its migrations, will serve as an example of those very singular birds.

#### STERNA OF THE TOTIPALMÆ.

These birds, which may perhaps without very much impropriety be considered as, in habit, taking up the system after the herons, have considerable diversity in their haunts and modes of life. Some, as the albatross, are almost habitually on the wing over the sea, while others, as the cormorants, are less discursive, resort sometimes to the fresh waters, and occasionally perch upon trees ; but they all agree in

finding the greater part, if not the whole, of their food in the waters, and descending upon it on the wing, instead of getting it by wading or by walking, as is the case with the groups last mentioned. Hence, in all the varieties, they have a sternum well adapted for flight; but it also combines another character, which will be better understood after examining the following figures of the sternal apparatus of the common cormorant, which are given of half the lineal dimensions of nature.



Cormorant.

It is however in the next figure, which is the profile on the same scale, that the peculiar modification of the sternum of these birds is best seen.

Upon examining the following profile figure, it will be found that this bone presents a still more powerfully-resisting arch to the front than that formerly alluded to in the divers. The anterior edge of the keel, the coracoid, and the clavicle, form a complete egg-shaped structure, with its narrow end in the head of the last bone, where it is greatly increased in

breadth, and consequently in firmness of resistance ; while, from the manner in which the head of this bone is formed, any strain given upon the more advanced part of it is divided among the coracoids, the scapulars, and the keel of the sternum, though the greater part of it goes in the direction of the first of these. They are well adapted, both from their form and the mode of their attachment to the sternum, for resisting the strain of a pressure from the front. The basal parts are very large, and so are the heads, with which the branches of the clavicle are in all cases firmly united, and in some they are soldered into one continuous bone.



Profile of Cormorant.

And there is no waste of strength in the firmness against a pressure from the front which is thus given to the shoulders of these birds ; nor is the advancement of the clavicle in front of the shoulder-joint, or the strength which it receives there from its increased curvature and breadth, and its intimate union with



the head of the coracoid, without an object and use in the economy of the bird.

These birds do not make way with their whole body in the water, as is the habit of the divers; but they take the water with much more force, and therefore with a greater shock upon their bodies. Almost all of them plunge headlong on their prey in the water, and some of them do so from a great height—a height from which if even the strongest of the mammalia were to fall on their feet upon the water, they would be in danger of dislocating their joints, or even breaking their bones. All who are in any way familiar with the water must be aware how dangerous it is to descend into that liquid, even from an inconsiderable height, in any other way than head foremost, and especially how very hazardous it is to jump into it from a greater height with the legs apart from each other. Many of the birds of this tribe descend from heights and with velocities which, notwithstanding their feathery covering and the yielding nature of the fluid on which they descend, would, if its effect came as a cross strain, break the stoutest bone in their bodies. The bird from its form penetrates the water easily, and the articulations of the neck are so many, and so free in their motions, that any shock which the head may receive by the plunge is so divided among them as not to occasion the least concussion of the contents of the skull. Thus the parts which come into the severest contact with the water are the shoulders: and this is met by the strong and comparatively narrow parts of the arches in the direction of the vertical plane. And, upon examining the front view of the sternum, it will be found that, besides the hold which the scapulars have on the back and the stiffness given by the clavicle, the great breadth

of the coracoids at their bases, and the form of the lines of their union with the sternum, afford a very firm base in the cross direction.

The more typical of these birds are not very rapid fliers, but many of them are much on the wing; and they fly by powerful strokes rather than quickly-repeated ones. Hence they have the sternum broad, and the fibres of the pectoral muscles long, so that, on the principle formerly explained while noticing the wings of the anisodactyli, these wings sweep over large arches and with much power, though slowly as compared with birds that have the sternum narrower and the muscular fibres shorter.

There is another advantage which this large sweep but slow motion of the wing has over a shorter and quicker one: the wind has much less effect either in fatiguing the bird or in drifting it to leeward; and hence we find that most sea birds have this long and swinging flight, whether they belong to this family or not. Those of this family are of course not the best fliers among sea birds, as their sternal apparatus is not formed wholly for flight, but for that and resisting the plunge jointly; and as each of these requires a different structure, each of them must, to some extent at least, weaken the other.

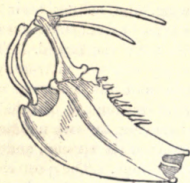
#### STERNA OF THE LONGIPENNES.

The birds which compose this order have some resemblance to those of the former tribe, and also to those of the grallidæ, as might be expected from the birds partaking in part of the habits of both; but they have also habits which are more peculiarly their own, and the sternal apparatus is modified to accord with these. Not only this, but as there is a gradation from the gulls, which feed on the wing, and also, in

walking on the shore, to the petrels, which are more exclusively seaward, and walk little : but there are so many modifications of the sternal apparatus, that no single bird can be selected as an average type of the whole. We shall therefore select two specimens : the laughing gull as nearly an average of the more landward subdivision, and the puffin petrel as nearly an average of the more seaward.

The sterna of the skuas, gulls, and terns, are in their general form intermediate between those of the entire footed birds and of the waders. They are rather longer and not quite so broad in proportion as those of the former ; but broader and less elongated than those of the latter. The keel also, though well developed, is not so high in proportion to the width of the sternum. From this structure it follows that the motion of their wings, though more powerful, must be slower than that of the waders ; and the wing itself is longer in its bones and its feathers, as well as in those muscles which put it in motion. This structure accords with the general habit, which is that of skimming about with smooth and moderately swift wing, and culling their food from the crests of the waves, or from substances cast up by the waters and left upon the strand. The keel of the sternum is deeply concave in front, with the angle much rounded ; and the posterior part, which is nearly square at the end, is divided more or less deeply by four notches, the two middle ones of which are larger in some of the species, and the two lateral in some of the others. The posterior, or carrying part, of the sternum is rather broader than the middle part to which the ribs, which are six or seven, are attached ; and the lateral processes extend on the flanks without any bending inwards. The coracoids

are strong and well set, the clavicle wide, convex anteriorly on the upper parts of its branches, but recurved at their junction, and always united to the keel of the sternum. The scapulars are sithe-shaped, rather long, and of moderate breadth. From its structure, this sternal apparatus indicates considerable power of flight, and also strength for resisting pressure on the anterior part, though in this last



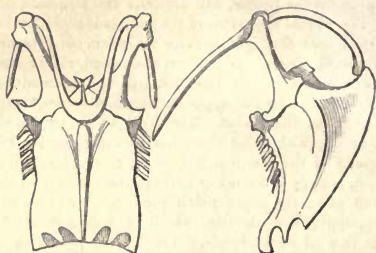
Laughing Gull.

respect it is much inferior to that of the entire footed birds; and in both it is very inferior to that of the

petrels. The preceding figures of the sternum of the laughing gull, and more especially the lower one which represents the profile, will illustrate this structure.

The sternal apparatus of the petrels is much better formed both for flight and for resistance of pressure against the front. It is short and broad, rather narrower in the middle than towards the extremities, very concave on the upper surface, and consequently convex on the under. The keel much produced, extending with some elevation to the posterior extremity of the sternum, but much more elevated in front, convex in its under outline, and concave in the front one; the angle much produced, rounded, and supporting the clavicle, which is enlarged at the junction of its branches. The lateral processes of the sternum are well produced, the grooves deep, and the coracoids firmly attached by large bases. The sides concave upwards, carrying six ribs. The posterior edges differing in different genera, being entire in the storm-petrels, having a large notch on each side in the albatross, and two small ones on each side in most of the others. The coracoids are strong in their whole length, but remarkable for the extent of their bases and the largeness of their heads, from the first of which structures they form a perfect arch in the lateral directions, even without the assistance of the clavicle. But the clavicle is also strong, and capable from its curvature of offering a powerful resistance to any strain, whether lateral or from the front. The scapular is slender, very slightly curved downwards, and continued in the same curve with the upper part of the clavicle. This is indeed one of the firmest shoulders which occurs in the whole class; and, as will be seen from the profile in the following figure, the keel of the sternum, the coracoid,

and the scapular form a very perfect ellipse, extending to about three-fourths of an entire circumference.



Puffin Petrel, half the size of nature.

Though the sternal apparatus of all these birds possesses great power, that power does not indicate an equal capacity of flight in the whole. The differences as connected with flying are chiefly found in the posterior edge; and as we have them in birds which have the rest of their sternal apparatus very much alike, and have the habit of flying connected with each, we are thereby better enabled to judge of the difference between entire and partially divided sternums than if we had the means of comparing these only in birds which less resembled each other in other respects. The different species of storm petrels which have the sternum entire, and consequently the firmest origin for their pectoral muscles, are among the most continued and excursive fliers of which we have any knowledge. The wide sea is their pasture, and, be its extent what it may, they range from shore to shore; now rushing at a mode-

rate height through the air, with light wing and with great velocity; again skimming close to the surface, so that the points of their wings tip the water at every stroke; and yet again running along the water, with expanded wings, which, though they seldom move, float them so buoyantly, that they just touch the water with the points of their webs, and thus paddle swiftly along, collecting on the feathers of their breasts that floating pellicle of oil which forms no inconsiderable portion of their food, and which, when they have wearied themselves in skimming, they lean on the wave, and remove with the bill at their leisure.

The albatross, which, though a very long-winged bird, has a more heavy and gull-like flight than the storm petrels, has, as already noticed, one notch in each posterior angle of the sternum, by means of which those parts of the bone are rendered feebler. These birds are scavengers for larger matters rather than skimmers of the oil of the sea, like the preceding genus, but they are wide ranging scavengers, and, when they are once on the wing, miles of ocean are of little consequence to them in their range.

The common petrels, and other birds which have four notches in the posterior part of the sternum, are inferior to the others both in the style and the rapidity of their flight, and a connexion may be traced perhaps as naturally from them through the puffins and auks to the wingless birds, as that which is traceable from the divers. The whole of this family may, however, be considered as the most pelagic of all birds, because, though there are others which are much more in the water, or on its surface, there are none which have equal power of wing, or are capable of extending their excursions so far from the land.

## STERNA OF THE GRALLIDÆ.

Though the birds which form this order, even when restricted by leaving out those groups which have been already mentioned in the course of these observations, differ very much in the structure of their bills, yet there is far less diversity in their sternal apparatus than the consideration of the bills, as their chief character, would lead us to suppose. But, when we consider that none of them are habitual fliers, that they fly only for change of place, and that their flight is generally taken by rather short and swiftly-moving wings, we might be prepared to find that agreement which there is in the sternal apparatus.

It suits the walking and the wading habits of those birds, and also the tangled herbage through which many of them have to make their way, to have the body narrow in proportion to its depth. The sternum is in consequence long, and rather narrow, a little enlarged towards the posterior portion, and divided there by four notches of considerable depth, the lateral ones generally the deepest; the processes between the notches feeble, but generally enlarged at their extremities, so as to form the posterior outline of the sternum into a convex curve. The crest is generally large, convex below, concave in front, with the angle terminating in a process; lateral processes not nearly so much developed as in the petrel family; the basis of the coracoids not nearly so large, and their attachment to the sternum not so firm; the coracoids are, however, short, stout, and considerably enlarged at the heads, but their position is too parallel to each other, and too much in the general line of the sternum, for giving that stability to the shoulder-joint which is essential to long-continued and rapid flight.



The clavicle is elongated, curved forward at the middle of its branches, and directed at their junction throughout the middle part of the anterior edge of the keel, and they are enlarged in breadth toward their junction with the coracoids. The scapulars are rather large, flat, straight for great part of their length, but bent downwards toward the points, so as to have a firm embedment on the back.

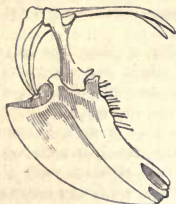
In this latter part of the structure it will be perceived that those birds have much more the character of walking or ground birds, than those of the preceding group, or indeed than any of the water birds which are much in the habit of using the wing, even though not so good fliers for a short time as some of the wading birds are. The enlargement of the clavicle toward the shoulder-joints, the large heads of the coracoids, and especially the increased size and peculiar form of the scapular, together with the comparatively loose attachment of the coracoids to the sternum, show that the strength of the shoulder in those birds is not wholly, or even chiefly, based upon the sternum, but that great part of it is connected with the back through the produced shoulder-bone, and being connected with the back, it is, by means of that, referred to the legs for support. This is not the case so exclusively as in the wingless birds, because all the grallidæ can fly occasionally, most of them can fly well, though their flights are rather short, and the wings of them all are ready in turning and wheeling; but still a careful examination of their sternal apparatus, as combining the elements of walking and the elements of flight, would probably be found a much better ground of classification than any to which systematists have hitherto resorted. We shall give the sternal apparatus of the lapwing, which is a

tolerably good runner, and also a ready flier, as nearly an average specimen of the whole.



Lapwing.

The following cut represents the sternal apparatus of the same bird in profile, and both cuts are of the natural size :



Profile of the Lapwing.

#### STERNA OF THE LAMELLIROSTRES.

As, in so far as their aquatic habit is concerned, the sternal apparatus of all the birds belonging to

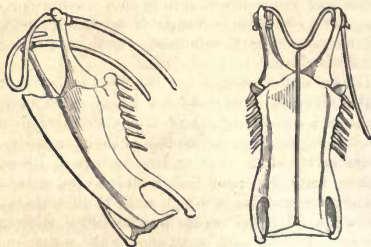
this order is adapted for the bearing up of their bodies while they float upon the water, there is, independently of their different degrees of adaptation for flight, a general character which runs through the whole order. The largest diameter of the body is reversed as compared with that of the *grallidæ*. These have it vertical, so that they may the more easily make their way among the herbage, and also present the least resistance to the air, and give the greatest scope to the legs in walking, wading, or running. But the flat-billed birds have the body more or less flattened horizontally, as well as the bill, by which means they present to the water a large base in proportion to their weight, and thus swim more lightly. The sternum is elongated, and also increased in width, so as to accommodate itself to this form of the body, and upon the average it is so placed that the centre of gravity of the bird is very nearly over its centre of resistance, so that all parts of it are pressed upon with nearly equal force as the bird floats along.

The habit of floating along the water is, however, in the different genera and species of these birds, combined with so many modifications of other habits, that it is subject to numerous though slight variations. Those habits are greater or less degrees of flying, walking, and diving; and, from what has been already said respecting birds of which each of these is the principal habit, it will readily be understood, without repetition, how far each must modify the swimming or floating character, which is the principal one of this class.

They have the sternum elongated, varying in breadth, narrower in the middle than at the extremities. The sternal keel is well developed, but

usually lower than the width of half the sternum. The lower edge of the keel is sometimes convex, sometimes straight, and the anterior one generally concave, and in some of the species there is a cavity at the base of the crest, in which a duplicature of the trachea is lodged. The coracoids are never very long; they are large at their bases, and rather firmly attached to the sternum.

There are seven or eight ribs (in some cases nine) on each side of the sternum, and the posterior part of that bone is generally divided by notches, though the heads of the processes are so much produced as nearly to meet each other. The clavicle is of moderate length, and well arched, and the shoulder bones rather slender, and arched through the whole extent. The general character is that of having the bones of the



White-eyed Pochard.

shoulder much more exclusively supported from the sternum than is the case in the wading birds. The above figures of the sternal apparatus of the

nyroca pochard, or white-eyed duck, may be taken as a specimen.

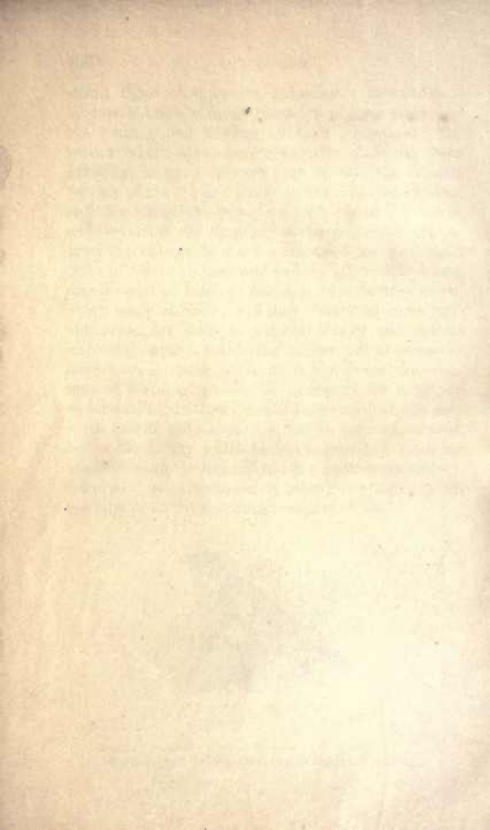
In this volume we have taken a rapid glance at the general structure of birds, and those characters which distinguish them from the other classes of vertebrated animals; and we have entered rather more minutely into those peculiarities of their three grand structures, the bill, the feet, and the wings, upon which, singly or jointly, the leading differences of their habits in a great measure depend. It would now remain to investigate their relations to the rest of nature in locality and in season; but as this part of the subject involves the knowledge also of the natural history of localities and of seasons, it is of too general a nature for being made a specific portion of the natural history of birds, though they cannot be known to the full extent without a knowledge of it, neither can it be understood to the full extent without a knowledge of them. Nature is one workmanship of one Author, and he who wishes to know any single part well, must lay the foundation in some general knowledge of the whole.

Though every effort has been made to bring into this volume the greatest possible quantity of matter, there still remain many general principles to be investigated before the reader can be fully prepared for entering upon the details of ornithology, in such a manner as to see clearly the place which each species fills in the system of nature, and the office which it performs. Among these may be enumerated the general and the seasonal distribution of birds; their migrations, and the reasons why some are migratory while others are not; their changes of plumage, whether in feathers, in colour, or in both, and the causes, whether of a physical or physiological nature, by

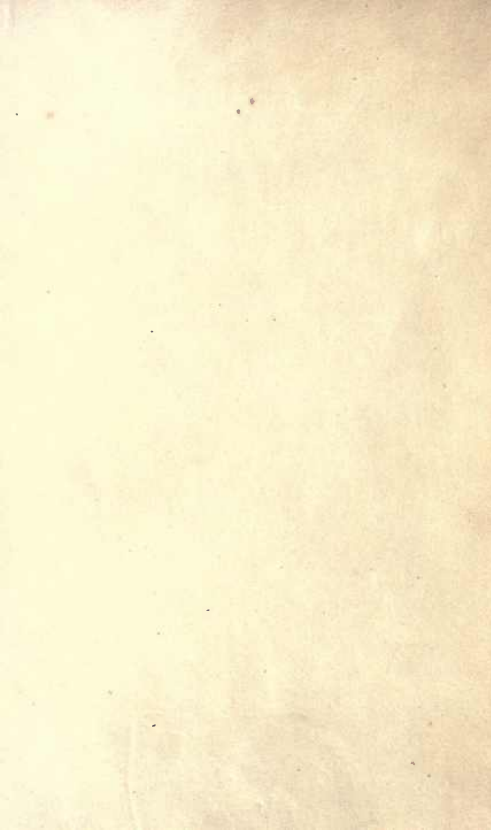
which these changes are influenced; the different labours of birds in the preparation of their nests, and the tending and feeding of their young, and the reasons which lead some species to make far more exertions in these respects than others; the relative periods of growth and decay in the different species; and the inferences which may be drawn from birds with regard to the character of the particular season, or of the climate in a more extended and prolonged point of view. These and various others it is necessary, in part at least, to know as introductory to the useful study of birds; and they involve so many facts and principles both in natural history and natural science generally, that if the reader will undergo the labour, or, to speak more correctly, enjoy the pleasure, of learning all that is necessary for a proper understanding of them, he will be astonished, not only at the quantity of knowledge that he has accumulated, but at the facility which he has acquired of obtaining accurate and practical information upon every subject, whether it more immediately belong to what is called learning or to the common business of life.

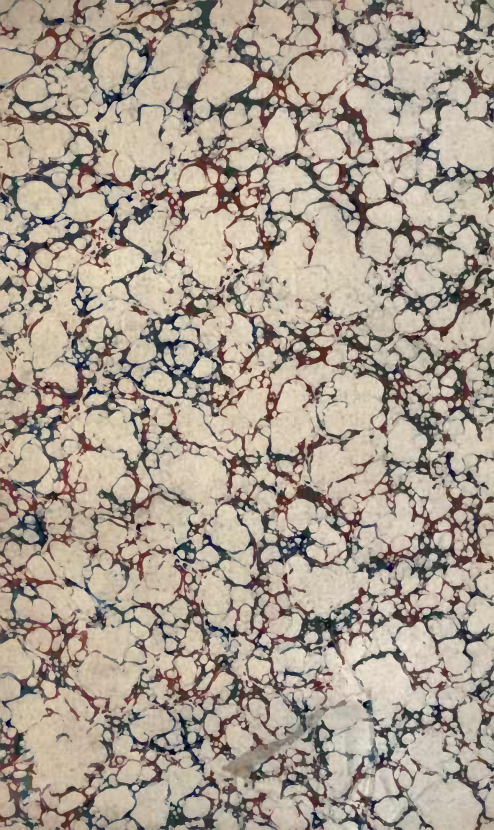












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