

**Lectures on comparative anatomy / translated from the French of G. Cuvier
by William Ross ; under the inspection of James Macartney.**

Contributors

Ross, William C., fl. ca. 1802.
Macartney, James, 1770-1843
Cuvier, Georges, baron, 1769-1832.
Royal College of Physicians of Edinburgh

Publication/Creation

London : T. N. Longman & O. Rees, 1802.

Persistent URL

<https://wellcomecollection.org/works/br6rjkmr>

Provider

Royal College of Physicians Edinburgh

License and attribution

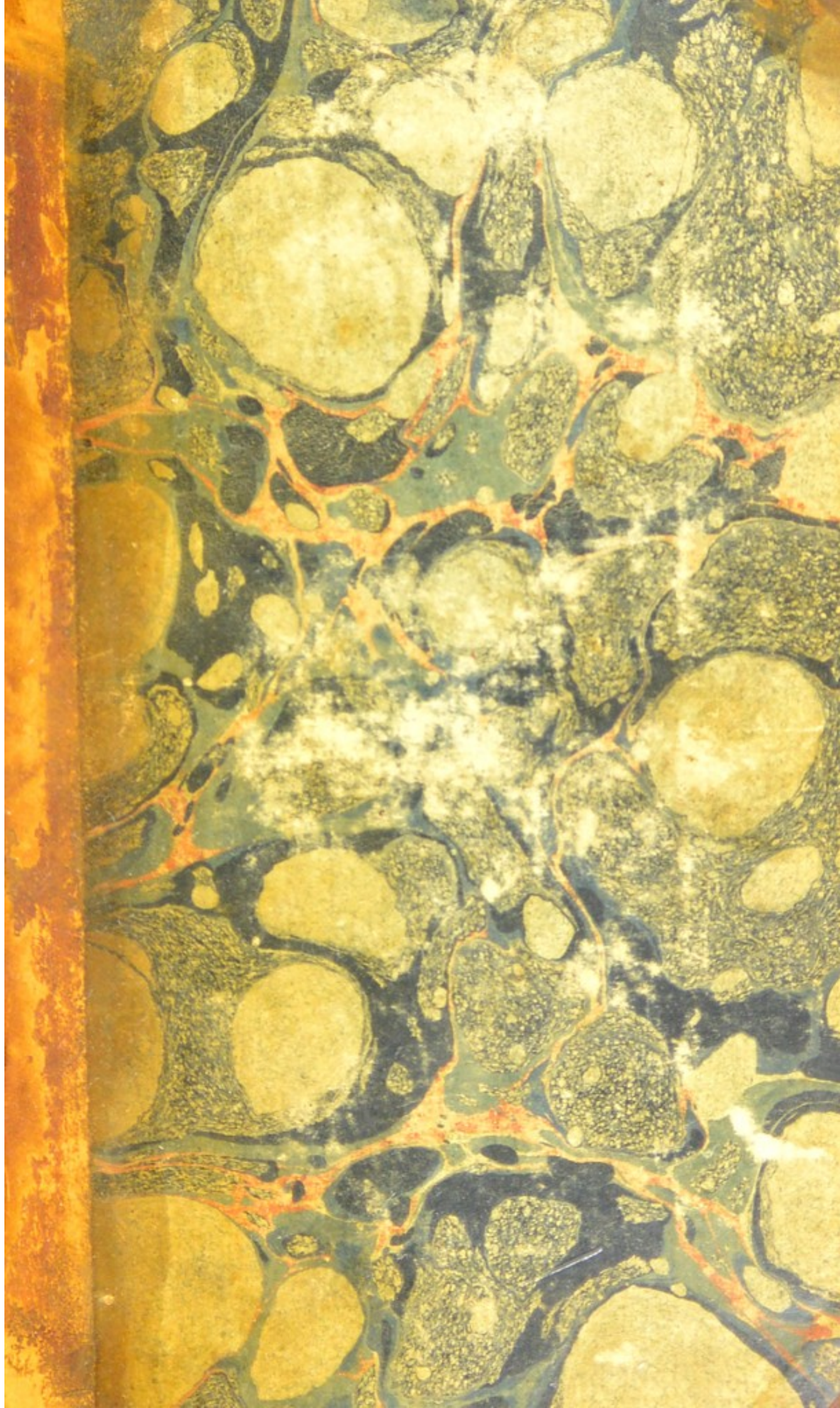
This material has been provided by the Royal College of Physicians of Edinburgh. The original may be consulted at the Royal College of Physicians of Edinburgh.

This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.

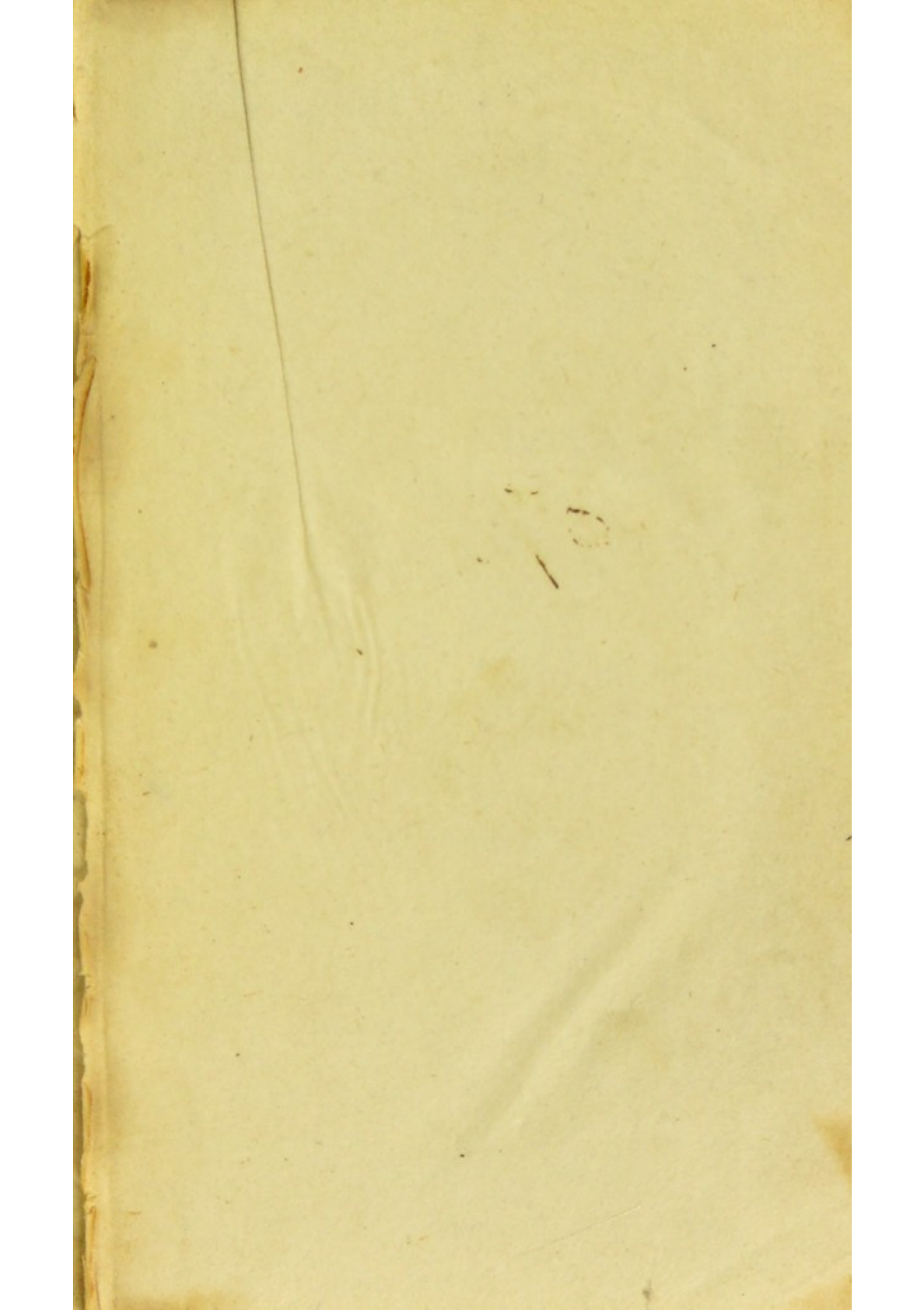


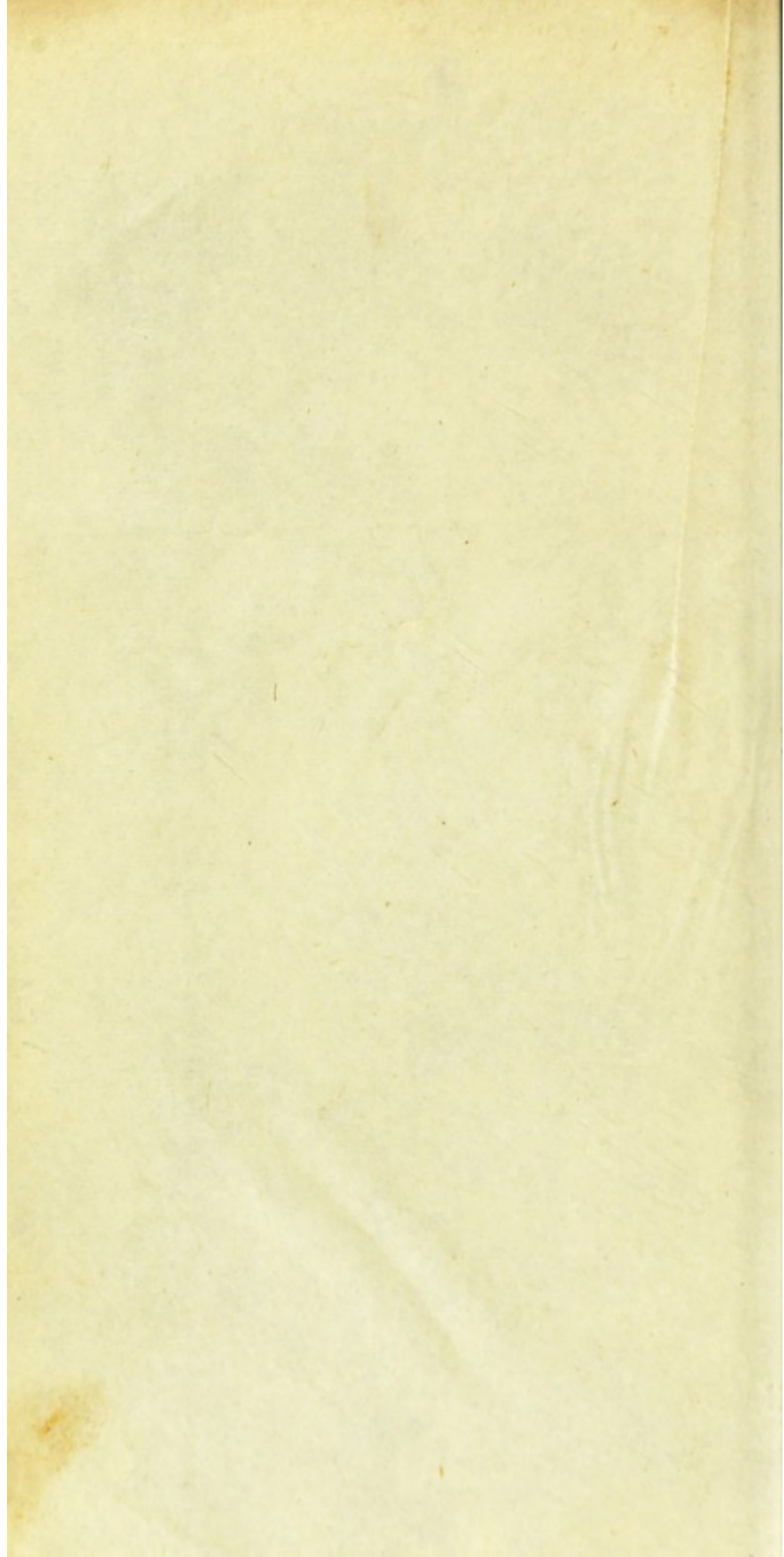
Wellcome Collection
183 Euston Road
London NW1 2BE UK
T +44 (0)20 7611 8722
E library@wellcomecollection.org
<https://wellcomecollection.org>

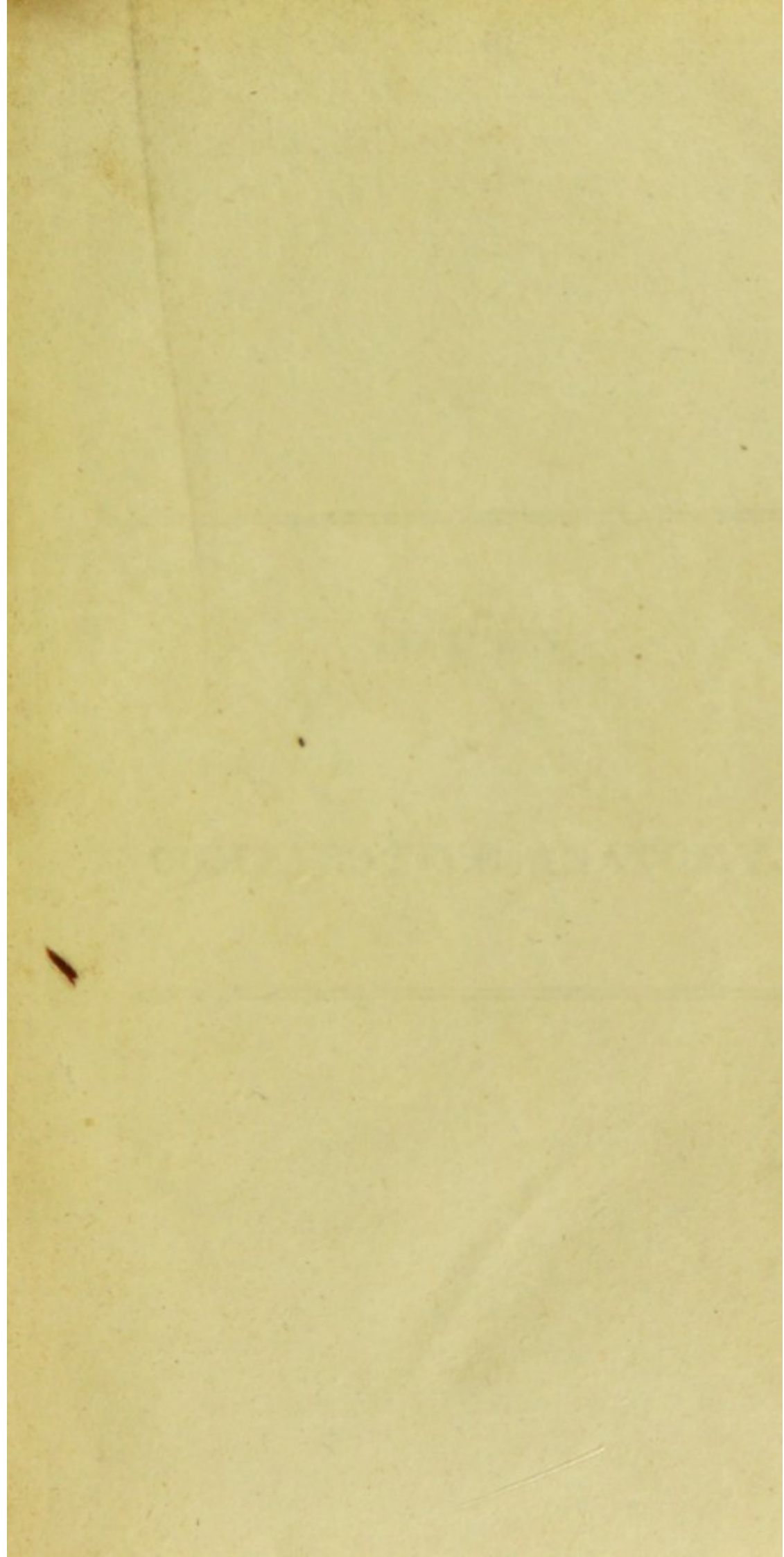


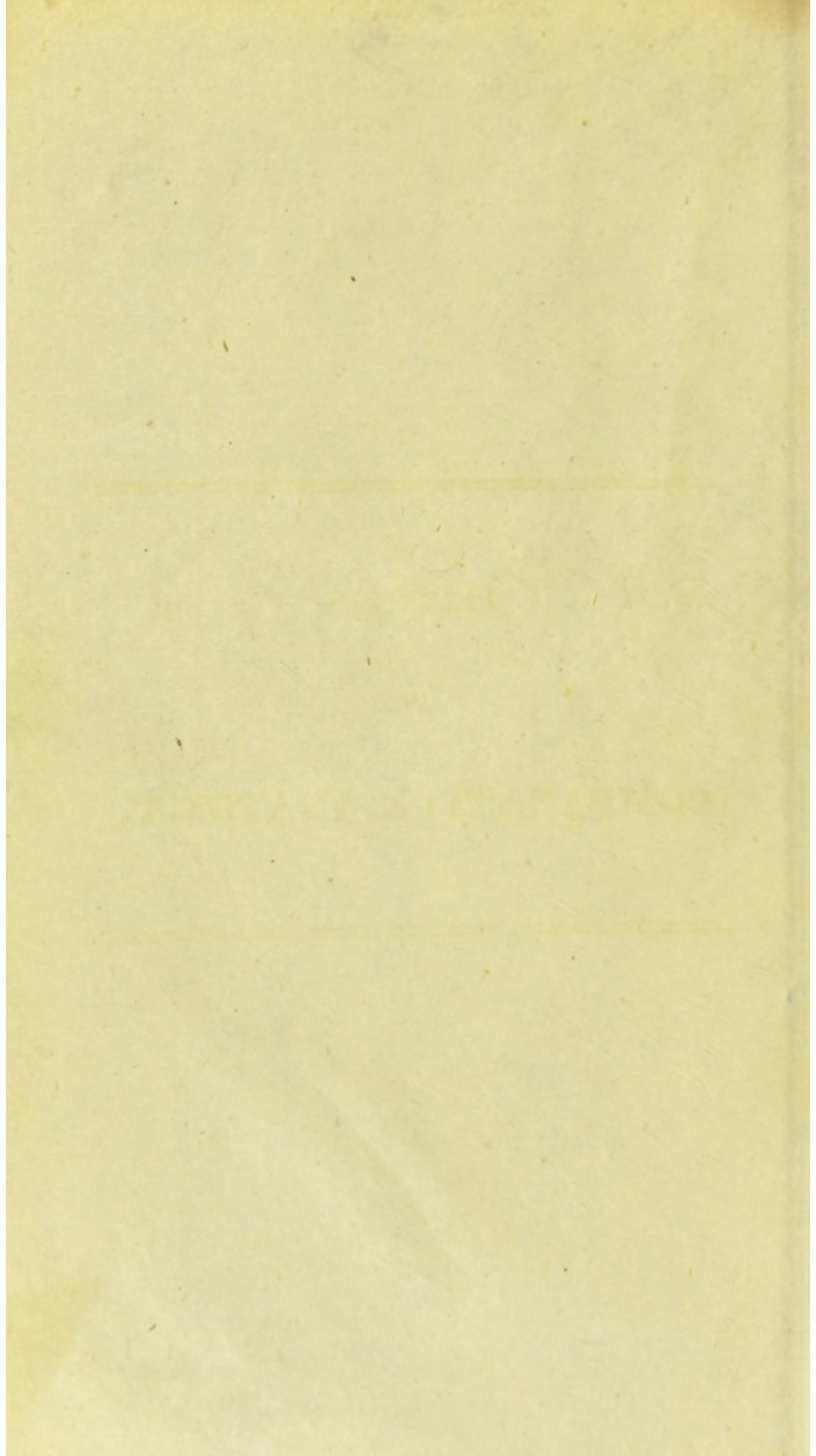
Φ⁵/29

R41676









LECTURES

ON

COMPARATIVE ANATOMY.

LECTURES

COMPARATIVE ANATOMY

TRANSLATED FROM THE FRENCH OF

G. CUVIER.

BY WILLIAM ROSS.

COMPARATIVE ANATOMY

OF THE CLASS OF MAMMALS

LONDON

Printed by J. JOHNSON, in Pall-mall.

*Ex Lib. Bib. Col. M.
Med. LECTURES ED. H. i.*

ON

COMPARATIVE ANATOMY.

TRANSLATED FROM THE FRENCH OF

G. CUVIER,

Member of the National Institute, Professor in the College of France, and in the
Central School of the Pantheon, &c.

BY WILLIAM ROSS;

UNDER THE INSPECTION OF

JAMES MACARTNEY,

Lecturer on Comparative Anatomy and Physiology in St. Bartholomew's Hospital, &c.

VOL. I.

ON THE ORGANS OF MOTION.

LONDON,

PRINTED, AT THE ORIENTAL PRESS, BY WILSON AND CO.

FOR T. N. LONGMAN AND O. REES, PATERNOSTER-ROW.

1802.

LECTURES
ON
ANATOMY
PREFACE
BY
J. C. WILKINSON
M.D.
F.R.C.S.
OF LONDON
Digitized by the Internet Archive
in 2016

PREFACE.

THE want of any thing like a System of COMPARATIVE ANATOMY—the extraordinary opportunities, talents and industry of Citizen CUVIER—and the acknowledged importance and utility of the subject, all contribute to render a translation of the present Work highly acceptable to the English Reader.

In conducting the translation which is here offered to the Public, all the care and diligence have been employed which the peculiar nature of the subject required.—

No

No labour or exertion has been spared by Mr. Ross ; and, in revising his manuscript, I have constantly and attentively compared it with the original Work, making such alterations as seemed necessary to render the Author's meaning more plain. The style is, of course, the Translator's own ; but I consider myself responsible for the fidelity of the Translation, as far as respects the science.

The names of the Muscles, which are introduced from the new French Nomenclature, have been rendered into Latin, as being most consistent with the general usage of Anatomists, and to avoid the circumlocution they would unavoidably produce in the English language. The same mode has been adopted with respect to many of the terms of Natural History. In every instance,
however,

however, where familiar or common language could with propriety be employed, it has been preferred. Considerable difficulty has been experienced in choosing proper English names to correspond with the genera and sub-genera contained in the Tables of Classification; and where these could not be found in popular use, it was judged more expedient to leave blanks, than to create English names, by only altering the termination of the word, which has been the plan pursued in the French Work, where the structure of the language made it more practicable.

I have taken the liberty of correcting some errors in the original, which seemed to have arisen from accidentally substituting one word for another; but in general the

strictest regard has been paid both to the Author's mode of description and expression, as making the chief merit in the translation of any work of science.

JAMES MACARTNEY.

LONDON, *March* 18, 1802.

TABLE
OF
CONTENTS.

VOL. I.

	<i>Page</i>
LETTER to J. C. MERTRUD,	xix

LECTURE I.

PRELIMINARY OBSERVATIONS ON THE ANIMAL ECO-	
NOMY,	1
ARTICLE I. <i>General View of the Functions of Animal</i>	
<i>Bodies,</i>	ib.
ART. II. <i>General Idea of the Organs of which the Animal</i>	
<i>Body is composed,</i>	20
ART. III. <i>View of the Principal Differences which Ani-</i>	
<i>mals exhibit in their several Organs,</i>	35
ART. IV. <i>View of the Relations which exist amongst the</i>	
<i>Variations of the several Organs,</i>	46
ART. V. <i>Division of Animals founded on the whole of</i>	
<i>their Organization,</i>	61

ib.

20354661

LECTURE II.

	<i>Page</i>
OF THE ORGANS OF MOTION IN GENERAL,	90
ART. I. <i>Of the Muscular Fibre</i> ,	<i>ibid.</i>
ART. II. <i>Of the Substance of the Bones, and the hard parts which supply their place</i> ,	105
ART. III. <i>Of the Articulations of the Bones, and their Motions</i> ,	125
ART. IV. <i>Of the Tendons, of the Composition of the Muscles, and of their Action</i> ,	135
ART. V. <i>General Remarks on the Skeleton</i> ,	146

LECTURE III.

OF THE BONES AND MUSCLES OF THE TRUNK,	152
ART. I. <i>Of the Bones of the Spine</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	156
1. <i>Number of the Vertebrae</i> ,	<i>ibid.</i>
2. <i>Proportions of the Spine</i> ,	160
3. <i>Form of the Vertebrae</i> ,	162
α. <i>Vertebrae of the Neck</i> ,	<i>ibid.</i>
β. <i>Vertebrae of the Back</i> ,	164
γ. <i>Vertebrae of the Loins</i> ,	165
δ. <i>Vertebrae of the Sacrum</i> ,	166
ε. <i>Vertebrae of the Tail</i> ,	167
C. <i>In Birds</i> ,	168
D. <i>In Reptiles</i> ,	173
E. <i>In Fishes</i> ,	178
ART. II. <i>Of the Muscles of the Spine</i> ,	181
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	186
a. <i>Muscles that raise the Tail</i> ,	188
b. <i>Muscles that depress the Tail</i> ,	189
c. <i>Muscles that bend the tail sideways</i> ,	191
C. <i>In</i>	

	<i>Page</i>
C. <i>In Birds</i> ,	192
D. <i>In Reptiles</i> ,	195
E. <i>In Fishes</i> ,	199
ART. III. <i>Of the Ribs and Sternum</i> ,	206
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	209
C. <i>In Birds</i> ,	211
D. <i>In Reptiles</i> ,	213
E. <i>In Fishes</i> ,	216
ART. IV. <i>Of the Muscles of the Ribs and Sternum</i> ,	218
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	222
C. <i>In Birds</i> ,	223
D. <i>In Reptiles</i> ,	224
E. <i>In Fishes</i> ,	225
ART. V. <i>Of the Motions of the Head upon the Spine</i> , ...	226
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	230
C. <i>In Birds</i> ,	234
D. <i>In Reptiles</i> ,	235
E. <i>In Fishes</i> ,	236
ART. VI. <i>Of the Muscles of the Head</i> ,	237
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	241
C. <i>In Birds</i> ,	242
D. <i>In Reptiles</i> ,	243
E. <i>In Fishes</i> ,	246

LECTURE IV.

OF THE ANTERIOR EXTREMITY, OR PECTORAL MEM-
BER,

243

ART. I. *Of the Bones of the Shoulder*,*ibid.*A. *In Man*,*ibid.*

b 2

B. *In*

	<i>Page</i>
B. <i>In other Mammiferous Animals</i> ,.....	250
C. <i>In Birds</i> ,	254
D. <i>In Reptiles</i> ,	257
ART. II. <i>Of the Muscles of the Shoulder</i> ,.....	259
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	263
C. <i>In Birds</i> ,	270
D. <i>In Reptiles</i> ,	271
ART. III. <i>Of the Bone of the Arm</i> ,	273
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	274
C. <i>In Birds</i> ,	277
D. <i>In Reptiles</i> ,	<i>ibid.</i>
ART. IV. <i>Of the Muscles of the Arm</i> ,	278
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	281
C. <i>In Birds</i> ,	286
D. <i>In Reptiles</i> ,.....	288
ART. V. <i>Of the Bones of the Fore Arm</i> ,.....	293
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	295
C. <i>In Birds</i> ,	300
D. <i>In Reptiles</i> ,.....	301
ART. VI. <i>Of the Muscles of the Fore Arm</i> ,	303
I. <i>Of the Flexors</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	304
C. <i>In Birds</i> ,	<i>ibid.</i>
II. <i>Of the Extensors</i> ,	305
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	306
C. <i>In Birds</i> ,	308
III. <i>Of the Supinators</i> ,.....	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	309
C. <i>In Birds</i> ,	<i>ibid.</i>
IV. <i>Of</i>	

	<i>Page</i>
IV. <i>Of the Pronators</i> ,.....	310
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	<i>ibid.</i>
C. <i>In Birds</i> ,.....	311
V. <i>Muscles of the Cubitus in Reptiles</i> ,.....	<i>ibid.</i>
ART. VII. <i>Of the Bones of the Hand</i> ,.....	312
I. <i>Of the Bones of the Carpus</i> ,.....	<i>ibid.</i>
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	315
II. <i>Of the Bones of the Metacarpus</i> ,.....	319
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	320
III. <i>Of the Bones of the Fingers</i> ,.....	321
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	322
IV. <i>Of the Bones of the Hand in Birds</i> ,.....	327
V. <i>Of the Bones of the Hand in Reptiles</i> ,.....	328
ART. VIII. <i>Of the Muscles of the Hand</i> ,.....	330
I. <i>Muscles of the Carpus, and Metacarpus</i> ,.....	<i>ibid.</i>
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	332
C. <i>In Birds</i> ,.....	333
D. <i>In Reptiles</i> ,.....	334
II. <i>Muscles of the Fingers</i> ,.....	335
A. <i>In Man, and other Mammiferous Animals</i> ,... <i>ibid.</i>	
1. <i>The Extensors</i> ,.....	<i>ibid.</i>
2. <i>The Abductors</i> ,.....	337
3. <i>The Flexors</i> ,.....	338
B. <i>In Birds</i> ,.....	339
III. <i>Short Muscles of the Fingers</i> ,.....	341
IV. <i>Table of the length, in Metres, of the different</i> <i>Parts of the Pectoral Member in Mammalia</i> ,.....	345
ART. IX. <i>Of the anterior Extremity of Fishes</i> ,.....	346
I. <i>Of the Bones</i> ,.....	<i>ibid.</i>
II. <i>Of the Muscles</i> ,.....	350

LECTURE V.

	<i>Page</i>
OF THE POSTERIOR EXTREMITY, OR ABDOMINAL MEM- BER,	353
ART. I. <i>Of the Bones of the Pelvis</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	357
C. <i>In Birds</i> ,	361
D. <i>In Reptiles</i> ,	363
ART. II. <i>Of the Muscles of the Pelvis</i> ,	364
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	365
C. <i>In Birds</i> ,	<i>ibid.</i>
D. <i>In Reptiles</i> ,	366
ART. III. <i>Of the Thigh Bone</i> ,	367
A. <i>In Man</i> ,	368
B. <i>In other Mammiferous Animals</i> ,	<i>ibid.</i>
C. <i>In Birds</i> ,	370
D. <i>In Reptiles</i> ,	<i>ibid.</i>
ART. IV. <i>Of the Muscles of the Thigh</i> ,	371
I. <i>Muscles of the Great Trochanter</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	373
C. <i>In Birds</i> ,	375
II. <i>Muscles of the Little Trochanter</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	377
C. <i>In Birds</i> ,	<i>ibid.</i>
III. <i>Muscles of the Thigh in Reptiles</i> ,	378
ART. V. <i>Of the Bones of the Leg</i> ,	380
A. <i>In Man</i> ,	381
B. <i>In other Mammiferous Animals</i> ,	383
C. <i>In Birds</i> ,	385
D. <i>In Reptiles</i> ,	<i>ibid.</i>
ART. VI.	

	<i>Page</i>
ART. VI. <i>Of the Muscles of the Leg</i> ,.....	386
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	388
C. <i>In Birds</i> ,.....	390
D. <i>In Reptiles</i> ,	391
ART. VII. <i>Of the Bones of the Ankle or Tarsus, and those</i> <i>of the Metatarsus</i> ,.....	393
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	395
C. <i>In Birds</i> ,	400
D. <i>In Reptiles</i> ,	401
ART. VIII. <i>Of the Muscles of the Ankle or Tarsus, and</i> <i>of the Metatarsus</i> ,.....	402
A. <i>In Mammalia and Birds</i> ,	<i>ibid.</i>
B. <i>In Reptiles</i> ,.....	407
ART. IX. <i>Of the Bones of the Toes, and their Motions</i> ,	409
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	<i>ibid.</i>
C. <i>In Birds</i> ,.....	411
D. <i>In Reptiles</i> ,	412
ART. X. <i>Of the Muscles of the Toes</i> ,	413
I. <i>The Extensors</i> ,	<i>ibid.</i>
A. <i>In Man</i> ,.....	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,.....	<i>ibid.</i>
C. <i>In Birds</i> ,	414
II. <i>The Flexors</i> ,	415
A. <i>In Man</i> ,	<i>ibid.</i>
B. <i>In other Mammiferous Animals</i> ,	416
C. <i>In Birds</i> ,	417
III. <i>Muscles of the Toes in Reptiles</i> ,	419
IV. <i>Table of the length in Metres of the different Parts</i> <i>of the Abdominal Member in Mammiferous Animals</i> , ..	420
ART. XI. <i>Of the Posterior Extremity in Fishes</i> ,.....	421
I. <i>Of the Bones</i> ,.....	<i>ibid.</i>
II. <i>Of the Muscles</i> ,.....	425

LECTURE VI.

	<i>Page</i>
OF THE ORGANS OF MOTION IN ANIMALS WITHOUT VERTÉBRÆ,	428
ART. I. <i>Organs of Motion in Mollusca Cephalopoda</i> , . . .	<i>ibid.</i>
1. <i>Muscles of the Body</i> ,	<i>ibid.</i>
2. <i>Muscles of the Feet</i> ,	429
3. <i>Muscles of the Suckers</i> ,	431
ART. II. <i>Organs of Motion in Mollusca Gasteropoda</i> , . . .	433
ART. III. <i>Organs of Motion in Mollusca Acephala</i> , . . .	436
ART. IV. <i>Organs of Motion in Crustacea</i> ,	443
I. <i>Of the Tail</i> ,	<i>ibid.</i>
1. <i>Solid Parts</i> ,	<i>ibid.</i>
2. <i>Muscles</i> ,	445
II. <i>Of the Feet</i> ,	448
1. <i>Solid Parts</i> ,	<i>ibid.</i>
2. <i>Muscles</i> ,	450
ART. V. <i>Organs of Motion in the Larvæ of Insects</i> , . . .	452
I. <i>Muscles of Caterpillars</i> ,	454
II. <i>Muscles of the Larva of a Scarabæus</i> ,	460
III. <i>Muscles of the Larva of a Hydrophilus</i> ,	464
IV. <i>Muscles of the Larva of a Cerambix</i> ,	466
ART. VI. <i>Of the Organs of Motion in perfect Insects</i> , . .	467
I. <i>Of the Head</i> ,	468
II. <i>Of the Corselet, or Thorax</i> ,	471
III. <i>Of the Pectus, or Breast</i> ,	472
IV. <i>Of the Abdomen, or Belly</i> ,	473
V. <i>Of the Members</i> ,	475
ART. VII. <i>Organs of Motion in Worms</i> ,	485
ART. VIII. <i>Organs of Motion in Zoophytes</i> ,	489

LECTURE VII.

	<i>Page</i>
OF THE ORGANS OF MOTION CONSIDERED IN ACTION,	494
ART. I. <i>Of Standing</i> ,	<i>ibid.</i>
A. <i>Standing on two feet, with the body vertical</i> ,	496
B. <i>Standing on two feet, with the body not vertical</i> , . .	502
C. <i>Standing on four feet</i> ,	505
ART. II. <i>Of Walking</i> ,	507
A. <i>Walking on two feet</i> ,	509
B. <i>Walking on four feet</i> ,	512
ART. III. <i>Of the Actions of Seizing and Climbing</i> , . . .	516
ART. IV. <i>Of Leaping</i> ,	520
ART. V. <i>Of Swimming</i> ,	525
ART. VI. <i>Of Flying</i> ,	534



ERRATA.

PAGE—LINE

For

Read

11—20	are of	are not of
42—24	<i>trachea</i>	<i>tracheæ</i>
78—1	single	single
81—16	<i>anseræ-birds</i>	<i>anserine birds</i>
84—17	in	on
84—29	from	form
184—3	between the longissimus	between the upper part of the longissimus
188—10	<i>lumbo-supra-caudalis</i>	<i>Lumbo-supra caudales</i>
217—20	<i>salmo rhomboides</i>	<i>salmo rhomboides</i>
<i>ibid.</i> —21	<i>Syngnathus hippocampus</i> , or little sea horse	<i>Syngnathus hippocampus</i> , or little sea horse
<i>ibid.</i> —23	his skin, which surrounds his body	its skin, which surrounds its body
281—5	muscles	muscle
293—7	(<i>epitrochlée</i>) and the external (<i>epicondyle</i>)	the <i>epitrochlea</i> , and the external, the <i>epicondyle</i>
355—20	bone	line
383—20	exterior	extensor
415—3	<i>Tarso-phalangeus</i>	<i>Tibio-phalangeus</i>

LETTER

FROM

G. CUVIER,

Of the National Institute of France, &c.

TO

JEAN CLAUDE MERTRUD,

Professor of the Anatomy of Animals in the Museum of Natural
History, Paris.

THE Book I address to you, owes to you its existence; for, whatever interest my Lectures may possess, has arisen from the use which you and your colleagues have permitted me to make of the excellent collection now entrusted to your care—that collection, to the perfection of which you have so greatly contributed, and from which Daubenton drew, while he formed it, materials for the most important part of an immortal work*.

Enriched

* Citizen Mertrud held the situation of Demonstrator of Anatomy in the Garden of Plants, from 1750, until that establishment was converted into a School of Natural History, when

Enriched by the assiduous labours of an enlightened administration, this collection now surpasses every thing of the kind that exists. It presents, in an arranged and systematic order, the most extensive development of all the parts of the animal body, prepared in species the most opposite—from those which, by their perfection, approach nearest to man, to those in which we perceive only a pulp scarcely organized: thus the study of Comparative Anatomy is rendered almost an amusement. A slight view is sufficient to enable us to perceive the variations and successive gradations of each organ: but the effects which these organs produce, remain still unexplained; because there is, in living bodies, something more than those tissues and fibres which the eye can trace; because the mechanical part of the organization is,

as

when he was appointed Professor of Comparative Anatomy. He assisted Daubenton in preparing his Anatomical account of most of the quadrupeds described in the Great Natural History; and Buffon, who loved and esteemed him, has complimented his talents in several of the volumes of that immortal work. His patriotism has induced him to refuse some distinguished appointments in foreign countries, and, among others, that of first surgeon to the King of Naples, which was offered to him in 1770, and that of first surgeon to the King of Spain, to which he was nominated in 1772. He is the inventor of several ingenious processes relative to making anatomical preparations,

as it were, only the passive instrument of vitality; and because there occurs, between the first impression of the imperceptible elements and the ostensible motion which is its last effect, an infinite number of intermediate actions, of which no idea has hitherto been formed.

How many combinations and decompositions have taken place in this interval! How many affinities have been brought into action!—What Physiologist is bold enough to hazard conjectures on the greater number of the operations which are performed in the impenetrable laboratory of the animal body? Notwithstanding the successful efforts of our co-temporaries, human Chemistry is but in its infancy when compared with that of Nature!

These difficulties, however, should not discourage us; and the Anatomist must make the first attempts to overcome them. It is his province to disclose to the Physiologist the material part of the phænomena and the instruments by which the processes are carried on; to describe the canals through which the fluids circulate, and to follow all their ramifications and discover all their communications. It belongs to him to measure the velocity and determine the direction of each motion.

But to perform this task in a satisfactory manner, he must not be contented merely with
a view

a view of what constitutes the individual character of the phænomena. It is necessary he should in particular distinguish what forms the general and necessary condition of each. To do this he ought to examine all the modifications that may result from their various combinations with other phænomena; and also, separate or disengage them from all the necessary circumstances with which they are involved. In short, he must not limit himself to a single species of organized beings, but must compare the whole; pursuing life, and the phænomena of which it consists, throughout all animated nature. These are the only means by which he can hope to remove the mysterious veil which conceals the essence of vitality.

Physiology, indeed, is necessarily in the same state as other physical sciences, which, from the complication and obscurity of the phænomena, have not hitherto been submitted to calculation. Possessing no demonstrated principle, whence the particular facts might be deduced as consequences, the whole science consists as yet in the series of these facts only; and we cannot hope to discover general causes but in proportion as we may be able to class the facts, and succeed in arranging them under certain common laws. But physiology does not possess the same advantage for attaining this object as those

those sciences which are applied to the examination of inorganic substances ; as for example, chemistry and experimental philosophy. The problems to be solved by the latter sciences, may be reduced to a simplicity almost indefinite ; and the substances, the nature and relations of which are to be investigated, may be separated from those with which they are connected, and successively combined with others. Far narrower are the bounds of physiological enquiries : all the parts of a living body are connected : they can perform no functions except when they act in union : to separate one from the mass, is to reduce it to the rank of inert matter, which is an entire change of essence. The machines which are the object of our researches, cannot be demonstrated without being destroyed. We have no means of discovering what would result from the absence of one or several of their parts, and consequently we remain ignorant of the operation of each of these parts, in producing the total effect.

Fortunately Nature herself seems to have prepared for us the means of supplying that want which arises from the impossibility of making certain experiments on living bodies. The different classes of animals exhibit almost all the possible combinations of organs : we find them united, two and two, three and three, and in
all

all proportions ; while at the same time it may be said that there is no organ of which some class or some genus is not deprived. A careful examination of the effects which result from these unions and privations is therefore sufficient to enable us to form probable conclusions respecting the nature and the use of each organ, or form of organ.

In the same manner we may proceed to ascertain the use of the different parts of the same organ, and to discover those which are essential, and separate them from those which are only accessory. It is sufficient to trace the organ through all the classes which possess it, and to examine what parts constantly exist, and what change is produced in the respective functions of that organ, by the absence of those parts which are wanting in certain classes.

But our researches must not be confined to a few species. One which is overlooked frequently, contains an exception fatal to a whole system ; and the method of reasoning, in physiology, just pointed out, acquires weight only in proportion as we approach to a perfect knowledge of the anatomy of animals. The latter science therefore cannot, in its present state, conduct us directly to certain discoveries, though it already forms a touchstone for the results obtained by every other means ; and a single fact, in Comparative

Anatomy,

Anatomy, often suffices to overthrow a complete train of physiological hypotheses.

The importance of Comparative Anatomy has therefore been at all times acknowledged. The abuse which prevailed towards the end of the 17th century, of so often describing the human body from the dissections of animals, was the cause of this branch of science being so much neglected during the early part of the present century. But the study has been resumed with ardour, and a number of eminent men have, for some time past, made it the object of their peculiar attention.

It is due to the National Museum of Natural History at Paris, to observe, that the learned men connected with that establishment, have constantly contributed to promote and encourage this study. The names of *Duverney*, *Ferrein*, and *Petit*, are celebrated in the annals of Science. *Buffon* gave a new attraction to Comparative Anatomy, by displaying its importance as the foundation of characters in Natural History; and the vast labours of his worthy assistant *Daubenton*, render it henceforth the fixed basis of Zoology. The latter encouraged, and aided by his advice, as well as by the use of the subjects entrusted to his care, another of your pupils, who would have carried this science to its height, had not the misfortunes of the times

6

deprived

deprived us of his talents in the vigour of life. As an elegant writer, an ingenious physiologist, and a profound anatomist, *Vicq-d'Azyr* never can be replaced; but fortunately those who formed him still exist; the treasures which were confided to him have increased; and the superintendants of those treasures will still find men equally grateful for their use, and equally devoted to the promotion of knowledge.

The learned men who compose the present administration of the Museum, are worthy of imitating the glorious examples of their predecessors. I have received from them, as well as from you, all the assistance I could have expected from an enlightened love for science, rendered more grateful by all the attentions the most generous friendship could suggest. Nothing has been spared that could lead to discoveries, or to the completion of the system of our knowledge in Comparative Anatomy. The correspondents of the Museum have imitated the example of its depositories. Citizen *Baillon*, in particular, so well known by the valuable observations which he furnished to Buffon, and by those which he continues to make, procured me, with unexampled zeal and generosity, the rarest birds and fishes. Citizen *Hombert* of Havre, who has applied with the greatest success to the study of Mollusca and Sea Worms, has favoured me
with

with a great number of these animals, the perfect preservation of which rendered their examination exceedingly useful. Citizens *Beauvois*, *Bosc*, and *Olivier*, the two first returned from North America, the third from Egypt and Persia, have kindly communicated to me some of the valuable specimens they have brought to Europe. I have therefore no reason to envy the good fortune of ARISTOTLE, when a conqueror, who was the friend of the sciences, made other men subservient to him, and placed millions at his disposal, to enable him to forward the History of Nature.

This assertion will not surprize, when it is known that I have been permitted to dissect not only the animals which have died in the menagerie, but also those which have been brought, during a great number of years, from all parts of the world, and preserved in spirits. Time only was capable of bringing this collection to its present degree of perfection, and has, in this instance, performed what no other power was capable of accomplishing.

In opening to me your treasures—in admitting me to a share of the labours necessary to their arrangement and their augmentation, you have imposed upon me only one condition: that is, to enable other naturalists to enjoy them, by giving such a description of them as they merit.

You know with what assiduity I endeavour to perform this task, but you also know better than any other what time such a work requires. However rich may be the acquisitions that are made, more will still be desired. Sometimes a new species is discovered, which we wish to compare with those we already know. Sometimes the consideration of an organ induces us to make farther attempts to develope its structure. On other occasions it is necessary to extend our observations; because something remains to be learned respecting the object as a whole or the relation of its parts. In Natural History, in particular, we are always dissatisfied with what we perform, for nature proves to us at each step that she is inexhaustible. The mechanical part alone, as making preparations, drawings, and engravings, require a time which no care and no expence can abridge.

I cannot therefore reasonably expect to finish my work for several years. But, in the mean time, I endeavour to disclose to young anatomists all that is new and important in the collections: I explain to them the relations which facts already permit us to perceive. I do not merely confine myself to an exposition of the observations contained in printed books, but conceal none that I have had the opportunity of making myself, in following, though at a distance,

tance, the footsteps of those celebrated authors who have preceded me. This frankness, and the efforts I have made to render the body of the science as complete as the present state of our knowledge would permit, having attracted to my class some pupils distinguished for their talents and assiduity, they have taken the trouble to collect my lectures in a very accurate manner. Different manuscripts have been drawn up from these notes, which may be considered as elementary works, varying in their manner, and I believe more complete in the materials, than any that have hitherto appeared on Comparative Anatomy. Imperfect as these manuscripts must in many respects be, several copies have got into circulation, which have been usefully employed by other Lecturers, and even in some printed works. This is a slight abuse, which, though it will not prevent me from continuing to communicate my own observations to all who may wish to be acquainted with them, is, however, sufficient to induce me to secure to myself, by means of the press, the property of some.

A reason of another kind has also contributed to determine me to consent to the publication of one of these manuscripts; and that is, the advantage which the students attending any course must derive from possessing a ~~work~~ that details,

in a suitable order, the facts of which the professor proposes to treat. It is almost impossible that this detail should be accurately given by a public speaker, who is naturally led to expatiate most on those subjects which are best calculated to attract the attention of his auditors; and besides the rapid succession of facts, prevents the student from fixing on them with sufficient attention, especially when they are so numerous and so varied as in Comparative Anatomy. Finally, it appeared to me that this publication might also prove both agreeable and useful, not only to those anatomists who have it not in their power to hear my lectures, but to all persons who apply themselves to the study of Physiology and Natural History, who have hitherto possessed no book in the form of a complete system on the internal organization of animals. Though the present ought not, and indeed cannot be considered in any other light than as a kind of abridgement or program of the great work in which I am engaged; it is not the less true, that it already contains a vast collection of facts, and that it may serve as the basis of more extensive researches. Perhaps it may prove an inducement, to persons interested in its object, to publish the new or separate facts that occur to them, and which may occupy a place in my great work.—Perhaps important views and corrections

rections may be pointed out to me. In a word, I shall not regret that I have submitted an imperfect work to the eye of criticism, if it may be hereafter the means of procuring, either through myself or others, some advantage to Science.

These Lectures were drawn up from my oral demonstrations by Citizen Dumeril, one of my dearest pupils and best friends, and whose talents have been lately rewarded by a public appointment to the important place of Chief of the Anatomical Labours of the School of Medicine. Having attended my course during four years, he has collected all my observations with so much accuracy, that it would have been difficult for me to have performed the task better. I have revised his manuscript with the greatest care. I have every where supplied details which could not be conveniently introduced in public lectures. I have rectified such statements as I had advanced too rashly. I have added every information connected with these lectures that I have obtained since their delivery by my dissections and reading. I therefore do not hesitate to acknowledge this work as my own, and to avow all the assertions it contains.

It is not, however, with his pen only that Citizen Dumeril has contributed to this work. He always assisted me in the numerous dissec-

tions I found it necessary to make. He conducted several of these dissections, according to views peculiar to himself, and suggested by his extensive knowledge in natural history and physiology. I am indebted to his perspicuity for a number of interesting observations and curious facts, which would have escaped me.

I am also much indebted to the complaisance of Citizen Rousseau, your assistant anatomist in the Museum of Natural History. Equally modest and indefatigable, he merits the thanks of all anatomists for the laborious duty he performs under your direction, in preserving and augmenting the anatomical collection. Without his assistance it would have been impossible for me to have rendered my lectures worthy of publication.

The necessity of such assistance will be easily conceived, when it is considered how many dissections are required in preparing a work of this kind, and how seldom opportunities occur for dissecting certain species. He who describes only the human body, may proceed at his leisure in the examination of a subject, of which only some minute parts remain to be discovered, and which he may always replace whenever he wishes to verify or correct his observations. But he who studies the structure of other animals, when he has a new subject to dissect, is obliged
to

to describe every part ; and if the species be also scarce, or that he has no hope of seeing it again, and cannot expect to be able to rectify his observations, he is under the necessity of making his researches as accurate as extensive. He must therefore pass his days and his nights in pursuits no less unhealthful than laborious.

It would indeed be impossible for one man to undergo the fatigue of even the purely mechanical part of the studies necessary in forming a system of Comparative Anatomy, were he not seconded by friends as zealous as himself for the progress of knowledge.

The reader will easily perceive that this assistance must have been extremely useful to me, as my Lectures are all founded on observation, and as, except a few facts, the authorities for which I have carefully cited, I have advanced nothing which is not consistent with my own knowledge. On this account I have thought numerous references unnecessary in this publication, though I shall not neglect them in my greater work ; because I consider these quotations as a tribute of respect paid to the memory of the first discoverers of useful facts. In omitting the names of authors, therefore, I do not pretend to any priority of observation, but I would have it understood that the statements I make may be considered as additional authorities

ties to those which already exist, respecting the same facts.

I must also observe, that this omission of citations as to the facts I have had the opportunity of proving myself, and which I have frequently demonstrated publicly in my class, or the proofs of which are deposited in the Anatomical Collection of the Museum, arose from the consideration, that these public demonstrations and expositions rendered all other authorities unnecessary, and not from my negligence in inquiring what others had performed before me. I believe I have not remained far behind my predecessors: in many cases I have found it more easy to resort to Nature, than to endeavour to explain the obscure and unsatisfactory descriptions of some moderns, or to spend my time in bringing to light a few valuable observations, which lie buried amidst the discussions of scholastic philosophy, which fill the pages of the authors of the sixteenth century: but this method, which relieves me from the necessity of having recourse to compilation, I regard as an advantage, procured to me by my fortunate situation, and by no means as a ground of censure.

I have, besides, been more particularly dissuaded from using foreign materials, by observing the imperfect works which some estimable authors, who wanted the means of observation, have

have produced by that mode of compilation : it was impossible they should avoid making false statements, since they had to rely upon incorrect, and even contradictory authorities ; and as the constant view of Nature did not restrain the flights of their imaginations, they could not resist the temptation of forming systems, nor secure their judgments from a partiality that induced them to select, in preference, those facts which were most favourable to their own ideas.

You will easily conceive, that the greater number of these authors are found among a people, who, though celebrated for their inventive genius, and indefatigable patience in every kind of research, have not always been able to confine, within due bounds, their desire to display erudition—a desire which perhaps proceeds from too much modesty, and a mistaken deference for others.

Another people, no less admirable for their bold views, and vigorous prosecution of the sciences, seem to have fallen into the opposite excess of that which I have just blamed, by contemning the labours of foreigners, and esteeming, and even consulting, almost exclusively, the works of their own countrymen. This kind of pride, which is perhaps useful in politics, when carried into the sciences, and above all in the sciences which depend on facts, tends only to pro-

duce contracted ideas, and leads to a barrenness which forms the character of some of their authors in Natural History and Comparative Anatomy.

I hope you will find that I have done every thing in my power to avoid these two errors; and that, though resolved always to examine nature myself, I have not attempted to proceed without guides, but have followed those who were capable of leading me in new or useful paths.

I believe I have made use of the principal discoveries of the modern authors, who have treated Anatomy in a physiological manner. Stenon, Swammerdam, Collins, Duverney, Petit, Lyonnet, Haller, Monro, Hunter, Geoffroy, Vicq-d'Azyr, Camper, Blumenbach, Scarpa, Comparetti, Kiemeier, Poli, Harwood, Barthé, have furnished the data with which I commenced my career; and though I have myself reviewed a considerable part of these data, the glory of discovering them is not the less due to the celebrated men I have mentioned; and, had it not been for their writings, the greater number of facts recorded in this work would have escaped my notice.

I ought also to acknowledge the advantages I have derived from the most modern naturalists. Since Nature is at last adopted as the basis of all arrangement in Natural History, the relations
of

of that science with Anatomy are become more intimate; the one cannot advance a step, which will not tend to the advantage of the other; the connections which the first establishes, frequently indicate researches, which the other ought to make: thus, without mentioning Daubenton and Pallas, equally placed in the first rank in either science, I am much indebted for views, and, above all, for the regularity of my plan, to the modern zoologists, among whom I ought, in particular, to name Ray, Klein, Linnæus, Buffon, Lacépède, Lamarck, Bloch, Fabricius, Latreille, and all those who have, by different ways, attempted to approach that simple natural method of classification, which ought to be the object of all the efforts of naturalists, though it may perhaps be the philosopher's stone of their art.

As some of these celebrated men honour me with their friendship, I have profited no less by their conversation than by their writings. Several of my ideas have originated in theirs, which I have so generally adopted, that it is with difficulty I can recognize what I owe to each of them.

I have endeavoured to approach nearer to a natural arrangement in the tables connected with this work, than I did in my *Elements of Zoology*. I have made several changes in the distribution

bution of the animals, which appear to me very advantageous; and I also owe a part of these improvements to the researches of the learned men I have just named. It will be easily discovered that I have profited by the works of Citizen Lacépède on Birds and Mammalia, by that of Citizen Lamarck on the Testacea, and that the division of Reptiles is the same which has been lately proposed by Citizen Brongniard.

In this avowal, you will doubtless recognize the desire of rendering a lasting testimony of the gratitude I owe to all whose ideas and labours have proved useful to me in the execution of this work; but I have also another object, which, perhaps, may escape your observation: it is my wish to promote and maintain that amiable and meritorious spirit of communication, which now prevails among the greater number of Naturalists. Employed in cultivating together the vast field of Nature, they may be said to live in a community of labour and advantage: if one, therefore, discover a fact, it is of little importance whose name is attached to it.

I besides rely on the judgment of persons skilled in Anatomy, to distinguish the observations which are peculiar to myself; and I hope they will find them sufficiently numerous to justify my consent to the premature publication of these Lectures. I may be permitted to express
this

this hope with the greater freedom, as I pretend to no other merit in preparing them, than that of having profited by a very favourable situation.

In the part which relates to Human Anatomy, I have not attempted to make any new observations: on that branch of the subject I have just said what appeared necessary to recal the idea of the parts to the Reader; and though my descriptions have actually been taken from the dead subject, some details in Neurology excepted, for which I have followed Sabattier and Sœmmering, they differ from those of my predecessors only in the expression.

Citizen *Dumeril* has almost every where inserted his new nomenclature, which is analogous to that proposed by Citizen *Chaussier*, and which Citizens *Dumas* and *Girard* have each modified according to their manner. Without attaching much importance to this improvement, I may observe, that it would be useful, were Anatomists to agree in fixing the language of their art.

Physiology occupies only an accessory place in these Lectures. I have only occasionally introduced it, to diminish a little the unavoidable tediousness of anatomical descriptions, and to point out different views, which Comparative Anatomy may furnish to the physiologist.

For the same purpose I have sometimes stated facts, which belong more particularly to what

is strictly called Natural History. It was found frequently necessary to remind the Reader of some fact, calculated to support the anatomical theories, or to indicate some corrections, which the observations of Comparative Anatomy render necessary in methodical classifications.

Such are the motives which have induced me to publish these Lectures. I have now only to express my hope, that Naturalists will not accuse me of having taken this step too hastily, and that the utility they may find in the work will appear to them sufficient to excuse its present imperfections.

Grant me then that indulgence, which, if not due to the importance of this Work, is at least merited by the sincere and respectful sentiments with which it is presented to you, by your Disciple and Friend.

G. CUVIER.

Garden of Plants,
28th of Ventose, and Year 8 (1800.)

LECTURES
ON
COMPARATIVE ANATOMY.

LECTURE FIRST.

PRELIMINARY OBSERVATIONS UPON THE
ANIMAL ŒCONOMY.

ARTICLE I.

General View of the Functions of Animal Bodies.

THE idea of *Life* is one of those general and obscure ideas produced in us by observing a certain series of phænomena possessing mutual relations, and succeeding each other in a constant order. We know not indeed the nature of the link that unites these phænomena, but we are sensible that a connexion must exist; and this conviction is sufficient to induce us to give it a name, which the vulgar are apt to regard as the sign of a particular principle, though in fact that name can only indicate the totality of the phænomena which have occasioned its formation.

Thus, as the human body, and the bodies of several other animals resembling it, appear to resist, during a certain time, the laws which govern inanimate bodies, and even to act on all around them in a manner entirely contrary to those laws, we employ the terms *life* and *vital force* to designate what are at least apparent exceptions to general laws. It is, therefore, by determining exactly in what the exceptions consist, that we shall fix the meaning of those terms. For this purpose, let us consider the bodies I have mentioned, in their active and passive relations with the rest of nature.

For example, let us contemplate a female in the prime of youth and health. That elegant voluptuous form—that graceful flexibility of motion—that gentle warmth—those cheeks crimsoned with the roses of delight—those brilliant eyes, darting rays of love, or sparkling with the fire of genius—that countenance, enlivened by sallies of wit, or animated by the glow of passion, seem all united to form a most fascinating being. A moment is sufficient to destroy this illusion. Motion and sense often cease without any apparent cause. The body loses its heat; the muscles become flat, and the angular prominences of the bones appear; the lustre of the eye is gone; the cheeks and lips are livid. These, however, are but preludes of changes still more horrible. The flesh becomes successively blue, green, and black. It attracts humidity, and
while

while one portion evaporates in infectious emanations, another dissolves into a putrid sanies, which is also speedily dissipated. In a word, after a few short days there remains only a small number of earthy and saline principles. The other elements are dispersed in air, and in water, to enter again into new combinations.

It is evident that this separation is the natural effect of the action of the air, humidity and heat—in a word, of external matter upon the dead body; and that it has its cause in the elective attraction of those different agents for the elements of which the body is composed. That body, however, was equally surrounded by those agents while living, their affinities with its molecules were the same, and the latter would have yielded in the same manner during life, had not their cohesion been preserved by a power superior to that of those affinities, and which never ceased to act until the moment of death.

Of all the phænomena, the particular ideas of which enter into the general idea of life, this is what at first sight appears to constitute its essence, since we can form no conception of life without it, and since it evidently exists without interruption until the instant of dissolution.

But a further study of any living body convinces us, that the power which preserves the union of the *moleculæ*, notwithstanding the external forces which tend to separate them, does not confine its activity to this tranquil operation,

tion, and that the sphere of its action extends beyond the bounds of the living body itself. At least it does not appear that this power differs from that which attracts new *moleculæ* to deposit them between those that already exist: and this action of the living body, in attracting the surrounding *moleculæ*, is not less constant than that which it exercises in retaining its own; for, besides that the absorption of the alimentary matter, its conversion into nutritive fluid, and its subsequent transmission to all the parts of the body, experiences no interruption, and continues from one repast to the other; another absorption constantly takes place at the external surface, and a third by the effect of respiration. The two latter are those only which exist in all living bodies which do not digest, that is to say, in all plants.

Living bodies however do not increase indefinitely. Nature has assigned to each limits which it cannot exceed. It follows, therefore, that they must lose, in one way, a great part of what they gain in another; and indeed an attentive observation has convinced us, that transpiration, and a number of other causes, tend continually to diminish their substance.

This consideration must modify the idea which we at first formed from the principal phenomenon of life. Instead of a constant union in the *moleculæ*, we cannot avoid observing, that there is a continual circulation from the exterior to the

the interior, and from the interior to the exterior of bodies—a circulation which, though uniformly preserved, is notwithstanding fixed within certain limits. Thus living bodies may be considered as a kind of furnaces, into which inert substances are successively thrown, which combine among themselves in various manners, maintain a certain place, and perform an action determined by the nature of the combinations they have formed, and at last fly off in order to become again subject to the laws of inanimate nature.

It must be observed, however, that there is a difference, depending on age and health, in the proportion of the parts which enter into this torrent, and those which abandon it; and that the velocity of the motion usually varies according to the different conditions of each living body.

It appears, at the same time, that life is terminated by causes similar to those which interrupt all other known motions; and that the hardening of the fibres, and the obstruction of the vessels, render death the necessary consequence of life, as repose is of motion, even though the crisis were not accelerated by innumerable causes which are foreign to the living body.

This general and common motion of all the parts forms so peculiarly the essence of life, that the parts which are separated from a living body soon die, because they possess no motion

of their own, and only participate in the general motion produced by their union. Thus, according to the expression of Kant, the mode of existence of each part of inanimate bodies belongs to itself, but in living bodies it resides in the whole.

The nature of life, as above described, being once well ascertained by the observation of the most constant of its effects, it would naturally be wished to investigate its origin, and to inquire how it is communicated to the bodies it animates. Living bodies have therefore been traced to their infancy; and it has been endeavoured to carry this examination as near as possible to the moment of their formation. But they have never been observed otherwise than completely formed, and already enjoying that vital force, and producing that vortex-like motion, the first cause of which we are desirous of knowing. In fact, however feeble and minute the parts of an embryo, or of the seed of a plant, may be at the moment we are first capable of perceiving them, they then enjoy a real life, and possess the germ of all the phænomena which that life may afterwards develope. These observations, extended to all the classes of living bodies, lead to this general fact, that there are none of those bodies which have not heretofore formed part of a body similar to itself, from which it has been detached. All have participated in the existence of other living bodies, before

fore they exercised the functions of life by themselves ; and it was even by means of the vital force of the bodies to which they formerly belonged, that they were enabled to develope themselves so completely as to become capable of enjoying separate vitality ; for, though the particular action of copulation is necessary for the production of a number of species, many are produced without it ; copulation, therefore, is only a circumstance peculiar in certain cases, and does not change the essential nature of generation. It appears then that the motion proper to living bodies has really its origin in that of their parents. It is from them they have received the vital impulse ; and hence it is evident, that, in the actual state of things, life proceeds only from life, and that there exists no other except that which has been transmitted from one living body to another by an uninterrupted succession.

Unable to ascend to the origin of living bodies, there remains then within our reach no source of information respecting the real nature of the powers which animate them, except the examination of the composition of those bodies, that is to say, of their texture, and the composition of their elements : for, though it may be truly said, that this texture, and this composition, are in some manner the result of the action of the vital impulse which has given them being, and which maintains them ; it is also evident,

that in them only this impulse can have its source and foundation: and if the first union of the chemical and mechanical elements of any living body has been effected by the vital force of the body from which it descended, we ought to find in it a similar power, and also the causes of that power, since it has to exercise a like action in favour of the bodies which are to descend from it.

But this composition of living bodies is too imperfectly known to enable us to deduce clearly from it the effects they exhibit. We observe, in general, that they are composed of fibres or laminæ, forming altogether a series of reticulated substances more or less compact, which form the bases of all their solids, as well of those that are massy, as of those that present the appearance of laminæ and filaments. We are acquainted with the form, the consistence, and the position of the larger of those solids; the ramifications of the most considerable of their vessels, and the course of the fluids they contain: but their more minute branches, and their more secret texture, cannot be traced by our instruments. We likewise know the chemical characters of the most apparent of the different fluids and concrete substances: we can even decompose them to a certain point. This analysis, however, is not only imperfect, since we cannot recompose them, but the phenomena indicate, that there must exist several
other

other fluids which it has hitherto been impossible for us to discover.

The efforts hitherto made by naturalists to prove a connexion between the phænomena of living bodies and the general laws of nature, have doubtless been unsuccessful. It would, however, be wrong, on that account, to conclude that those phænomena are absolutely of a different kind; but, on the other hand, there would be much temerity in resuming this task, while our knowledge of the bodies in which the phænomena appear is so limited. We should be able to give only an empirical exposition, instead of a rational system. All our labours on organic œconomy must therefore be confined to its history.

If, however, our knowledge of the composition of living bodies be not sufficient for the explanation of the phænomena they exhibit, we may at least employ it in recognizing those bodies when out of a state of action, and in distinguishing their remains long after death; for we find in no inert body that fibrous or cellular texture, nor that multiplicity of volatile elements which form the characters of organization and organized bodies, whether in those that are alive, or in those that have lived.

We know that inert solids are composed only of polyædrous moleculæ, which attract each other by their sides, and never move except to separate—that they resolve into a very small
number

number of elementary substances with respect to our instruments—that they are formed of the combination of those substances, and the accumulation of those molecules—that they grow only by the juxtaposition of new molecules, the strata of which envelope the preceding mass—and that they are destroyed only by some mechanical agent separating their parts, or some chemical agent altering their combinations; but organized bodies, which are tissues of fibres and laminæ, and have their interstices filled with fluids, resolve almost entirely into volatile substances, are produced by bodies similar to themselves, from which they do not separate until they are sufficiently developed to act by their own force; constantly assimilate foreign substances, and deposit them between their particles; grow by an internal power, and finally perish by that internal principle, or by the effect of life itself.

Origin by *generation*, growth by *nutrition*, termination by *death*, are the general and common characteristics of all organized bodies: If, however, there are bodies which perform only these functions, and those which are subsidiary to them, and possess only the organs necessary for such operations, there are a great number of others which perform particular functions, that not only require appropriate organs, but necessarily modify the manner in which the general functions are performed, and the organs proper to those functions.

Among

Among the less general faculties which indicate organization, but which are not the necessary consequences of it, the faculty of sensation, and that of voluntary motion, in whole or in part, are the most remarkable, and those which have the greatest influence on the other functions.

We are conscious that these faculties exist in ourselves, and we attribute them, by analogy, and from their apparent existence, to a number of other beings, whom we therefore name *animated* beings, or, using a single word, *animals*.

It appears that these two faculties are necessarily connected, the idea of *sensation* is even included in that of *voluntary motion*; for we cannot conceive volition without desire, and unaccompanied by the sentiment of pleasure or pain. There may indeed exist inanimate bodies, that manifest external motion produced by an internal principle; but their movements are of the same nature as those which constitute the functions essential to life, and do not merit the name of voluntary.

On the other hand, the bounty which nature displays in all her productions, does not permit us to believe that she has deprived beings susceptible of sensation; that is to say, of pleasure and pain—of the power, in a certain degree, of avoiding the one and pursuing the other.—Among the misfortunes which afflict our species, one of the most painful is the situation of a man
of

of courage withheld by a superior power from resisting oppression; and the poetic fictions best calculated to excite compassion, are those which represent sentient beings inclosed within immoveable bodies. The sighs of Clorinda issuing, with her blood, from the trunk of a cypress, would arrest the fury of the most savage of mortals*.

But, independently of the chain which connects the two faculties, and the double system of organs they require, they are accompanied by several modifications in those faculties which are common to all organized bodies: these modifications, joined to the two first mentioned faculties, are what more particularly constitute the nature of animals.

With respect to nutrition, for example, vegetables, which are attached to the soil, absorb immediately, by their roots, all the nutritive
parts

* In this elegant illustration, Citizen Cuvier has made a very happy use of the fable of Tasso:

- ‘ Pur tragge al fin la spada, e con gran forza
- ‘ Percote l’alta pianta; O meraviglia:
- ‘ Manda fuor sangue la recisa scorza,
- ‘ E fa’ la terra intorno a se vermiglia:
- ‘ Tuto si raccapriccia, et pur rinforza
- ‘ Il colpo, e’l fin vederne ei si consiglia.
- ‘ Allhor, quasi di tomba, uscìr ne fente,
- ‘ Un’ indistinto gemito dolente. &c.’

See *La Giernusalemme Liberata*—Canto XIII.

TRANSLATOR.

parts of the fluids which they imbibe. These roots are subdivided to extreme minuteness; they penetrate into the smallest interstices, and proceed, if it may be so said, to seek at a distance food for the plant to which they belong. Their action is tranquil and uniform, and never is interrupted except when deprived by drought of the juices which they require.

Animals, on the contrary, which are not fixed, and which frequently change their place, can transport with themselves a portion of the substances necessary for their nutrition: they have therefore received an internal cavity, into which they deposit the matters destined for their aliment; and the inward surfaces of this cavity are furnished with innumerable absorbing pores or vessels, which, according to the energetic expression of Boerhaave, are real *internal roots*: the magnitude of this cavity, in a number of animals, permits them to introduce solid substances into it. It was necessary, then, that they should have instruments for dividing those substances, and liquors for dissolving them. In a word, with such animals nutrition does not immediately commence upon the absorption of the substances which the soil or the atmosphere furnish them. It is necessarily preceded with a vast number of preparatory operations, the whole of which constitute *digestion*.

Thus, it appears, that digestion is a function of a secondary order, proper to animals, the existence

ence of which, as well as of the alimentary canal in which it is performed, is rendered necessary by the faculty they possess of voluntary motion; but this is not the only consequence of that faculty.

The faculties of vegetables being very few, their organization is very simple; almost all their parts are composed of fibres, which are either parallel, or diverge very little. Farther, their fixed position admits, that the general motion of their nutritive fluid may be preserved by simple external agents. It appears that it proceeds upwards, by the effect of the suction of their spongy or capillary texture, and the evaporation which takes place at their top, and that its motion in that direction is the more rapid in proportion as the evaporation is great. It appears also that the motion of this fluid may even become retrograde, when it ceases to flow in its usual course, or changes into absorption by the coolness and humidity of the air.

It is not only necessary that animals destined continually to change their place of existence, and to live in all kinds of situations and temperatures, should possess within themselves an active principle of motion for their nutritive fluid; but, their more numerous and more developed faculties requiring a much greater complication of organs, their various parts being differently formed, often at a distance from each other, and even capable of changing their respective positions and directions, means more
powerful,

powerful, and otherwise disposed than in vegetables, are necessary for transmitting this fluid through such a multiplicity of intricate windings.

In the greater part of animals, therefore, this fluid is contained in innumerable canals, which are the ramifications of two trunks communicating with each other, in such a manner that the one receives in its roots the fluid which the other has pushed into its branches, and carries it back to the centre, to be again driven forward from that point.

Where the two great trunks communicate, the heart is placed: it is merely an organ, the contractions of which drive this fluid forward with great force into all the ramifications of the arterial trunk. It has two orifices, the valves of which are so disposed that the fluid contained in the whole vascular system can proceed in no other manner than in that we have pointed out; that is to say, from the heart towards the other parts of the body by the *arteries*, and from those parts back to the heart by the *veins*.

In this movement, by rotation, consists the circulation of the blood, which is another function, of a secondary order, proper to animals, and of which the heart is the principal agent and the regulator; but this function is not so necessarily connected with the faculties of sensation and motion as the function of digestion is; for two numerous classes of animals

are completely deprived of circulation, and are nourished like vegetables, by simply imbibing a fluid which is prepared in the intestinal canal.

In the animals that have a circulation, the blood appears to be merely a vehicle which is continually receiving from the alimentary canal, from the external surface of the body, and from the lungs, different substances, which are intimately incorporated with it, and with which it replaces those it furnishes to all the different parts of the body for their preservation and growth. It is on its passage to the extremities of the arteries that the blood effects the real nutrition of the parts; and also changes, in its passage, its nature and its colour: and it is only by the accession of the different substances which I proceed to point out, that the venous blood is rendered proper for nutrition, or, in one word, becomes *arterial* blood.

It is by particular vessels, called *lymphatics*, that the venous blood receives the substances with which the skin and the alimentary canal supply it. By them, also, it receives even the residuum of nutrition, and the particles which are detached from different parts, to be carried out of the body by various excretions.

With respect to the lungs, the air that penetrates into them produces, with the venous blood, a kind of combustion, which appears to be necessary to the existence of all organized bodies:

bodies; for it takes place in them all, though in very different ways.

Vegetables, and animals which have no circulation, *respire* throughout the whole of their surface, or by vessels which introduce the air at different points into the interior of their bodies. No animals respire by a particular organ, except those that have a real circulation, because, in them, the blood coming from one common source, the heart, to which it constantly returns, the vessels that contain it are so disposed that it cannot arrive at the other parts until it has passed through the lungs. This, however, cannot take place in vegetables, or in those animals in which this fluid is every-where diffused in an uniform manner, without being contained in vessels.

Hence it appears that pulmonary or branchial respiration is a function of a third order, the existence of which depends on that of circulation, and which is one degree removed from those faculties that characterize animals.

It is not so with generation, as the manner in which this act is performed by animals does not depend on their particular faculties, at least with regard to the fecundation of the ova; for the faculties they possess, of moving and advancing towards each other, of desiring and enjoying, has fitted them for tasting all the delights of love: with respect to the purely mechanical part, their spermatic fluid has no

occasion for any envelope, and is capable of being transmitted directly to the ova; but in vegetables, which do not possess within themselves the power of directing this fluid, it was necessary that it should be enclosed in little capsules, which are susceptible of being transported by the winds, and which form what is called the *pollen* of the *stamina*: thus, while animals, for the performance of most of their other functions, have, in consequence of faculties peculiar to themselves, received more complicated organs, they are enabled, by those characteristic faculties, to exercise the functions of generation in a manner more simple than vegetables.

These examples shew how much influence the faculties of sensation and motion, which animals possess in addition to those of vegetables, have over the organs of all the other faculties which are common to both these kind of beings. The comparison which we shall hereafter make of the different orders of animals, will, in the same manner, demonstrate that the modifications of their principal functions exercise a similar influence on all the others:—Such is the union and harmony which prevails in all the parts of living bodies.

We have thus described the principal functions which compose the animal œconomy. It is obvious that they may be divided into three distinct orders. There are some which, in constituting animals what they are, fit them for fulfilling

filling the part that nature has assigned to them in the general arrangement of the universe—in a word, which would be sufficient for their existence, if that existence were only momentary. These are the faculties of sensation and motion: The latter enables them to execute certain actions, and the former determines their choice of the particular actions they are capable of performing. Each animal may be considered as a partial machine, co-operating with all the other machines, the whole of which form the universe: the organs of motion are the wheels and levers, in short, all the passive parts; but the active principle, the spring which gives the impulse to every part, resides only in the sensitive faculty, without which the animal, plunged in a continual slumber, would be reduced to a state purely vegetative;—plants themselves, as Buffon has observed, may be called animals which sleep. These two functions form the first order, and are termed *animal functions*. But animal machines, unlike those we construct, possess an internal principle of preservation and reparation. This principle consists in the union of the different functions which serve to nourish the body, that is to say, *digestion, absorption, circulation, respiration, transpiration, and the excretions*. These form the second order, and are denominated *vital functions*.

Finally, the duration of each animal's life being determined according to its kind, *genera-*

tion is a function of a third order, by which the individuals that perish are replaced by others, and the existence of each species maintained.

Having considered these functions with respect to themselves, and to their reciprocal relations, we shall next examine the organs by which they are performed.

ARTICLE II.

General Idea of the Organs of which the Animal Body is composed.

No part of the animal body is composed entirely of solid particles; they all yield fluids by expression, or lose them by exsiccation; and they all exhibit the appearance of an areolated or reticular texture.

The mechanical division of the solids conducts us, in the last result, to lamellæ, or filaments, which seem to be the elementary molecu læ. When the lamellæ are separate, and intercepted by sensible vacancies, they form what is called cellulosity. This cellulosity not only envelopes and pervades the most dense parts, but it appears to form almost always their basis; for membranes consist only of a more compact cellulosity, the lamellæ of which are more closely approximated, and placed more exactly above each

each other, and are resolved into an ordinary cellulosity by maceration. The vessels are merely membranes rounded into cylinders. All the soft parts of the body, the fibres excepted, seem to be an assemblage of vessels, differing from each other only according to the nature of the fluids they contain, and by their number, their direction, and the structure of their coats.

The chemical analysis of these substances, solids as well as fluids, exhibit only a few principles, almost all of which are to be found in each of them, though in very different proportions. Some earths, some salts, phosphorus, carbon, azote, hydrogen, oxigen, a little sulphur, and a little iron, combined in a great variety of ways, produce different compositions, viz. gelatine, albumen, and fibrous matter, &c. which, uniting in their turn, form animal solids and fluids, such as we know them. But, distant as we are from a complete analysis, we see enough to convince us, not only that we alter these compositions by our experiments, but also that several of their principles entirely escape our instruments.

The general organ by which we exercise the faculty of sensation, is the medullary substance. In all the animals in which we can distinguish it, that substance is divided into filaments, which, arising from certain centres, distribute themselves over most parts of the body, where they appear to serve other purposes besides that of pro-

curing sensations. The centres from which those nervous cords proceed, communicate with each other in a manner more or less intimate, and several of the filaments seem of no other use than to establish those communications.

A nerve, when touched by a foreign body, causes the sensation of pain, though its contact with the parts of the body which are naturally contiguous to it, produces no sensible effect in a state of health. The nerves, by which we discern external objects, are provided, at their extremities, with organs, each of which are disposed in a particular manner, and which always possess an admirable relation to the nature of the objects, a knowledge of which each of these senses is destined to convey to us.

The general organ of motion is the fleshy or muscular fibre. This fibre contracts itself by volition; but the will only exercises this power through the medium of the nerves.—Every fleshy fibre receives a nervous filament; and the obedience of the fibre ceases, when the communication of that filament with the rest of the system is interrupted. Certain external agents, applied immediately to the fibre, likewise cause contraction: and they preserve their action upon it, even after the section of its nerve, or its total separation from the body, during a period which is longer or shorter in different species of animals. This faculty of the fibre is called its irritability. Does it in the latter case depend upon the portion
tion

tion of the nerve remaining in the fibre after its section, which always forms an essential part of it? Or is the influence of the will itself only a particular circumstance, and the effect of an irritating action of the nerve on a faculty inherent in the muscular fibre? Haller and his followers have adopted the latter opinion; but every day seems to add to the probability of the opposite theory.

Be this as it may, all the internal parts of the bodies destined to produce a compression on the substances they contain, have their parietes furnished with fleshy fibres, and receive nervous filaments; such is the case with the arteries, the intestines, the heart, &c. But the principal use of these fibres is the formation of *muscles*. This is the name given to the bundles of fleshy fibres, the extremities of which are attached to the moveable parts of the animal body. When the fibres which compose the muscle shorten, the two points to which it is attached are brought towards each other: this is the sole means by which all the external motions of the body and the members, even those which are necessary for removing the body entirely from one place to another, are produced.

Animals that can only crawl have their muscles attached to different parts of their skin, on which they alternately produce dilatations and contractions, which are the only motions of which they are susceptible: but those which are capable of

moving themselves by steps or otherwise, either wholly or partially, have their muscles attached to hard parts placed externally or internally. Those parts perform the office of levers, and have points of support on each other, which are called their *articulations*.

All the hard parts taken together form the skeleton. When they are covered by the muscles, they receive the name of bone; when they cover muscles, they are denominated shell, crust, or scale, according to their degree of consistency. In both cases they always enclose viscera, and determine the exterior form of the body, and the proportions of its different parts.

The articulations are provided with as many muscles as are necessary for the different movements of which they are susceptible; each muscle moving the bone to which it is attached, in its proper direction. They may be regarded as the moving powers. Their force, the point of their insertion, and the length and weight of the parts attached to the lever they have to move, determine the velocity and the duration of the motion they are capable of producing. On these different circumstances depend the force of leaping, the extent of flight, the rapidity of the race, and the prehensile power possessed by different species of animals; but, as we have already observed, all this organization would remain immoveable, were it not animated by the nervous system.

The soft white substance which forms the
essence

essence of this system, is divided into filaments that approach each other, and unite in bundles, which contain more filaments in proportion as they are traced nearer to the common fasciculus of all the nerves, called the spinal marrow, the anterior extremity of which is joined to the brain, that is to say, to a medullary mass of more or less magnitude, and differently formed according to the various kinds of animals.

From the action of external bodies on our own, we perceive that the nerves affected by that action communicate with the common fasciculus, and that it communicates with the brain. A ligature or a rupture intercepts the physical communication, and destroys sensation.

The only sense which belongs generally to all animals, and which pervades almost the whole surface of the bodies of each of them, is that of feeling. It resides in the extremities of the nerves which are distributed to the skin, and makes us sensible of the resistance of bodies, and their temperature.

The other senses seem to be only modifications of this one, but more exalted, and capable of receiving more delicate impressions. Every one knows that the other senses are seeing, which resides in the eye; hearing, which belongs to the ear; smelling, which is attached to the membranes within the nose; and tasting, the seat of which is in the surface of the tongue. These senses are almost always situated in the same
extremity

extremity of the body which contains the brain, and which we call the head.

Light, the vibrations of the air, the volatile emanations which float in the atmosphere, and saline particles soluble in water, or saliva, are the substances which act on these four senses; and the organs, which transmit the action to the nerves, are appropriate to the nature of each. The eye presents transparent lenses to the light, which refract its rays. The ear offers membranes and fluids to the air, which receive its concussions. The nose inhales the air which is to go to the lungs, and seizes, in their passage, the odoriferous vapours it contains. Finally, the tongue is covered with spongy papillæ, which imbibe the savory liquids that are taken into the mouth.

By these means we obtain a knowledge of what passes around us: but the nervous system likewise makes us acquainted with a great deal of what passes within us. Independently of those internal pains which indicate some disorder in our organization, and the disagreeable state in which we are placed by hunger, thirst, and fatigue, it is in consequence of the operation of this system that we experience the agonies of fear, the emotions of pity, the desires of love. Sensations of this last kind seem, however, to be rather the effects of the re-action of the nervous system, than immediate impressions; though, at the sight of any imminent danger, we hasten to avoid

avoid it before it appears that the mind has had time to act; and the same observation applies to the transports we feel on the presence of a beloved object, or to the tears we shed over the spectacle of suffering virtue. These effects of the nervous system are produced by numerous communications which particular nerves, called *sympathetics*, establish between different branches of the general trunk, by means of which the impressions are transmitted more rapidly than by the brain. The knots called *ganglia*, when they are considerable, are each a kind of secondary brain; and it is observable, that they are larger and more numerous in proportion as the principal brain is less.

The faculty of sensation, and that of contraction, the first of which, in most animals, is exclusively appropriated to the nervous substance, and the second to the fleshy fibre, appears to be equally diffused in all the parts of certain gelatinous animals, in which we cannot perceive either fibres or nerves.

It is by the means of these two faculties that animals feel, desire, and are enabled to provide for their wants. The most irresistible feeling of all is that of hunger, which constantly reminds the animal of the necessity of procuring new materials for its nutrition. This third function commences in the mouth, into which the aliments are taken, and, when they are solid, masticated and moistened with dissolving liquors; thence

thence they traverse the alimentary canal, which is longer or shorter, and more or less convoluted and dilated in different animals, and the parietes of which are composed of several continued tunics, analogous to those which form the external teguments of the body.

These coats act in a mechanical manner on the substances which they contain, by slight contractions of their fibres, and in a chemical manner by the liquors which are poured out within them.

The first dilatation of the alimentary canal is called the stomach. There are sometimes several stomachs, or several divisions of that organ; its parietes yield a liquid which reduces the aliments to a homogeneous pulp, during the time they remain in it. The remainder of the canal is more particularly called bowels or intestines. Independently of the juices which the different coats of the bowels produce, there are some which are separated from the mass of blood by glands, and which penetrate the intestinal canal by particular conduits. The most remarkable and the most general of these glands are the liver and the pancreas. The first, which secretes the bile, is always of a considerable size; and besides the effect of its liquid on the intestines, produces another very remarkable effect on the blood itself, from which it removes several principles.

It is in the intestines that the aliments undergo

go that change which fits them for nutrition. The nutritive part is absorbed, during the act of digestion, either by the pores of the canal itself, in animals that have no circulation, or, in those that have, by very small vessels which conduct it into the general system of nutritive vessels. Those small vessels are called *lymphatics*. They are very distinct from the veins, in animals whose structure most resembles that of man: In the more inferior animals they become gradually more like the veins, and cannot be distinguished from them in those which have white blood. The membranes which compose the lymphatic vessels and veins, are thin, and without apparent fibres. Internally they are furnished with valves, all opening in the direction in which the fluid they convey has to flow, that is to say, towards the heart. The arteries, on the contrary, are strong and muscular, but have no valves; the vigorous impulse of the heart is sufficient to impress a constant direction on the blood they contain.

But the chyle, or the liquor produced by digestion, is not sufficient for renewing the venous blood, and rendering it fit for the nutrition of the different parts of the body. It is necessary that it should experience the contact of the air before it enter into the arterial system. This is effected by respiration. The organs of respiration, in animals which have blood vessels, consist in a ramification of those vessels, which in-

creases their surface to such a degree, that almost all parts of the fluid are separated from the surrounding element by only a very thin pellicle, which cannot obstruct its action. This ramification takes place on the surface of certain folds or lamellæ in aquatic animals, and on that of certain cells in aerial animals. In the first case the organ is denominated *branchiæ*, in the second *lungs*. In animals which have no vessels, the air reaches all parts of the body, and acts on the nutritive fluid at the same moment in which that fluid combines with the parts of the body which it is destined to nourish. This is the case with insects that have *tracheæ*. It will be easily conceived that there must be muscular organs appropriated to each of those species of respiration destined to attract or impel the ambient fluid towards the place where it has to act upon the blood. This office is performed by the ribs, the diaphragm, the muscles of the abdomen, the flaps of the gills, and several other parts, according to the nature of the animal.

The air cannot be employed in the formation of the voice, except in the animals that respire by cellular lungs, because it is in them only that it enters by a single and lengthened tube. At one or two parts of this tube there are membranes susceptible of tension, which vibrate when the air acts upon them, and thereby produce the various sounds which we call the *voice*. The animals which have no voice, properly so

called;

called, are not, however, deprived of the power of producing certain sounds, but they are produced in them by other means.

The blood, on its passage into the organ of respiration, experiences a kind of combustion, which removes a part of its carbon, carrying it off under the form of carbonic acid, and which thereby augments the proportion of its other elements. The effect of this process on the respired air, is to deprive it of its oxygen, which is the only aeriform fluid that can be serviceable to respiration. Its effect on the blood is less known: we know that it heightens the colour of the blood in red-blooded animals, and gives it the power of exciting the heart to contraction. There is even reason to believe that it is this action of the air on the blood which gives, indirectly, to the fleshy fibres their contractile power. It is still necessary that the blood should lose several other principles: some are carried off by the kidneys, which secrete the urine, and which are found in all animals that have red blood. The matter which transpires through the pores of the skin, and the substances which pass through the intestinal canal, a great part of which are carried away with the excrements, relieve the blood of other principles. These three kinds of excretions, to a certain degree, supply the place of each other, and appear, therefore, to tend towards one common object.

These are all the organs which constitute the
animal,

animal, considered individually, and which are sufficient for its separate existence, while the object is not the multiplication of the species: Such, I say, are the whole of the organs in the higher orders of animals. We shall see that, in proportion as we descend in the scale of being, they successively disappear, and that at last we shall find, in the lowest classes, only what is necessarily connected with the idea of an animal that is a sack, sensible, moveable, and capable of digesting.

Upon a close observation of the action of all these organs, it will appear, that all the operations which take place in the animal body, depend on the combination and decomposition of the fluids contained within it. To the animal process, by which one fluid is separated from another, or is formed from a part of the elements of one, mixed with a part of those of another, we give the name of *secretion*: this term, however, is usually confined to the changes which take place in different kinds of glands, that is to say, in bodies more or less thick, in which the blood-vessels being infinitely subdivided, permit the liquid which the gland separates from the blood, to transude from their extremities. But the animal œconomy exhibits a number of other transformations, or separations of humours, which equally merit this name. It cannot be supposed that the nerves act on the muscular fibres without producing a chemical change on
the

the fluid that may be contained in the one, by the accession of that which the others may transmit, nor that external objects act upon the nerves otherwise than by producing a change of the same kind. The fluid contained in the nervous system must have been separated from the blood in the brain, and, in general, in all the medullary organ. The blood itself does not attain its state of perfection until a multitude of substances have been detached from it by the lungs, the kidneys, the liver, &c. and until after it has received a number of others which have been separated from the alimentary mass by the lacteal vessels: on the other hand, this mass is not capable of yielding chyle until it has in its turn received different liquors which have been secreted from blood by several organs; and the blood only nourishes the parts to which it is distributed, by the particles that are detached from its mass, while other particles are separated from these parts to return into the mass of the blood through the medium of the lymphatic vessels.

In a word, all the animal functions appear to reduce themselves to the transformation of fluids. In the manner in which these transformations are produced, the real secret of the admirable œconomy of animals consists, as health depends upon their perfection and regularity.

If we do not perceive this process in a manner sufficiently clear when the embryos of new

individuals begin to develope themselves within or without the bodies of their mothers, we can at least discover it in the preparation of the male liquor, which, by its presence, excites or occasions that development in all the species in which copulation is necessary. This development takes place in the same manner as the ordinary growth. It, therefore, comes under the general rule.

The organs of generation, which alone remain to be noticed, are those which prepare the prolific liquor, and convey it to the ova, and those which are destined to contain and protect the embryo during its development. The first constitute the male, the second the female sex.

The testicles are the glands which secrete the feminal fluid; several other glands prepare liquors which mingle with it. The penis contains the feminal canal; it swells by the accumulation of blood when the nerves are excited by desire: by that means, it is rendered capable of penetrating the vagina, which leads to the matrix, or to the *oviductus*, and of conveying thither the fluid destined to vivify the ova. The oviduct or tube receives the ovum at the moment in which it is detached from the ovarium; and conducts it without the animal if it be of the oviparous kind, or into the matrix if it be viviparous. The little embryo developes itself, and draws its nourishment, either from the
body

body of its mother, by the absorption of a large tissue of vessels connected with those of its own body, or from an organized mass attached to it in the same manner, and which forms the yolk of the egg, or the *vitellus*. When the embryo attains a certain state, the matrix expels it; or it breaks the shell of the egg in which it is contained, and escapes from its prison.

ARTICLE III.

View of the Principal Differences which Animals exhibit in their several Organs.

IT appears from the preceding Article, that what is common to each kind of organs, considered in all animals, resolves itself into a very small compass, and that frequently they only resemble one another in the effects they produce. This is particularly obvious with respect to respiration, which is performed in the different classes of animals by organs so various, that their structure presents no common point of comparison. Those differences in the organs of the same kind are precisely the object of Comparative Anatomy; and the short exposition we are about to make, of the principal of these differences, may be regarded as the general

plan of this Course of Lectures. We shall, therefore, return to each of the functions of which we have treated, and examine the different degrees of energy it possesses, and the particular means by which it is carried on in different animals.

The organs of motion present us at first sight with two important distinctions with respect to their situation. Sometimes the bones form an internal skeleton, articulated and covered by the muscles; sometimes there are no internal bones, but merely scales or shells which cover the skin, within which are the muscles: in other cases there is no hard part that can serve as a lever or point of support for the motions of the animal's body.

Animals of the first kind have the whole body supported by a strong pillar, formed of several bony pieces placed one above the other, and called the spine of the back, or the vertebral column. They are therefore denominated *Vertebral Animals*. These are the *Mammalia*, *Birds*, *Reptiles*, and *Fishes*.

The animals without vertebræ are either entirely soft, or have their bodies and members enveloped in scales articulated on one another, or, finally, are enclosed in shells. These are the *Soft Worms*, *Insects*, and the *Teslacea*.

It is by the greater or less perfection of certain parts that the animals of these different classes become susceptible of various kinds of motion.

The

The organs of sensation present considerable varieties—some have a relation to the internal part of the nervous system, others to the external senses. The first gave rise to three classes:—that of animals which have no apparent nervous system, and in which we discover neither vessels nor nerves; such are the *Zoophytes* or the *Polyps*:—that of animals in which there is only the brain above the alimentary canal, and which have all the remainder of the common bundle of nerves situated underneath, and contained in the same cavity with the other *viscera*; these are the *Mollusca*, the *Crustacea*, *Insects*, and a part of the *Articulated Worms*:—lastly, that of animals in which the common fasciculus of the nerves is situated entirely in the back above the alimentary tube, and enclosed in a canal which passes through the vertebral column; these are all the *Vertebral Animals*. Their ganglia are placed on the sides of their medullary cord, or dispersed in the large cavities. Among the invertebral animals there are some that have ganglia only in the large cavities, as the *mollusca*, and others which have them all on the medullary cord itself, of which they appear to be swellings; these are the insects, and some articulated worms.

The differences in the external senses consist in their number, and in the degree of energy that belongs to each.

All vertebral animals possess the same senses as man.

Sight is wanting in the zoophytes, in several kinds of articulated worms, in several larvæ of insects, and in the acephalous mollusca. Hearing does not exist, at least we have not yet discovered its organ in some mollusca and insects. The other three senses, but particularly those of taste and touch, appear never to be wanting.

But each of these senses may vary considerably, in the degree of its susceptibility, and the complication of its structure. The perfection of the sense of touch, for example, depends upon the delicacy of the external teguments, and on the division of the extremities that more particularly enjoy that sense; their formation rendering them capable of being applied more or less exactly to the bodies of which the animal would acquire a knowledge. Above all, it is in the number and flexibility of the fingers and toes, and the smallness of the claws or nails, that the anatomist discovers important characters.

The eyes may be more or less moveable, more or less covered, and more or less numerous. The ears may be sunk within the cranium, or exposed outwardly; or they may be provided with an external trumpet, which collects the rays of sound. The membranes in which the sense of smelling resides may be more or less extensive: those which are the seat of taste, may be
more

more or less delicate and humid ; but it is only by particularly considering each of those senses that we can take a comprehensive view of the differences that exist in the various classes of animals.

The organs of digestion exhibit two important differences in their general dispositions. In certain animals, (in the greater part of zoophytes,) the intestines form a sack with only one aperture, which serves at once for the entrance of the aliments, and the issue of the excrements : all other animals have two distinct apertures, for those purposes, at the two extremities of the same canal ; but the convolutions of this canal may be such as to remove these openings to a greater or less distance from each other. Another difference which has much influence on the nature of the aliments appropriated to each species, is, that in certain animals the mouth is armed with teeth, or hard parts proper for grinding solid substances, while in others they do not exist. In the latter case, the animal can only swallow whole bodies if its mouth be large, or merely suck in fluids if its mouth be in the form of a tube. The structure of those teeth has itself much influence on the substances the animal can submit to mastication. The remainder of the alimentary canal varies also considerably in its structure, according to the different substances which the mouth conveys to it. On this likewise depend the length of the

D 4
canal,

canal, and the member of stomachs, cæca, &c. The details on this subject must, however, be referred to particular articles.

The chyle produced by the action of the digestive organs on the alimentary substances is transmitted to the various parts of the body in two different ways. It either simply transudes through the parietes of the intestinal canal, to bathe all the interior of the body, or it is absorbed by particular vessels which convey it into the mass of the blood. The first is the mode in which this operation is performed in zoophytes, and, in my opinion, also in common insects, which appear to have no kind of vessels proper for circulation. As to the other animals, viz. the mollusca, and the vertebral animals, that have absorbent vessels, they exhibit two new differences. The latter have red blood, and the lymph and chyle white. Almost all the others have these two fluids of the same colour.

Vertebral animals differ among themselves, with regard to the colour of the chyle, which is white and opaque in the mammalia, and transparent like the other lymph in birds, reptiles, and fishes. The three last classes, therefore, have no conglobate glands in their chyliferous vessels, while they are very numerous in the first.

The circulation of the blood is accompanied with very important differences in its organs. In the first place, there are animals which have no circulation whatever, viz. insects and zoophytes :
others

others have a double, and others a single circulation. We call that a double circulation in which no part of the venous blood can enter the arterial trunk, until it has passed through the organ of respiration, which is generally formed of the ramifications of two vessels; the one arterial, the other venous; each nearly as large but not so long, as the two principal vessels of the body. Such is the circulation of man, of all *mammalia*, of *birds*, *fishes*, and a number of *mollusca*.

In the single circulation a great part of the venous blood re-enters the arteries without passing through the lung; because only one branch of the arterial trunk is expanded upon that organ; such is the circulation of the *Amphibia*.

There are besides other differences in the hearts, or muscular organs, destined to give impulse to the blood. In the single circulation there is only one heart; but, when the circulation is double, there is sometimes an organ at the base of the aorta, and also at that of the pulmonary artery. At other times it is at one of the two only.

In the one case, the two hearts, or rather the two ventricles, may be united, as in man, *mammalia*, and *birds*; or they may be separate, as in the cuttle fish.

Where there is only one ventricle, it may be placed at the base of the artery of the body, as in snails, and other *mollusca*; or at the base of the pulmonary artery, as in fishes.

The organs of respiration are likewise distinguished by a number of remarkable differences — When the element that acts on the blood is the atmospheric air, it penetrates even into the interior of the respiratory organ; but when that element is water, it simply glides over a surface more or less multiplied.

The lamellæ which compose the organ, in the latter case, are called *branchiæ*. They are found in fishes, and in a number of mollusca: instead of lamellæ, we sometimes find fringes or tufts.

The air either enters the body by a single aperture, or by several. In the first case, which is that of all animals that have what is properly called lungs, the canal which receives the air divides into a number of branches, terminating in as many small cells, that are usually united into two masses, which the animal has the power of compressing or dilating at pleasure.

When there are several apertures, which is the case only with insects, the vessels that receive the air are ramified ad infinitum, and convey it to all parts of the body without exception. This we call respiration by *trachea*.

Lastly, the zoophytes, if we except the echinodermata, have no apparent organ of respiration.

The organs of the voice present only two differences, which may be regarded as general. They depend on the position of the *glottis* in which the sound is formed. In birds, it is at
the

the lower part of the *trachea* or tube, which conducts the air, where it divides into its two branches to pass into the lungs. In quadrupeds and reptiles it is situated in the beginning of the trachea, at the root of the tongue.

Only these three classes have a glottis; but the other animals produce sounds by different means. Sometimes they employ the friction of certain elastic parts; sometimes they beat the air with other parts, or produce a rapid motion in certain portions of air, which they somewhere retain in their bodies.

Generation gives rise to varieties of two kinds. The one relates to the actions which occasion it, the other to the result.

In a small number of animals, belonging almost entirely to the class of *zoophyta*, generation is performed without copulation, and the young animal grows on the body of the parent, like a shoot on a tree: others only produce in consequence of copulation, and are therefore provided with two sexes; but these two sexes may be separate in different individuals, or united in the same. It is only in the mollusca and zoophyta that this last case occurs: all animals with vertebræ, and insects, have the sexes separate.

Hermaphrodite animals, such as the bivalve shell fish, generate singly; in others, a reciprocal copulation take place, each of the two individuals performing the functions of male
and

and female : this is the case with the snails, and other mollusca that crawl on the belly.

The produce of generation is either a bud which developes itself into an animal, remaining some time on the body from which it proceeds, and of which it forms as it were a branch ; or it is a foetus, which unfolds itself in the uterus of its mother, to which it is connected by a plexus of vessels, and from which it comes forth alive ; or, finally, it is a foetus inclosed in a shell, with a substance adhering to it by vessels which it must absorb before it is discharged.—These are the *gemmiparous*, *viviparous*, and *oviparous* modes of generation.

The first occurs, in some zoophytes, and in some articulated worms ; the second in man and other mammalia only ; the third is common to all other animals ; and when their young come forth alive from the body of the mother, as is the case with the viper, it is because the eggs are hatched in the oviduct.

Lastly, if we consider the states through which the young animal is obliged to pass before it becomes, in its turn, capable of perpetuating its species, we again discover two principal differences.—Some have at their birth the form which they will always preserve, with the exception of a few inconsiderable parts which have yet to disclose themselves, and to change their proportions : the others, on the contrary, have a form altogether different from their perfect

fect state, and not only have to produce and unfold new parts, but must lose their old ones: these are the animals which undergo a *metamorphosis*. Hitherto this change has only been observed to take place among insects, and among the reptiles without scales, that is to say, *frogs* and *salamanders*.

Such are the chief varieties which the organs belonging to the several functions of animals exhibit.

We have, however, yet to notice one very important variety which extends to several of these functions; it relates to the organs of secretion. In the four classes of vertebral animals, and in some mollusca, these organs are glands, or at least expansions of blood vessels; the name of gland being particularly applied to them when they form masses of some thickness.

It is not so in insects, which, instead of secretory organs, have only tubes more or less long, which attract into the spongy texture of their parietes, that portion they have to separate from the mass of the nutritive fluid.

We are as yet little acquainted with the organs of secretion in zoophytes, if indeed they can be said to have any particular organ for that purpose.

ARTICLE IV.

*View of the Relations which exist amongst the
Variations of the several Organs.*

THE preceding Article has pointed out the principal differences of which the organs, belonging to each animal function, are susceptible in their structure and operation. The number of these differences would have been much greater had we entered into details, and descended to the less important circumstances.—It is obvious, however, from the manner in which we have described them, that, by supposing each of the differences of one organ united successively with those of every other, there would be produced a very considerable number of combinations, which would correspond with as many classes of animals. But these combinations which appear possible, when we consider them abstractedly, do not all exist in nature; because, in a state of life, the organs do not simply join their effects, but act on each other, and concur altogether to one common object. Hence the modifications of any one of them exercise an influence on those of every other. Such of these modifications as cannot exist together, reciprocally exclude one another, while others are, as it were, called into the system; and this takes place, not only in the organs which have an im-
mediate

mediate connexion, but in those which at the first view appear the most separate and independent.

In fact there is not one function which does not stand in need of the concurrence of almost all the others, and which is not more or less affected by their degree of energy.

Respiration, for example, cannot take place without the aid of the motion of the blood, since it consists in bringing that fluid in contact with the surrounding element; but as it is circulation that gives motion to the blood, it therefore is a necessary mean in producing respiration.

Circulation itself has its cause in the muscular action of the heart and arteries: it is produced, therefore, by the aid of irritability. That faculty, in its turn, derives its origin from the nervous fluid, and, consequently, from the function of sensibility which returns, by a kind of circle to the circulation of the blood, which is the cause of all the secretions, and of that of the nervous fluid as well as others.

Of what value would sensibility be, were it not aided by the muscular force, even in the most trifling circumstances? What would be the utility of the sense of feeling, were we not able to turn our hands towards palpable objects? And what would be the advantage of seeing, if we could not turn the head or eyes in every direction?

It is on this mutual dependance of the functions, and the aid they reciprocally yield to one another, that the laws which determine the relations

lations of their organs are founded—laws which have their origin in a necessity equal to that of metaphysical or mathematical laws: for it is evident that a suitable harmony between organs which act on one another, is a necessary condition of the existence of the being to which they belong; and that if any one of the functions were modified in a manner incompatible with the regulations of the others, that being could not exist.

We are about to take a view of the most remarkable of these relations, by entering into a comparison of the different functions of animals. To begin with one of the most obvious: we observe that the mode of respiration constantly depends on the manner in which the motion of the nutritive fluid is performed. In animals that have a heart and vessels, this fluid is continually collected in a central reservoir, whence it is forcibly impelled towards all the parts of the body. It always comes from the heart, and always returns thither before it revisits the other parts. It can, therefore, be exposed to the action of the air at its source; and, in fact, before it returns through the aorta and its ramifications to the parts which it has to nourish, it passes through lungs or branchiæ, to be there subjected to that action. But this is not the case with the animals, which, like insects, have neither heart nor blood vessels: their nutritive fluid has no regular motion, and departs from no
common

common source. It is not possible that it should be prepared in a separate organ before it is distributed to the rest of the body, since, arising like a dew from the pores of the intestinal canal, it constantly bathes all the parts; and since these parts always receive from it the particles which are deposited between those of which they are already constituted. The action of the air, therefore, can only be exercised at the time and place of this deposition. This operation takes place very perfectly by the disposition of the tracheæ; there being no solid point in the body of insects where the fine ramifications of these aerial vessels are not attached, and on which the air does not immediately exercise its chemical effect. As we clearly see the causes of this relation between the organs of these two functions, we are authorized to presume that other relations equally constant, which exist between them, have also their foundation in causes of the same kind, though they are not so evident to us.

Thus, among the animals that have blood-vessels, and enjoy a double circulation, those which respire the air by receiving it immediately into the cellular lungs, have always the two trunks of their arteries approximated, and furnished with muscular ventricles, but joined together in one mass; while those which respire only through the medium of the water that passes between the folds of their branchiæ, have

always two separate trunks, whether they be both provided with ventricles as the *Sepia*, or have a ventricle for one only, like fishes and mollusca.

We can more readily perceive the reason of the relations which connect the mode and extent of respiration, with the different kinds of general motion of which each animal is susceptible, and which render the air more necessary to them in proportion as their manner of moving enables them to procure it with facility; or, what amounts to the same thing, those which can the most easily obtain pure air, are precisely those to whom respiration is most indispensably necessary.

Modern experiments have demonstrated, that one of the principal uses of respiration is to reanimate the muscular force, by restoring to the fibre its exhausted irritability. We, indeed, observe, that the animals which respire immediately, and have a double circulation, and in which none of the veinous blood can return to the various parts until after respiration, that is to say, birds and mammalia, not only always live in air, and move in it with greater force than the other red-blooded animals, but each of those classes enjoys the faculty of motion precisely in a degree corresponding to its quantity of respiration. Birds which are, as it were, always in the air, are, if I may be allowed the expression, equally impregnated by that element both internally

ternally and externally. The cellular part of their lungs is not only very considerable, but these organs have sacks and appendices which are prolonged throughout the body. Birds therefore consume, within a given time, a much greater quantity of air, in proportion to their bulk, than quadrupeds. Doubtless this is the circumstance which gives to their fibres an instantaneous force so very prodigious, and which renders their flesh capable of becoming the moving power in machines which require actions so violent as to sustain them in the air by the simple vibration of wings.

With respect to the force of their motion, and quantity of respiration, the mammiferous animals seem to hold a middle place between birds and reptiles, which form the opposite extremes. With the latter, respiration appears to be only an accessory circumstance; they may dispense with it almost as long as they please. Their pulmonary vessels are merely branches of the great trunks. On the one part their organs of motion reduce them to remain on the earth, in obscure and close places, in the midst of foul air: and their instinct frequently directs them to shut themselves up in cavities in which the air cannot be renewed, or even to bury themselves under water during a great portion of the year: on the other part, their motion is in general very slow; and they pass a great part of their life in a state of complete repose.

As it is one of the conditions of the existence of every animal, that its wants should be proportioned to the ability it possesses of satisfying them, irritability remains longest unexhausted in those cases in which respiration is least prompt and efficacious in repairing it. This suggests the cause why reptiles are so remarkable for irritability; and why their flesh palpitates so long after they are dead, while those animals that have warm blood lose that quality as their blood becomes cold.

This relation of the extent of the motive power to the action of the ambient element, is confirmed by the example of fishes, which having cold blood like reptiles, have also, like them, little muscular force, and an irritability capable of a long duration. The velocity with which some of them swim, must not deceive us in this respect; because, being then placed in an element as heavy as themselves, no force is requisite for their support.

If, however, their respiration have the same result as that of reptiles, that result is obtained by other means. Their circulation, indeed, is double, like that of warm-blooded animals: but as it is air mixed with water which acts on their blood, it is necessary that the little activity of the element should be counterbalanced by the prompt return of the blood into the pulmonary organ. Here we find a new relation between the modifications of the respiratory organs and those

those of circulation. Animals of every class which respire by branchiæ, and through the medium of water, have always a double circulation; while, of those that respire the air directly, several have a single circulation, that is, those which do not require an excessive irritability: but it appears that an inferior degree would have been insufficient to preserve the muscular force, and that the union of these two modes, which both weaken the effect of respiration, would have prevented the renewal of the energy of the fibre.

The nervous system has likewise its relations to respiration with respect to the varieties observed in both those functions. The external senses have much less energy, and the brain is considerably smaller in the animals that have cold blood, in which that organ occupies only a small part of the cranium, than in those of warm blood, in which the brain fills the whole cavity. Doubtless, the little irritability of the fibre in those animals requires but a small degree of activity in the organs that put it in motion: lively sensations and strong passions would have too much exhausted their muscular force. In this manner the organs of sensation are immediately connected with those of respiration.

But to what secret cause is it owing, that in all the animals which respire by distinct organs, the medullary masses form a small number, and are collected in the cranium, or, at least, detached

from the spinal marrow, while in those that respire by tracheæ, nearly equal ganglions are distributed throughout the whole extent of their nervous cord? How does it happen, too, that there is no nervous system apparent in animals which have no organs particularly designed for respiration? These two relations must be included amongst those whose causes are unknown to us.

Digestion, also, has its connection with respiration: the latter being one of the functions which consume and expel, with the greatest rapidity, the substances of which the body is composed, the digestive power is generally the greater in proportion as respiration is more complete, in order that the quantity which is acquired may be equal to that which escapes.

In consequence of the connection that subsists between the organs of respiration and the modifications of several other functions, some of the latter have relations to one another which at first sight did not appear necessary. This is the reason why birds have in general an exceedingly strong stomach, and a very quick digestion. This also is the reason why their repasts are so frequently repeated; while reptiles, which among the red-blooded animals seem to be contrasted to them in every respect, astonish us by the little aliment they take, and the length of time they abstain from food. These differences in the digestive powers do not depend upon
the

the nature of the organs of motion which characterise these two classes, but upon that of the organs of respiration, the modifications of which have an immediate relation with those of motion.

It is easy to perceive that these two very different degrees of digestive powers depend on two dispositions equally different in the alimentary organs, and that each of these dispositions must be co-existent with a corresponding one in the respiratory organs. The latter also being always connected with a disposition equally determined in the organs of motion, in those of sensation, and in those of circulation, each of those five systems of organs may be said to regulate and govern the others.

The system of digestive organs has also immediate relations with those of motion and sensation. The disposition of the alimentary canal determines, in a manner perfectly absolute, the kind of food by which the animal is nourished; but if the animal did not possess, in its senses and organs of motion, the means of distinguishing the kinds of aliment suited to its nature, it is obvious it could not exist.

An animal, therefore, which can only digest flesh, must, to preserve its species, have the power of discovering its prey, of pursuing it, of seizing it, of overcoming it, and tearing it in pieces. It is necessary, then, that this animal should have a penetrating eye, a quick smell, a swift motion, address, and strength in the claws

and in the jaws. Agreeably to this necessity, a sharp tooth, fitted for cutting flesh, is never co-existent in the same species, with a foot covered with horn, which can only support the animal, but with which it cannot grasp any thing; hence the law by which all hoofed animals are herbivorous; and also those still more detailed laws which are but corollaries of the first, that hoofs indicate dentes molares, with flat crowns, a very long alimentary canal, a capacious or multiplied stomach, and several other relations of the same kind.

Those laws which determine the relations of the organs belonging to the different functions, likewise exercise their powers on the different parts of the same system, and connect its variations with equal force. The application of these laws is particularly evident in the alimentary system, the parts of which are more numerous and distinct. The form of the teeth, the length, the convolutions, and the dilatations of the alimentary canal, and the number and abundance of the dissolving liquors poured into it, have always an admirable relation to each other, and to the nature, the hardness, and the solubility of the substances the animal eats. This connection is so evident, that the skilful anatomist, upon knowing one of those parts, may easily conjecture most of the others, and may, agreeably to the preceding laws, even guess the extent of the other functions.

The

The same harmony exists between all parts of the system of the organs of motion; as each of those organs acts upon the rest, and experiences their action in its turn, particularly when the animal is completely in motion, all their forms have relation to one another. Not a bone is varied in its surfaces, in its curvatures, or in its eminences, without subjecting the other bones to proportionate variations: we may, therefore, on the view of one of them, form, with a certain degree of accuracy, an idea of the whole skeleton.

These laws of co-existence, which we have thus far pointed out, may be said to be reduced by reasoning from the knowledge we have of the reciprocal uses and functions of each organ. Observation having confirmed these laws, we are authorised to follow an opposite course under other circumstances; when, therefore, we observe constant relations of form, between certain organs, we may conclude that they exercise some influence on one another, and we may even make pretty accurate conjectures as to the uses of both. Thus the considerable magnitude of the liver in those animals which respire least, and its total absence in insects, which possess the most complete kind of respiration, since their whole body forms as it were their lungs, have induced us to conclude that the liver, in a certain degree, supplies the place of the lungs, and, like them, serves to remove from the blood its two combustible principles.

In

In this manner we account for the whiteness and opacity of the chyle in some animals, while in others it is as transparent as lymph, when we know that the first are all those which have mam-mæ, and suckle their young. It is only by a profound study of those relations, and by the discovery of those which have hitherto escaped our observation, that we can hope to extend physiology. Comparative anatomy may, therefore, be regarded as one of the richest sources of observation for perfecting that important branch of knowledge.

Nature never oversteps the bounds which the necessary conditions of existence prescribe to her; but whenever she is unconfined by these conditions, she displays all her fertility and variety. Never departing from the small number of combinations that are possible, between the essential modifications of important organs, she seems to sport with infinite caprice in all the accessory parts. In these there appears no necessity for a particular form or disposition. It even frequently happens, that particular forms and dispositions are created without any apparent view to utility. It seems sufficient that they should be possible, that is to say, that they do not destroy the harmony of the whole. In proportion, therefore, as we turn our attention from the principal organs to those which are less important, we discover increasing variations; and when we arrive at the surface of
bodies

bodies where the nature of things requires that the parts least essential, and the injury of which is least dangerous, should be placed, the number of varieties becomes so considerable, that all the labours of naturalists have not yet been able to give us an account of them.

Among these numerous combinations there are necessarily many which have common parts, and there is always a certain number which exhibits very few differences; by the comparison therefore of those which resemble each other, we may establish a kind of series, which will appear to descend gradually from a primitive type. These considerations are the foundations of the ideas from which certain naturalists have formed *A Scale of Being*, the object of which is to exhibit the whole in one series, commencing with the most perfect, and terminating with the most simple kind of organization—with that which possesses the least numerous and most common properties; so that the mind passes from one link of the chain to the other, almost without perceiving any interval, and, as it were, by insensible shades.

Indeed, when we confine ourselves within certain limits, and particularly when we consider each organ separately, and follow it through all the species of one class, we observe that its progression in the scale is preserved with a singular regularity; we even perceive the organ partially, or some vestige of it in species, in which
it

it is no longer of any use ; so that Nature seems to have left it there only to shew how strictly she adheres to the law of doing nothing by sudden transitions : but, on the one hand, the organs do not all follow the same order of gradation ; one is found in its highest degree of perfection in one species, while another is most perfect in a species altogether different. If, therefore, we were to class the different species according to each organ considered separately, it would be necessary to form as many series as we should adopt regulating organs ; and to make a general scale of perfection, it would be necessary to calculate the effect resulting from each combination. This, however, is far from being practicable.

On the other hand, the gentle and insensible shades of gradation prevail so long as we confine ourselves to the same combination of the principal organs, and so long as the great central springs remain the same. All the animals in which this takes place, seem to be formed upon one common plan, which serves as the basis of all the little external modifications : but the moment we turn our attention to those animals in which other principal combinations take place, there is no longer any resemblance, and an interval or marked transition is obvious to every one.

Whatever arrangement may be given to vertebral animals, and those which have no vertebræ,
we

we never shall succeed in placing at the bottom of one of those great classes, and at the head of the other, two animals which sufficiently resemble each other to serve as a link between them.

ARTICLE V.

Division of Animals founded on the whole of their Organization.

It is the object of Comparative Anatomy to point out the differences which each organ presents when considered in every animal; but this exposition would prove very tedious and intricate, were we obliged at every step to enumerate all the animals in which particular organs have a uniform structure. It is certainly much more convenient to indicate them all at once, under the name of a class or genus, which may comprehend the whole: but to enable us to form this arrangement, it is necessary that all the animals which compose a genus or class, should possess some resemblance not only in one, but in all their organs; otherwise we should be obliged to adopt new classes and new genera, and a particular nomenclature every time we treated of a particular organ, by which a greater degree of confusion would be produced

than that we are desirous of avoiding. But this confusion would certainly prevail, were we to take the characters of the subdivisions of the different gradations from organs, and modifications of organs, chosen arbitrarily and at hazard. Though the organ selected should be found among the least important, and among those which have the least influence on the whole, it does not follow that the other organs would resemble one another in all the animals in which the likeness of this one might be preserved. Nothing, therefore, could be affirmed respecting the other organs belonging to the whole of a class or genus of animals, which we should have attempted to distinguish by characters taken from this unimportant organ.

Suppose, for example, that we had made three divisions of animals, the aerial, terrestrial, and aquatic, as they were anciently classed; there would be included, in the first class, besides what are commonly called birds, some mammiferous animals, (as bats;) some reptiles, (as the dragon;) some fishes, (the different kinds of flying fish;) and a multitude of insects. Similar difficulties would occur in a greater or less degree in the other two classes. If, therefore, we had to describe one of their organs, the liver for instance, it would not be possible to find a single quality which we could attribute to it, throughout the whole of one class, nor one which could be said to belong to it peculiarly
in

in any one of the three classes, to the exclusion of the other two.

This example is well calculated to shew how important it is that the characters of our divisions should be well chosen; for, though in the formation of methods and systems of natural history, errors so flagrant as the above are not now committed, several naturalists, even in modern times, have adopted divisions which, in the detail, lead to similar results.

The object of every good method is to reduce a science to its simplest terms, by reducing the propositions it comprehends to the greatest degree of generality of which they are susceptible. A good method in comparative anatomy must, therefore, be such as will enable us to assign to each class, and to each of its subdivisions, some qualities common to the greater part of the organs. This object is to be attained by two different means, which may serve to prove or verify one another. The first, and that to which all men will naturally have recourse, is to proceed from the observation of species to uniting them in genera, and to collecting them into a superior order, according as we find ourselves conducted to that classification by a view of the whole of their attributes. The second, and that which the greater part of modern naturalists have employed, is to fix, before-hand, upon certain bases of division, agreeably to which, beings, when

when observed, are arranged in their proper places.

The first mode cannot mislead us; but it is applicable only to those beings of which we have a perfect knowledge: the second is more generally practised; but it is subject to error. When the bases that have been adopted remain consistent with the combinations which observation discovers, and when the same foundations are again pointed out by the results deduced from observation, the two means are then in unison, and we may be certain that the method is good.

But when it is not possible to employ the first means, it becomes necessary to calculate the importance of the distinctions we adopt, in which we are much assisted by considering the consequence of those organs upon which they are founded. Naturalists have not been inattentive to these principles, and upon them they have established their distinctions between the organs of the first, second, third rank, &c.

It would have been better, however, had they directed their inquiries rather to the functions themselves than to the organs; for all the parts, all the forms, all the qualities of an organ of the first rank, are not equally calculated to furnish characters for the superior classes: the only forms and qualities fitted for this purpose, are those which modify, in an important manner, the function to which the organ belongs; those
which

which may be said to give it a new direction, and to produce new results. All the other considerations to which an organ, whatever be its rank, may give rise, are of no importance, so long as they do not directly influence the functions it exercises. In this respect some naturalists have been misled: they have believed that every thing was important in an important organ, and have therefore, without any just reason, rejected well-formed divisions: this, however, is not the place to discuss those principles, and still less to apply them. The formation of systems is the object of natural history, properly so called: Anatomy receives them, as it were, ready made; the latter takes its first direction from the former, but is not slow in reflecting back the light it has received. By applying a system of natural history to comparative anatomy, we are speedily enabled to discover whether it deviates from the path of nature.

We shall, therefore, turn our attention to the whole of the animal kingdom, and endeavour to discover what is common in the organization of each of the families of the different classes into which it is divided. This general review is further necessary to us for another object: in the descriptions we shall have to make, in the succeeding Lectures, of the different organs, and their various conformations, we shall frequently have occasion to refer to the several genera and families of animals. It is therefore necessary

that we should possess, at least, a summary knowledge of them; and this the following examination may enable us to procure.

The whole animal kingdom is, in the first place, divided into two great families:—1st. That of the animals which have vertebræ, and red blood: 2d, That of the animals without vertebræ, almost all of which have white blood.

The first have always an internal articulated skeleton, the principal support of which is the vertebral column which joins the head at its anterior extremity, and incloses, in its conduit, the common fasciculus of the nerves: its posterior extremity is frequently prolonged to form the tail: the ribs, which are almost always found in animals of this class, are attached to both sides of this column. There are never more than four members; two, or all of which, sometimes may, however, be wanting.

The brain is always contained in a particular osseous cavity of the head, called the cranium. All the nerves of the spine contribute, by filaments, to the formation of a nervous plexus, which derives its origin from some of the nerves of the cranium, and is distributed over most of the viscera.

The senses are always five in number. The eyes are two, and moveable at will. The ear has at least three semicircular canals. The sense of smelling resides exclusively in the cavities in the fore-part of the head.

The

The circulation is always maintained by a heart, consisting of at least one fleshy ventricle : and when there are two ventricles, they are never separate. The lymphatic vessels are distinct from the veins.

The two jaws are placed horizontally ; and the mouth always opens by their separation from above downwards. The intestinal canal is continued from the mouth to the anus, which is uniformly situated in the back of the pelvis, that is to say, behind the bones which support the posterior extremities. The intestines are surrounded with a membranous covering called the peritonæum. There is always a liver and a pancreas which secrete dissolving liquors, and a spleen, in which a part of the blood which proceeds to the liver undergoes a previous preparation.

There are always two kidneys for the secretion of the urine, situated on each side of the spine, and without the peritonæum. The testicles are two in number. Above the kidneys there are always two bodies, the use of which is not yet known :—they have been named *capsulæ atrabiliarie*.

The vertebral animals are subdivided into two branches, those with warm blood, and those with cold blood.

The animals that have vertebræ and warm blood, have always two ventricles to the heart, and a double circulation. They breathe by
F 2 lungs,

lungs, and cannot exist without respiration. Their brain fills up exactly the cavity of the cranium. Their eyes close by palpebræ. Their ear has its tympanum sunk in the skull. All the parts of the labyrinth are closely enveloped by the bones; and in it we always find, besides the semi-circular canals, an organ with two cavities resembling the shell of a snail. Their nostrils communicate with the back of the mouth, and serve as passages to the air in respiration. Their trunk is always surrounded with ribs; and almost all of them have four members.

It is by privations, rather than by common properties, that the vertebral animals with cold blood are to be compared. Several of them are destitute of ribs; others have no members. Their brain never occupies all the cavity of the cranium. Their eyes very rarely have moveable palpebræ. The tympanum of their ear, if it exist, is always level with the head: it is often wanting, as well as the ossicula auditus. The cochlea is always wanting. The different parts of the ear are not attached closely to the cranium; they are even frequently at liberty in the same cavity with the brain.

Each of these two branches is divided into two classes. Those of the animals with warm blood are *mammalia* and *birds*.

The mammiferous animals are viviparous, and nourish their young with milk, which is supplied
by

by their mammæ: they have always an uterus with two cornua; the males have always a penis, which, in copulation, they introduce into the female organ of generation.

Their head is joined to the first vertebræ by two eminences. The vertebræ of the neck are never less than six, nor more than nine. Their brain is more complicated than that of other animals: it has parts which are not found in the other classes; such as the *corpus callosum*, the *fornix*, the *pons varolii*, &c.

Their eyes have only two palpebræ; their ear has four little articulated bones, and a cochlea truly spiral; their tongue is entirely soft and fleshy. The skin of the greater number is covered with hair, and there is at least some hair on all of them.

Their lungs are enclosed within the thorax, which is separated from the abdomen by a fleshy diaphragm: they have but one larynx, situated at the base of the tongue, and covered by an epiglottis while the animal swallows.

The lower jaw only is moveable: both jaws are furnished with lips.

Their biliary and pancreatic ducts are inserted at the same point. Their lacteal vessels contain a white milky chyle, and traverse a multitude of conglobate glands, situated in the mesentery. A membrane, called the epiploon, suspended at the stomach and neighbouring parts, covers the intestines anteriorly. The spleen is

always situated on the left side, between the stomach, the ribs, and the diaphragm.

The *birds* are oviparous. They have but one ovarium, and one oviduct—a structure which is entirely peculiar to this class. They have the head connected with the first vertebræ of the neck by one eminence only: the cervical vertebræ are very numerous; the sternum is very broad; the anterior members are only used in flying, the posterior in walking.

Their eyes have three palpebræ: they have no external ear, and their tympanum has only one bone; their cochlea is conical, and slightly twisted; their tongue has a bone internally; the body is covered with feathers; the lungs are attached to the ribs; and the air, in passing through them, is communicated to all the body, as the animals of this class have no diaphragm. Their trachea has a larynx at each of its extremities; the superior has no epiglottis: their mouth is a bill, or beak, of a horny consistence, the two mandibles of which are moveable.

Several ducts proceed from the pancreas and liver, and enter the intestinal canal at different points. The chyle is transparent; and there are no mesenteric glands, nor omentum. The spleen is in the centre of the mesentery. The ureters terminate in a cavity called the cloaca, which is common to the excrements and to the eggs. They have no urinary bladder.

The

The classes of vertebral animals, that have cold blood, are *reptiles* and *fishes*.

Reptiles differ with respect to one another in several very important points, and have not, perhaps, common qualities in so great a number as the other classes: some of them walk, some fly, others swim, and a great number can only crawl. Their organs of sensation, particularly the ear, vary almost as much as those of motion; they have, however, no cochlea; their skin is either naked, or covered with scales; their brain is always very small; their lungs float in the same cavity with the other viscera, but do not suffer the air to pass beyond them. The cells of the lungs are very large: there is only one larynx, which has an epiglottis; the two jaws are moveable; they have no omentum, nor mesenteric glands; their spleen is in the centre of the mesentery: the female has always two ovaries, and two oviducts; they have an urinary bladder.

Fishes respire by organs in the form of combs, placed on both sides of their neck, between which they transmit the water: they have, therefore, neither trachea, larynx, nor voice; their body is adapted to swimming, but their fins are sometimes wanting. Besides the four which represent the extremities, they have vertical fins on the back, under the tail, and at its extremity.

Their nostrils are of no use in respiration;

their ear is entirely concealed within the cranium; their skin is naked, or covered with scales; their tongue is bony; their two jaws are moveable; the pancreas is frequently replaced by *intestinula cæca*; they have an urinary bladder: the ovaries are double.

The invertebral animals have not so many qualities in common, and form a less regular series than those of which we have spoken. If they have hard parts, however, they are generally external, at least when they are articulated. Their nervous system has not its connecting parts enclosed in a bony case, but floats in the same cavity with the other viscera.

There is only a brain above the alimentary canal: it furnishes two branches, which envelope the œsophagus, like a collar, and the continuation of which forms the remainder of the common bundle of the nerves.

They never respire by cellular lungs, and none of them have any voice: their jaws have all kinds of directions, and frequently their mouths are only suckers; they have neither kidneys nor urine: if they have articulated members, they are always at least six in number. Considered anatomically, they ought to be divided into five classes.

The *mollusca* form the first.

In them the body is soft, fleshy, and destitute of articulated members; though sometimes there are hard parts placed internally: and though

frequently it is covered externally with hard shells, they have arterial and veinous vessels, in which the blood undergoes a real circulation.

They respire by branchiæ. Their brain is a distinct mass, from which proceed the nerves, and a medulla oblongata. They have ganglions in different parts of the body.

Their external senses vary as to number. In some the eyes and ears are very perceptible, while others appear to enjoy the senses of tasting and touch only. There are many that can masticate, and others that can only swallow.

They have a voluminous liver, which furnishes a great quantity of bile. Their organs of generation are exceedingly various.

The *crustacea* form the second class.

In them the body is covered with scaly pieces. They have frequently a considerable number of articulated members. Their nervous system consists of a long knotted cord, from the ganglions of which all the nerves proceed.

We find in them hard moveable eyes, composed of different parts; and ears are discovered which are very imperfect. They have for the sense of touch, antennæ and feelers like insects. They have a heart with arterial and veinous vessels, and branchiæ for respiration: their jaws are transverse, strong, and numerous; the stomach has internal teeth; a number of intestinula cæca supply a brown fluid, which answers
instead

instead of bile. The male has two penes, the female two ovaria.

The *insects* form the third class.

In their perfect state, they have antennæ and articulated members like the crustacea. The greater part have wings, which enable them to fly; and these have all passed through other states of existence, one of which is frequently completely motionless. They all have a nervous system, similar to that of the crustacea; but they have neither heart nor vessels, and respire only by trachea. Not only the liver, but all the secretory glands, are in them replaced by long vessels which float in the abdomen. The form of the intestinal canal is frequently very different in the same individual, as the insect passes through its three states.

The animals which resemble the larvæ of insects, and have, like them, a knotted medullary cord, might be joined with insects, though they do not undergo a metamorphosis; some of them, however, have blood vessels very distinct, and ought, therefore, to form a separate class, intermediate between the *mollusca*, the *crustacea*, and *insects*; such are the *terrestrial worms* and *leeches*.

This is the fourth class: the *zoophyta* form the fifth.

The parts of the body in this last class are formed like a star, or the radii of a circle, in the
centre

centre of which the mouth is placed. They have neither heart nor blood-vessels, and we cannot perceive in them either brain or nerves.

We must now return to each of the nine principal classes which form the animal kingdom, and divide them into families of a lesser order.

The mammalia exhibit, in the first place, an order, the species of which are deprived of the posterior feet, and have the neck so short, and the tail so thick, that, at first sight, we would be inclined to class them with fishes. They live constantly in water, though they can only respire in air; but their nostrils open at the summit of their head, which enables them to inhale the air, without raising the mouth out of the water. These nostrils also serve them in expelling the superfluous water, which they take in at their mouth every time they attempt to swallow their prey; they are, therefore, ill calculated for exercising the sense of smelling, for which nature has formed particular cavities.

The *cetacea*, which is the name given to this order of mammalia, have a smooth skin, which covers a great mass of fat. They have no external ear: their teeth, which serve to retain their prey, and not to masticate, are sometimes replaced by laminæ of horn. The stomach is multiplied; the intestinal canal is uniform, and has no cæcum; the kidneys are much divided; they have lungs, and a liver, the lobes of which are not very numerous: the larynx is of a pyramidal

midal form, and opens into the nose: the testicles are concealed in the abdomen, and the mammæ are situated by the sides of the vulva. Their anterior extremities are so short, and the bones and articulations are so much concealed under the skin, that they represent oars, and are only fitted for swimming.

Among the mammiferous quadrupeds, there are a great number which have the toes so much enveloped by horn, that their feet can only serve to support them in progression.

These are all herbivorous, and their teeth are therefore fitted for bruising vegetables. They have very long intestines, and large bellies. They form three families.

That of the *ruminantia*, which is the most numerous, is cloven-footed. The dentés molares, which are wanting in the upper jaw, are supplied by round callous eminences. The stomach is divided into four cavities; and the aliments which have passed through the two first, return to the mouth to be masticated a second time. The intestinal canal is exceedingly long, as is also the cæcum. Their fat becomes hard and brittle when it has cooled. Their mammæ are situated between the thighs. The penis of the male has no internal bone.

That of the *pachydermata* has more than two toes to the foot; incisive teeth in both jaws; and frequently enormous canine teeth. The stomach in these animals has some contractions,
but

but it is not divided into several cavities, and they do not ruminate. Their mammæ extend under the belly when they are numerous.

That of the *solipeda* is distinguished by having only one apparent toe to each foot. They have incisive teeth in both jaws; a simple and small stomach, but very large intestines, and particularly an enormous cæcum. Their mammæ are situated in the groin, like those of ruminating animals. The cetaceous and hoofed animals have, in general, the liver very little divided.

The mammalia, that have distinct toes, covered merely with nails or claws at their extremities, form likewise several families, to which we may assign common characters deduced from the entire of their organization.

The least numerous, and the least perfect, is that of the *tardigrada*. Though their toes are not covered with horn, they are united by the skin, and cannot be moved separately; they are besides few in number. The dentes incisores are wanting in both jaws. The stomach is quadruple, as in the ruminantia; but the aliments do not return to the mouth. The mammæ are placed on the breast. The anterior legs are long, which considerably embarrasses the motion of the animal in walking.

The *edentata* is a second family, which resembles the former in the little freedom of the toes, and the want of the incisores. Several species are indeed entirely destitute of teeth: they

they have a simple stomach; their mammæ are situated under the abdomen; they have all a snout more or less prolonged; and most of them have a defensive covering, consisting of scales, &c.

The *rodentia* form a third family of mammiferous animals with claws, characterised by two long incisive teeth, at the end of each jaw, which are succeeded by an interval without any canine teeth. This organization compels them to gnaw their aliments, or to reduce them to very small fragments, instead of cutting them in mouthfuls, as is done by those animals that have a number of short incisive teeth. The rodentia feed on vegetable or animal substances, or on them both mixed, according as their molares have flat crowns, or sharp points, or are merely elevated into blunt tubercles. Their intestines are long; their stomach simple; and they have almost always a large cæcum. Their posterior feet are longer than the anterior, which gives to their motion the appearance of leaping. Sometimes the difference in the length is so great, that these animals cannot employ the fore feet in walking.

The *farcophaga*, which do not differ much from the rodentia in the disposition of their claws, have, however, a more complete set of teeth: their incisors are short and strong, their canine teeth strong and pointed, and their molares sharp and denticulated. These three kinds of
teeth

teeth form altogether an uninterrupted series. The alimentary canal is short; the stomach and the cæcum small. The latter, indeed, does not exist in those *sarcophaga* which walk wholly on the sole of the foot, or that have long bodies supported by very short feet. In all of them the belly is more or less slender, on account of the smallness of their intestines.

These two families, the *rodentia* and *sarcophaga*, have their *mammæ* situated under the belly, and the *urethra* partly enveloped in a bone. All those quadrupeds we mention have the penis enclosed in a sheath attached to the abdomen.

The *amphibious mammalia* form a small family, similar in many respects to the *sarcophaga*; but their members are so short that they can scarcely serve for any other purpose than that of swimming.

The *bats* likewise form another little family, somewhat similar to the *sarcophaga* in their teeth and intestines; but the intervals between the toes, (which are very long,) and also those between their members, are occupied by a fine skin. This organization enables them to fly. They have no cæcum. Their *mammæ* is situated on the breast, and the penis is pendent.

The two last circumstances exist in the *quadruped*, which, of all the *mammiferous* animals, are those that most resemble man. Like him they have the thumb separate from the fingers,
to

to which it is capable of being opposed when it is requisite to perform any delicate operation. The feet are similarly formed; the great toe is shorter than the others, which are long, like the fingers. The teeth resemble those of man, except that the dentes canini are longer than the others. The alimentary canal, except in some species, is composed, as in man, of a simple stomach, of small and great intestines, and of a thick and short cæcum. The liver of animals that have claws, is divided into more numerous lobes than that of man and hoofed animals.

The class of birds do not present as many anatomical characters as that of mammalia, to enable us to distinguish into families the different species that compose it. The form of their feet does not, as in quadrupeds, determine the nature of their food, because the power of flying, of swimming, or of diving, affords them other means of pursuing their prey.

Birds of prey, properly so called, are not the only birds that live on flesh. They are distinguished by their beak and hooked claws. Their stomach is membranous; their cæca are very short; their inferior larynx has only one muscle.

The *piscivorous birds* of the family of river-birds, such as the *herons*, &c. have a large membranous stomach, and one very short cæcum.

The other *piscivorous birds* of the family of swimming-birds, such as the *cormorant*, *pelican*, &c.

&c. of the passerine family, as the *king-fisher*, have likewise a membranous stomach. This organ is also of a similar structure in the birds that live on worms, such as the *wood-pecker*, &c. but it is very muscular in most other birds, and particularly so in those that live entirely on grain.

The other internal parts do not furnish very marked characters; or it may rather be said, that as these parts do not exercise a powerful influence on the whole, they have but few variations in their structure.

Confining ourselves, therefore, to the considerations of the organs of motion, we find, besides the family of the birds of prey mentioned above, that of the swimming or *anser-birds*, which have short palmated feet, a close plumage, besmeared with an oily liquor, and which live almost constantly in water: the families of the *wading-birds*, or *grallæ*, which have long feet, naked legs, long necks, and bills, and which wade among the water, by the banks of rivers, streams and marshes: that of the *gallinaceous birds*, which have short feet, fly heavy, or do not fly at all, have short arched bills, and which reside on the earth, where they live upon grain. The last have a large ingluvies, a strong fleshy gizzard, and the intestines, particularly the two *cæca*, very long: their inferior larynx has no particular muscle. The family of the *climbers*, or *scanfores*, are distinguished by two toes placed

Vol. I. G before

before and two behind, and by the power which this structure gives them of climbing in all directions; some of them, as the *wood-peckers*, have a membranous stomach, and no cæcum; others, as the *parrots*, have a muscular stomach, and also want the cæcum: finally, there are others which have cæca, and a gizzard, as *cuckoos*, &c. The former live on insects, the latter on fruits.

The numerous genera of birds which cannot be included in the preceding families, are known, by naturalists, under the general denominations of *sparrows* and *rollers*. It is difficult to assign to them any common characters: we may, however, reduce them into tribes of an inferior order, which form very natural divisions; such are, that of the small birds with delicate bills, which live upon insects, and leave our climates in winter; that of the little birds with large bills, which live on grain, and injure cultivated fields; that of the birds with long and thick beaks, which live on fruits, grain, and animal substances, and some of which even do not disdain carrion; &c.

The reptiles may be reduced to a regular division much more easily than birds: those which have no feet, as the serpents, have the body of a long form, to which that of the viscera corresponds. Their jaws are both moveable, and are capable of so great a separation that the animal swallows bodies thicker than itself, their
cartilaginous

cartilaginous and forked tongue has a kind of sheath, from which it is thrown out, and into which it returns, at the animal's pleasure. The stomach is long and membranous. The alimentary canal is short, and has no cæca. The male has two penes, covered with prickly eminences; the female produces eggs, which are sometimes hatched in the oviduct.

There are very few reptiles with two feet. Among those that have four feet we ought to distinguish the tortoises, which are partly covered with an osseous shell, and the lizards, which have scales, from the frogs and salamanders, which have naked skins; because the two first kinds lay eggs completely fecundated, with a hard shell from which their young come forth under the form they always retain; while the two latter lay soft eggs, that swell after they are deposited in water, and produce young, which have a form similar to that of fishes,—live like fishes in water, and respire during a considerable time by branchiæ, after which they assume the form of their parents.

The fishes are divided into two principal families, which are very different as to number. The smaller, that of the *Chondropterygii*, resembles some reptiles, particularly in the female organs of generation, which consist in two very long oviducts, terminating at the one end in the ovaries, and at the other in a common uterus.

The second family comprehends all the other kinds of fish; but with respect to them the anatomist can form no distinction except what is founded on the structure of the bones, and which divides them into *cartilaginous fishes* and *osseous fishes*. The other characters employed by naturalists, are relative to the position of the fins, and to some less important varieties, which are more or less apparent in the parts that cover the branchiæ externally; but which do not indicate any thing uniform in the internal organization of the animal.

The class of *molusca* is distinguished into three families, which appear to form very natural divisions. The first includes the animals called *cephalopoda*, because they have their feet in the head. Their body has the form of a sack. They have three hearts. They respire in water by branchiæ. Their mouth is placed in the centre of their feet, and resembles a beak. The head is also distinguished by very large eyes, and has the ears placed internally. The stomach is muscular, like a gizzard. The liver is very voluminous. A particular gland secretes a black liquor, which they throw out, and which darkens the water around them whenever they wish to conceal themselves. Their sexes are separate.

The *gasteropoda*, which are so called because they crawl on their bellies from the second order. —in these animals the head is moveable, and frequently provided with tentacula. The heart

is single. Their organs of respiration vary in their form and position, according to the genera. The liver is very voluminous. The two sexes are united in the same individual. They cannot, however, fecundate themselves, but for that purpose require a reciprocal copulation. A considerable number are provided with shells, but they are never bivalvular.

The bivalves are found in the third order, that of the *acephala*. There are also some of these animals which crawl on the belly. The head is enveloped in a fleshy involucrum or hood; the shells are double; properly speaking they have no head, but only a mouth. The heart is single, and situated towards the back. The branchiæ are laminæ, or leaves, placed on each side within the hood. They do not copulate; several of them even experience no change of place, but remain perpetually attached to rocks.

The *worms*, which we place next to the *mollusca*, are the animals that formerly bore that name, in which we observe a vascular system, and a spinal marrow, knotted like that of insects; they form two families. Those which have branchiæ appearing externally, and those which have none. The latter appear to have their sexes united like the *gasteropoda*.

The *crustacea* furnish only two divisions, which correspond with two genera established by Linnaeus, under the names of cancer and monocus.

The *insects* divide at first into two great branches. The first comprehends those which cannot masticate solid bodies, and which live only by sucking vegetable or animal juices; some, as the *hemiptera* or *ryngota*, only undergo a semi-metamorphosis; that is to say, the larvæ differ from the perfect insects only with respect to the wings, which they want. These insects have a sharp rostrum, containing several bristles, which are capable of cutting the skin; the stomach is single and muscular, the intestines are short.

Others, (as the *diptera* or *antliata*,) undergo a complete metamorphosis. Their larva resembles a worm; their nympa is immoveable. The perfect insect has only two wings; its sucking tube is armed with bristles or lancets; some of them have besides a fleshy proboscis with two lips. The tracheæ terminate in air-bags, which frequently occupy the greater part of the abdomen.

A third order, that of the butterflies, (*lepidoptera* or *glossata*,) also undergoes a complete metamorphosis. Their larva (the caterpillar) is provided with long jaws; with a short, straight, thick, and very muscular intestinal canal; with very long hepatic vessels, and with vessels fitted for producing silk. The perfect insect has very small convoluted intestines, one inflated stomach, and tracheæ, supplied with vesicles, &c. the mouth is a double spiral syphon.

Finally, there are a small number of insects of this class, that are never metamorphosed, and never have wings.

The

The other branch, that of the insects which are provided with jaws, and which feed upon solid substances, likewise includes several orders.

The *coleoptera* have two wings, which fold under two cases; the metamorphosis of this kind of insects is complete; their larva has six short feet, a vermiform body, a scaly head, strong jaws, short and thick intestines, four long hepatic vessels, tubular tracheæ, &c. The perfect insect has four jaws. The feelers are attached to the two inferior jaws, which are partly covered by the lower lip; the intestinal canal is frequently much longer than in the *larva* state; the parts of generation occupy the greater part of the abdomen.

This order might itself be subdivided into families, several of which have very distinct anatomical characters. For example, the *scarabæi*, the larva of which have an alimentary canal, divided into a stomach, a small intestine, a colon and rectum; the colon is thick and swollen, the tracheæ are tubular. The perfect insect has long slender intestines, without any sensible dilations; its tracheæ are vesicular, its testicles very numerous.—Next, the *carnivora*, which have six feelers; their intestinal canal, in the perfect state, is very short; they have two stomachs, the second of which is villous on the external surface, &c.

The second order of insects with jaws is that of the *orthoptera* or *ulonata*. The cases of their wings are soft; they fold them under, in the manner of a fan; their jaws are covered by a peculiar part

called the helmet (galea); their stomach is at least quadruple, and not unfrequently they have more than four stomachs; their hepatic vessels are extremely numerous and intricate. Those insects only undergo a semi-metamorphosis; the rudiments of the parts of generation are often observed in their larvæ.

The third of these orders include the *neuroptera*; the insects of this kind have four membranous articulated wings. Considered in the whole, they have not many common anatomical characters; but there are some remarkable families which have an uniform structure; as (1) the *libellulæ* or *odonata*, the larvæ of which catch their prey at a distance, by a sudden extension of the lower lip; the alimentary canal is short, straight, and a little dilated at the part of the stomach. The rectum is the principal organ of respiration, as almost all the tracheæ arise from it. The internal parts of the perfect insect are smaller than those of the larva, and its tracheæ are vesicular.—(2) The *agnatha*: the larva of this family exists a long time previously to its metamorphosis, but the perfect insect perishes at the end of a few hours. It exhibits only the vestiges of the jaws, &c.

The fourth order is that of the *hymenoptera* or *piezata*: this order has four wings, which are veinous, but not reticulated. These insects resemble the *coleoptera* in the disposition of their jaws, and the complete metamorphosis they undergo.

The

The intestinal canal is very large in the larva; but it is much less in the perfect state, in which it displays only one or two slight dilatations. The hymenoptera includes the insects most remarkable for industry, and particularly the bees.

Finally, there are a small number of insects with jaws, and destitute of wings; on the anatomy of which no general observation occurs.

The *zoophyta* are very naturally divided according to the simplicity of their organization. The first order, the *echinodermata*, includes the zoophytes, that are provided with feet, teeth, a distinct stomach and intestinal canal, and with evident respiratory organs; these are the *sea-urchins*, the *star-fish*, &c. A second order may be formed consisting of those that have their digestive or respiratory organs very distinct, but are destitute of teeth; these are, the *medusæ*, the *æliniæ*, &c.

Finally, the *polyps*, whether we consider those that are naked, or those that have calcareous coverings called corals, seem to consist only of a gelatinous sack, the aperture of which is surrounded with some tentacula. They are placed in the lowest rank of animal life.

N. B. The tables connected with this work contain a recapitulation of this chapter, and an enumeration of all the genera that enter into the different divisions and sub-divisions of which we have treated.

LECTURE SECOND.

OF THE ORGANS OF MOTION IN GENERAL.

WE propose to employ the first part of this Course in describing the organs of motion, that is to say, the bones and the muscles; but before we proceed to treat of each bone and muscle in particular, we shall examine the mechanical structure, the chemical nature, and the organic functions of the osseous and muscular systems in general, and the variations which occur under those three heads, in the different classes of animals.

ARTICLE I.

Of the Muscular Fibre.

ANY portion of muscle presents, on the first view, filaments sometimes red, sometimes white, according to the kind of animal from which it is taken. These filaments, which are generally placed parallel and close to each other, seem to form small fasciculi, or rather large filaments, which, by their union, constitute the muscles. Some intervals are observed between the different fasciculi. In the animals that have red blood, and the molusca, these interstices are filled

filled with a cellular substance finer than that which separates the muscles, and less compact than that which covers them. The filaments that compose each fasciculus, are united by a cellular membrane finer than the former: and when we examine one of these filaments in a microscope, we observe that they are divided into still smaller filaments, but similar to the first, and united in the same manner. This division continues as far as we can follow it, and our instruments are incapable of shewing where it terminates.

The last of those filaments, or the most delicate fibres we can perceive, do not appear hollow;—we do not observe any cavity in them. It should seem that they may be regarded as the most simple collections of the constituent particles. In fact, their formation, or, as it might be termed, their crystallization, is obvious when the blood congeals. When a muscle has been freed by boiling, and maceration of its blood, other fluids, and, in general, all the substances it contains that are foreign to its fibre, it exhibits a white filamentous tissue, which is insoluble even in boiling water, and resembles, in all its chemical properties, the residuum of the crassamentum of the blood, after all the colouring part has been removed by ablution. This matter, in consequence of the abundance of azote which enters into its composition, possesses a character of animality perhaps more striking than

than the other animal substances. It appears, then, that the elements of fibrous matter are so closely approximated in the blood, that very little repose is sufficient to make them coagulate: In the state of life, therefore, the muscles may doubtless be regarded as the only organs capable of separating that matter from the mass of the blood, and appropriating it to themselves.

The *fibrine* (for this is the name which the chemists have given to the substance we have described,) is not confined to red blood only; the white fluid, which supplies the place of the blood in so great a number of animals, also contains it. But it is not found in the crassamentum of their blood; its filaments merely float in the serum*.

As the substances of which the blood is formed do not contain, at least in herbivorous animals, any thing that resembles this fibrous matter, and as, even in those that are carnivorous, it appears to be decomposed by the act of digestion, and is manifestly neither contained in their blood nor their lymph, it may be concluded that it is respiration which so changes the composition of the blood as to render it capable of engendering

* This discovery has not yet been published by its author; I ought, therefore, to state that it belongs to Citizen Hombert, of Havre, a very ingenious chemist, who has applied himself, with much success, to the comparative chemistry of animal substances.

engendering the fibrine. This idea is supported by the nature of the chemical operations which constitute the act of respiration, and the effects of that function on the organic system. Respiration, by removing the hydrogen and carbon from the blood, augments the proportion of its azote; and as it is respiration which preserves the muscular irritability, it is natural to suppose that this is performed by increasing the quantity of the substance in which that irritability exclusively resides.

But though there is no irritability without fibrine, that property does not shew itself in the pure fibrine when detached from the organic mass; it only retains it during life, and while its natural connection with the nerves and blood vessels, or at least with their most minute ramifications, subsists. In fact, there is no part of the body which may be properly called fleshy, that is not penetrated, in every direction, by nervous fibres; and though we cannot trace nervous filaments in their distribution over each particular fleshy fibre, the sensibility which pervades the whole muscular substance, even in its smallest portions, does not permit us to doubt the existence of this distribution.

The animals that have not distinct and separate nerves, have no visible fleshy fibres, and, as we have already shewn, irritability and sensibility do not in them appear to belong exclusively to
any

any particular system of organs. The existence of vessels, and a cellular substance, are neither so necessary nor so general; for the muscles of insects, though very distinct and very powerful, contain neither the one nor the other. The fibres which compose these muscles are simply contiguous and parallel, and have no adhesion. As they are only fixed at their extremities, if we cut them at the part by which they are attached, the fibres separate like the threads of a piece of cloth when the woof is unravelled. Cellular substance is even very uncommon in the muscles of molusca, though their vessels are pretty numerous. In all red-blooded animals, however, the muscular fibres are strongly united by cellular membranes, and are every-where interlaced by numerous blood-vessels.

The colouring matter of the blood seems to attach itself by a kind of preference to the fibrous substance, as it does to the crassamentum at its formation, since the red colour is more peculiarly proper to muscular flesh, though other kinds of organs appear to contain proportionally as much blood. Besides, the fibre of white-blooded animals is, the colour excepted, exactly similar to that of the red-blooded; the latter exhibits several shades of red: certain classes having, in general, the muscles more pale, as the reptiles and the fishes; and the muscles themselves have not all the same degree of redness.

Muscular

Muscular irritability is that property which the fleshy fibre possesses of shortening itself by oscillation, and of contracting itself, in consequence of certain determinate actions external to the fibre itself, and in which the mechanical cause cannot be discovered. This property is very distinct from the elasticity of the fibres, which is common to them, with many other natural bodies; as well as from another faculty, which is common to them, with many other parts of living bodies, by which they tend continually to shorten themselves, and, in fact, always contract when they are at liberty so to do. Irritability is not constant, but when it exists, it produces contraction, notwithstanding the ordinary obstacles.

The causes which occasionally excite the irritability of the fibres, may be divided into five orders: volition, external actions operating on the nerves, external actions operating on the fibre itself, mixed actions operating on both the nerves and the fibres, and finally, certain diseases and certain violent emotions.

When the body is in a state of health, and awake, the will exercises a most constant and prompt empire over the greater part of the muscles, which are for that reason called voluntary. A small number are not subject to the will; these produce internally the movements that are necessary to life, and which cannot
be

be interrupted; such as the motion of the heart and the intestines. It is to be observed, however, that some of the muscles which act involuntarily in men and several animals, obey the will in others: such, for example, is the stomach in ruminating animals, the movements of which they can command at pleasure, in two different directions. The motion of some other muscles appears to be of a mixed nature; we can stop their action, but their motion is continued by habit, without our formally willing it, or even without our consciousness—such are the muscles of respiration.

The muscles that are absolutely involuntary, are continually exposed to the action of an irritating cause of an extraneous nature; for the venous blood which arrives on each diastole to the heart, determines that organ to contract itself, and the aliments act in a similar manner on the stomach. It seems, therefore, that the will is not necessary to make these muscles act, and that it cannot stop their motion. A muscle laid bare, and exposed to an irritating cause, would contract itself, even in the living subject, without any participation of the will. It should also be remarked, that the nerves of the involuntary muscles are generally smaller than those of the other muscles. Indeed it was long doubted whether the heart really had any nerves; yet the irritability of the involuntary muscle is more durable,

urable, and more easily excited than that of the voluntary kind. This seems to prove that irritability is not entirely connected with the largeness of the nerves, though, at least, it partly depends on these organs.

Indeed, volition, the irritating cause which we have at present to consider, acts only through the medium of the nerves; and if a nerve be cut, or a ligature made upon it, the muscles over which it is distributed no longer obey the will. This action of the will may be imitated by concussions, punctures, or lacerations, made on the nervous trunks. These operations are immediately followed by convulsions in all the muscular parts to which the ramifications of the nerves extend, and this takes place even after death. The irritation of the medulla oblongata, after decollation, agitates all the muscles of the face; and that of the cervical part of the spinal marrow, throws the whole body into convulsions.

Violent passions may, in a certain degree, be regarded as the acts of the will strongly excited, which, in some cases, has an influence even upon the involuntary muscles: of this the palpitations of the heart and large vessels, and the suspension even of their motions, are examples.

These actions, however, may be prevented by prudently moderating the excess of that sensibility which occasions them. Even in nervous diseases, which appear to have the least connec-

tion with the passions, at least with those, the influence of which is immediately felt, the will is capable of preventing their access, when the patient is determined to resist it with firmness.

The effect of the will on the muscles is not then immediate; it depends on the action of the nerve on the muscular fibre, which it is in our power to determine by the means of that incomprehensible influence which the mind exercises over the nervous system: but if this connection between the understanding and the nerve appears to be beyond the limits of our knowledge, it still seems possible that we may one day discover the nature of the relation that subsists between the nerve and the fibre, which can only be purely physical, or the action of one portion of matter upon another.

The galvanic experiments render it exceedingly probable that this action is performed by an invisible fluid, of which the nerves are the conductors, and which, under certain circumstances, changes the nature or quantity of the fibre.

It is well known, that these experiments consist in establishing, between a muscle and the trunk of the nerves which extend to it, an external communication with one, or a series of substances placed close to each other. Metals are not the only means that may be employed in this operation; and, in general, the conductors are not the same as those of electricity. Experiments

ments have sometimes been successfully performed, when an interval was left in the series of excitators*: this circumstance proves the existence of an atmosphere.

The moment the contact takes place, the muscle suffers violent convulsions. These experiments succeed on the living body, on animals recently dead, and even on parts separated from the body, precisely in the manner of those which Haller accounts for on the principle of irritability. Neither pointed instruments nor acrid liquors are necessary; and the galvanic experiments even succeed when those means have failed.

It is evident that the galvanic convulsions can only be ascribed to a change in the internal state of the nerves and fibres, towards the production of which both those organs concur. But in the galvanic sensations which occur in living bodies, when an excitatory communication is established between two branches of nerves, we have a proof that this change may even take place in the nerve alone, whether that change be produced simply by transmission, or by a chemical decomposition. The fibre, therefore, may be simply passive in its contractions; but it should always be recollected, that it is the only part of the body which is so constituted as

H 2

to

* The name given to the foreign substances that act on the muscles, in the galvanic experiments.

to be capable of receiving this kind of impression from the nerves; for it is well known that the nerves are distributed over a number of other parts, which possess no appearance of irritability.

The influence and joint operation of the nerves are, therefore, clearly demonstrated in four of the irritating causes we have mentioned above; that is to say, in volition, in the passions and nervous diseases, in mechanical actions directed immediately on the nerve, and in galvanism, in which the nerve and the fibre are both acted upon at once.

A fifth order of irritating causes remains to be examined—those which operate when immediately applied to the fibre, and which act on the fibre only; that is to say, all external stimuli, such as pointed instruments, &c. But as every portion of muscular flesh is penetrated by nervous substance, it is difficult to suppose that the nerve may not be affected upon touching the fibre; and it appears probable that the contractions which the latter in this case experiences, proceed, as in all the preceding cases, from the influence of the nerve, in consequence of the state of its internal fluid being changed by the action of the stimulus. A muscle taken from the body, doubtless, preserves a sufficient portion of the nervous substance to render it, for some time, irritable; and the muscles over which volition has lost its empire in consequence

quence of a paralysis, or the ligature of a nerve, may, notwithstanding, obey external stimuli, because the nerve, in that state, still retains the faculty of producing, or transmitting the fluid, on which the contraction of the fibre depends; for as we are totally ignorant of the manner in which the will acts on nerves, we cannot pretend to say that the interruption of its action must necessarily be accompanied by that which the nerves themselves exercise on the muscle.

It should be further observed, that every thing proves that this action of the nerve on the fibre does not require sensation, and consciousness. This is obvious, from the example of paralytic members, which not only contract when stimuli are applied, but which sometimes even obey the will; from that of the viscera, which are continually performing motions within us, of which we are insensible; and finally, by the experiments made on portions of animals; for it appears repugnant to the notions we entertain of *self*, and of the unity of our being, to admit the possession of sensation to those fragments, though it must be confessed, that there are several examples of animals, in each part of which there appears to be formed, at the very moment of their division, a particular centre of sensation and volition. This difference between irritability, even that kind which is voluntary, and sensibility properly so called, is still more easily proved by the experiments of Arnemann, from which it appears, that

a nerve cut, and afterwards united, has recovered the first of those faculties, but not the other. The nerves and their functions are only dependent on the mind, while different ramifications communicate with the general trunk of the nerves; but they appear capable of exercising, through the medium of their own substance, that part of their functions which is purely physical: and if those functions depend upon a fluid, it may be supposed that it is capable of arising from all the points of the medullary substance. This is the opinion of Reil, and it is supported by experiments, long before made, by Stenon and others, which shew that a ligature on an artery paralyzes the muscle through which it passes.

The whole of what we have stated above applies equally well to all the different classes of animals. They are all irritable, and all those that have nerves and muscles apparent are subject to galvanism. M. Humbolt has adopted an ingenious method of distinguishing the nerves from the arteries, or other parts, in the smallest animals. He uses two needles, one gold, and another silver: A point of one is applied to the muscles, and a point of the other to the filament, the nature of which he wishes to discover, while the other extremities of these instruments are brought in contact. If the filament be a nerve, contractions immediately take place in the muscular fibre.

When

When it has once been discovered that the concurrence of the nerve is necessary to produce the contractions of the fibre, and that the latter is the only part over which the former possesses this influence, it remains to be inquired by what agent, by what medium, the nerve produces this effect upon the fleshy fibre. The principal difficulty which occurs in this question, is the consideration of the prodigious force with which the muscles contract, and the great weights they are capable of raising in a living state, while immediately after death they are torn asunder by weights infinitely smaller. This induces us to believe, that in the moment of action the particles that compose the fibre, not only approach towards each other longitudinally, but that their cohesion, or the tenacity of the fibre, becomes instantaneously much greater, without which the tendency to shorten would not prevent its rupture. Now, were it to be imagined that the texture of the fibres was such that the accession of a fluid or a vapour might give them this tendency, a supposition which at least appears very difficult, it must still be admitted, that nothing but a sudden change in their chemical composition could be capable of augmenting so promptly, and so powerfully, their cohesion. We are already acquainted with the prodigious force, with which the particles of some bodies tend to assume a new situation whenever their chemical composition is somewhat changed. The best

known example of this kind, is that which is furnished by freezing water. The loss of a little caloric disposes its molecules to condense into acute solids, and they assume this form with so much force that they burst the sides of very strong vessels. The living and contracted fibre is not therefore, strictly speaking, the same body, nor composed of the same chemical materials as the relaxed fibre; and this change is produced through the medium of the nerve by the different irritating causes. Is it by losing or abandoning to the nerve some of its elements, or is it by receiving from the nerve some new principle, that the fibre thus changes its composition? for we must adopt one of these alternatives. Farther, what is this element which passes from the one to the other?—Does it exist completely formed in one organ, and is it simply transfused into the other?—Is it formed by composition at the moment of irritation?—or lastly, does it develop itself by decomposition? These are the questions necessary to be discussed.—The new galvanic experiments, and those of an older date, improperly called magnetic, joined to the discoveries of modern chemistry, and pursued with that delicacy now introduced into the study of nature, permit us to hope for their solution. But men cannot be induced to give themselves up to those inquiries, if they are habituated to refer every effect to a particular and occult cause.

ARTICLE II.

*Of the Substance of the Bones, and the hard Parts
which supply their Place.*

THE bones of animals that have red blood differ entirely in their structure and in the manner of their growth from those parts which supply their place in other animals. It is therefore necessary that they should be separately treated.

The substance of the bones, considered abstractedly from the marrow and other foreign bodies, which cannot be completely removed, yields, upon analysis, a variable quantity of animal jelly, or gluten, soluble in boiling water, congealable by cold, alterable by fire and putrefaction; and an earthy matter, soluble in acids, which has been discovered to consist of a combination of lime and phosphoric acid, or a phospat of lime.

The quantity of calcarious phospat increases in the bones with age; the gelatinous substance, on the contrary, is most abundant in proportion as we examine it near to the epoch of birth. In the early periods of gestation, the bones of the foetus consist merely of cartilage, or indurated jelly; for cartilages resolve almost entirely into jelly when subjected to the action of boiling water. In the very young embryo there is no such thing as real cartilage; in its stead, we find a substance which has all the appearance, and
even

even the semi-fluidity of ordinary jelly, but which has already assumed a certain shape, and is covered by a membrane, which afterwards becomes the periosteum. In the first stage of ossification, the flat bones have the appearance of simple membranes; those which are to move on each other, exhibit visible articulations, though the periosteum pass from the one to the other, and envelopes the whole in one common sheath; but those which join only by sutures, as the bones of the cranium, for example, form a continued whole, in which nothing indicates that those sutures will one day exist.

The phosphat of lime, which gives consistence and opacity to the bones, is deposited in this gelatinous basis: but it is not deposited in an uniform manner; nor do the two substances unite in such a manner as to form a homogeneous whole.

In ossification, we first observe fibres or lamellæ developing themselves separately; these are succeeded by new fibres or lamellæ, which serve to unite them, and which are extended in every direction.

The surface of the bones is most generally formed of close and compact fibres, more or less regular; that is to say, of fibres which diverge as radii in flat bones, and are parallel in long bones. These fibres proceed from certain centres, which are called points of ossification; each long bone has usually three points of this kind,

kind, one towards its middle, which surrounds it as a ring, and the fibres of which extend in a direction parallel to the axis: and another principal point at each extremity of the bone, accompanied sometimes with several smaller points. When the three osseous pieces, formed by the successive extension of these three points of ossification, have even approached so closely as to be within contact of each other, they remain for some time unconsolidated, and there appears between them a quantity of matter purely gelatinous, capable of being destroyed by boiling water, or by maceration. The extremities, while separated, are called *epiphyses*, in contradistinction to the body of the bone which is denominated *diaphysis*. In the flat bones the centres of ossification may be compared to suns, of which the osseous fibres are the rays, rendered visible in the semi-transparent cartilage by their opaque whiteness. In the round bones these centres of ossification have the appearance of grains, or nuclei. In the very angular bones they assume a variety of positions and forms.

When the fibres of one centre have advanced so far as to come every-where in contact with those which are next them, the bones are then only separated by futures, which may afterwards be more or less promptly effaced. Some of those fibres turn aside to join others on the right and left, and thus produce the appearance of lattice-work. New strata are also placed above or
below

below the former, and thus the texture of the bones assume a lamellous aspect.

We are accustomed to regard as single bones, all those in which the different parts ossify and unite in youth; as the vertebræ, os occipitis, os frontis, &c. while we consider those that do not form a union with the neighbouring bones until an advanced period of life as distinct bones. Thus the frontal bone, which sometimes remains separate from the two parietals to a very old age, is regarded as a distinct bone; but at the same time it is also regarded as a simple bone, though the two parts of which it is always composed, in infancy, frequently remain separate until the age of thirty or forty.

While the bones by the successive accumulation of calcarious phosphat, attain a certain consistency in their surface, they also receive inwardly laminæ and fibres from the same substance; but which in general do not approximate so much as those of the former. The internal laminæ are placed irregularly, like those of the cellular membrane; so that generally considered, they present a real cellular structure, indurated by the accession of earthy matter. In proportion as this spongy texture acquires consistency, the gelatinous substance, which at first fills up the whole mass of the bone, seems to disappear, and to concentrate itself in the parts that are ossified. By this means cavernous interstices are formed, which are gradually occupied by an unctuous medullary substance.

substance, This is always the state of the flat bones, in which this spongy part imbued with marrow, is included between two compact surfaces, and is called *diplœe*. In the long bones, however, a considerable cavity is formed at the middle of the body of the bones: this cavity being extended towards both extremities, to the exclusion of the spongy substance, the bone at last becomes a real tube. In this case, the extremities only are occupied by an osseous, spongy cancelli, while all the middle parts are filled up with a kind of cylinder of marrow, inclosed in a very fine membrane, and provided with numerous vessels and nerves, which penetrate to it through holes formed in the compact substance of the bones.

Ossification, whether we consider it in each kind of animal, or in the different bones of the same animal, does not take place with an equal rapidity. In man, and all other mammalia, we observe that the bones of the internal ear are not only first ossified; but that they surpass all others in density, and in the quantity of calcarious phosphat they contain. The bone of the cavity of the tympanum, in the cetacea, and particularly in the whale and the cachalot, is superior in density and hardness to marble. Its section appears equally homogeneous, and exhibits no vestige either of fibres, cancelli, or vessels. On the contrary, there are other bones that are very slow in acquiring the consistency they ultimately possess. The epiphyses, for example, do not ossify until
long

long after the bodies of the bones to which they belong. Finally, there are some cartilages which, in certain classes of animals, never admit a quantity of calcarious phosphat sufficient to render them completely osseous: such are the cartilages of the ribs, and the larynx. It is certain, then, notwithstanding the general predisposition of the gelatinous parts to receive calcarious matter, (as appears from the example of tendons, and several white parts, ossifying with more facility than others,) and though there is no bone which did not formerly exist in the state of a cartilage, that there are several cartilages which are never converted into bones.

The same differences which exist in this respect between the several bones of the same species, are also found to subsist between species and species, on the comparison of the whole skeleton.

We not only find that the bones of an animal are slow in arriving at the degree of hardness which belongs to them, in proportion to the period of the growth of the animal; but we farther know, that there are some animals in which ossification is never complete, and whose skeletons are always cartilaginous. This is the case with the *sharks, rays, sturgeons*, and all those fish which are on that account called cartilaginous, or *Chondropterygii*; and though the bones of other fishes, and of reptiles and serpents, attain a greater degree of hardness, they still however preserve

preserve much more flexibility, and retain a far greater proportion of the gelatinous substance, than the bones of animals that have warm blood. These animals therefore grow during the whole course of their existence: for it is the cartilage only that grows; and when once the bones have attained their proper degree of hardness, their dimensions do not alter. The animal then can only increase in thickness. At this epoch the animal œconomy commences a retrograde progress, and the first steps are made towards old age and decrepitude. Independent of the rapidity of ossification, and the proportions which the constituent parts of bones bear to one another, animals differ among themselves, with respect to the texture of the bones, and the cavities of various kinds formed within them. In man, the internal texture of the bones is very fine. The laminæ of their spongy substance are small and close, and where this texture is most unlike latticework, it exhibits long and delicate fibres. In quadrupeds, the texture of the bones is in general coarser: in the cetacea it is more loose; their cells are larger, and the laminæ which form them much broader: it is easy to distinguish their external fibres, which in the jaws and ribs of whales, and cachalots, become, by maceration, as distinct as those of half-rotten wood. With respect to size, however, they bear no proportion to the magnitude of the animal to which they belong; for the dimensions of the bony fibre, as

6

well

well as those of the muscular, appear to depend more upon a chemical composition than upon any other circumstances.

The bones of birds are of a slender, firm, and elastic nature, and seem formed of laminæ soldered one upon the other. The bones of reptiles and fishes are in general more homogeneous. The calcarious matter seems more uniformly distributed in the gelatinous. This observation becomes more striking as we approach the cartilaginous fishes, in which the gelatinous substance completely overcomes, and appears to conceal the calcarious phosphat.

Several animals have no large medullary cavities, even in their long bones. We find none in the *cetacea* and *seals*. Caldesi long since remarked the same thing with regard to the *tortoise*; and I have made the like observation myself. The *crocodile*, however, has these cavities very distinct.

In some bones we find other cavities, called *sinuses*, which contain no marrow. They all communicate more or less directly with the exterior of the body. Man has sinuses in the *os frontis*, the *os sphenoides*, and the *ossa maxillaria*, which communicate with the nasal cavity.

In several mammiferous animals these sinuses extend much farther backward, and penetrate through a great part of the body of the cranium. In the *hog* they proceed as far as the occiput. It is they that swell so singularly the cranium of
the

the *elephant*. They even penetrate into the heart of the bones of the horns of *oxen*, *goats* and *sheep*. The *gazells* are the only animals with hollow horns that have the nucleus of their horns solid or spongy without any large cavity.

There are other sinuses in the temporal bone which communicate with the cavity of the tympanum. These are particularly extensive in birds, and in them occupy as much space as the nasal sinuses do in quadrupeds. They produce the same effect on the cranium of the *owl* as the other kind of sinuses have upon that of the elephant.

Birds have, in this respect, a very particular structure: their bones, almost without any exception, are hollow internally; but their cavities contain only air, and never marrow. These are real sinuses in their kind, which, instead of being confined to the head, as in quadrupeds, extend throughout the whole skeleton, and have a direct communication with the lungs; the air which is pushed into the trachea arteria, escaping and returning reciprocally by a hole in some one of the bones. This organization unites in their bones that levity and strength which is requisite for the kind of motion which has been assigned to them, and, like all the rest of their structure, tends to separate them from the cold blooded animals, the cavities in the bones of which are either very few or inconsiderable.

The *periosteum* is a strong white membrane, which adheres to the whole superficies of the bones, except at their articulations. It is called *perichondrium* when it covers cartilages only. This membrane has numerous vessels; and through it those pass which convey blood to the cartilages and bones. We know that the principle of the gelatinous substance is contained in the blood, and that it forms a considerable portion of the serum, or fluid part, which remains liquid on the formation of the crassamentum. We also know that there is phosphat of lime in the blood, and particularly, that milk, which is the natural food of man, and several animals, at the period when ossification is most active, contains a great deal of that substance. It is, therefore, easily discovered whence the bones derive their nourishment; but the manner in which the calcarious phosphat deposits itself, is by no means so obvious: some imagine that it transfuses from the sides of the arteries; others, that it simply passes from their open extremities; and finally, others, that the arteries themselves ossify. It is perhaps more probable that it combines with the jelly of the cartilage, and that this combination is more particularly effected at the time when the blood is fullest of calcarious phosphat, in consequence of the kind of nourishment which the animal receives, or by the general disposition of the organs, which act in the formation of its blood. We know

too well that there are diseases in which the calcarious phosphat is removed from the bones by more powerful affinities; and that there are others in which its too great abundance injures certain organs, by inducing rigidity, or produces excrescences more or less monstrous: its disproportion in the living body is the cause of disorders that are accompanied by much inconvenience and pain.

Among the more remarkable phænomena of *osteogeny*, or the developement of the substance of the bones, Comparative Anatomy particularly exhibits the formations of the horns of the deer.

These horns, in their perfect state, are true bones both in their texture and in their elements: their external part is hard, compact, and fibrous; their internal part is spongy, but very solid. It has no large cells, no medullary cavity, and no sinuses. It is sufficiently well known what their external forms are, whether in different species, such as the *elk*, the *rein-deer*, the *fallow-deer*, the *stag*, the *roe-buck*, &c. or at different ages in the same species. But these objects belong to natural history, properly so called. The bases of the horns adhere to, and form one body with the *os frontis*, in such a manner that, at certain ages, it is impossible, from their internal texture, to determine the limits between them; but the skin which covers the forehead does not extend further; a denticulated osseous

substance, called the burr, surrounds it; there is neither skin nor periosteum on this substance, nor on the rest of the horn; on these parts are only to be seen furrows more or less deep, which are the vestiges of vessels that were distributed along their surface when they were soft. These hard and naked horns remain only one year on the head of the stag; the period of their fall is varied according to the species; but when it is near, there appears, on sawing them longitudinally, a reddish mark of separation between them and the eminence of the frontal bone which supports them. This mark becomes more and more apparent, and the osseous particles of that part lose, at last, their adhesion. At that period a very slight shock frequently makes the horns drop off; two or three days commonly intervening between the fall of the one and that of the other.

The eminence of the frontal bone, at that time, resembles a bone broken, or sawed transversely, and its spongy texture is laid open. The skin of the forehead soon covers it; and when the horns are about to shoot again, tubercles arise, which are, and which remain, covered by a production of the same skin, until they acquire their perfect size. During the whole of that time the tubercles are soft and cartilaginous: under the skin is a true periosteum, in which vessels, sometimes as thick as the little finger, are distributed, and penetrate the
mass

mass of cartilage in every direction. The cartilage ossifies gradually as other bones; it passes through the same stages as the bones of a fœtus, or of an infant, and finishes by becoming a perfect bone. During this time the burr at the base of the horn penetrates the indentations through which the vessels pass, and also develops itself. The indentations, by their growth, confine the vessels, and in the end obstruct them. Then the skin and periosteum of the horns wither, die, and fall off; and the bones again becoming bare, in a short while drop off, to spring up anew, and always more considerable in size.

The horns of the stag are subject to diseases exactly similar to those of ordinary bones; thus, in some the calcarious matter is extravasated, and has formed different exostoses; in others, on the contrary, it is found in too small a quantity, and the horns continue porous, light, and without consistence.

Shells are envelopes, formed by a calcarious substance, of a foliated texture, and almost as heavy and hard as marble. These make coverings for a great number of animals of the class of molusca; and every one knows that the variety of their forms, their more or less vivid colours, and the brilliancy of their mother of pearl, constitute some of the finest ornaments of the cabinets of virtuosi. Natural history sufficiently explains these forms, and their relation with the orders and genera of the animals which inhabit

them: at present I have only to consider their texture, their growth, and the manner in which they are united to the rest of the body.

They are composed like bones of a calcarious matter, intimately connected with a gelatinous substance, and which may be, in like manner, separated by means of acids; but this matter is not disposed in lamina, or in fibres; it is uniformly extended throughout the whole body of the shell.

It is only in some species that we find strata easily separated, and, as it were, agglutinated to each other like the leaves of paper in the formation of pasteboard. We know, from observation, that these strata do not all exist in young animals; they have only the most external, which are, at the same time, the smallest. In proportion as the animal increases in age, it forms a new stratum on the internal surface of the shell, which extends beyond the edges of all the preceding strata, so that each operation of this kind adds to the size of the shell, in length, breadth, and thickness. These are certain facts; to prove them it is only necessary to compare some shells of the same species that have belonged to individuals of different ages; the fewest strata will always be found in the shells of the young. *Muscles*, which may be observed when they are very young, and even before they quit the matrix of their mother, have, at that period, shells consisting of one stratum only; but the
shell

shell is not therefore soft and gelatinous; it possesses the same firmness as the adult shell, and its greater fragility is merely owing to its thinness.

But are the strata which thus successively augment the dimensions of shells, produced by developement; or by a simple juxta-position? Do the nutritive vessels deposit the calcarious juice at different points, or does it only transude through the skin of the animal, and attach itself to the pre-existing strata? These are questions with respect to which physiologists are not agreed.

The body of the snail appears to adhere to its shell only where the muscles are attached; but Reaumur having placed thin pellicles between the body and parts of the shell, which he purposely broke, these fractures were not repaired; but when this, or any other obstacle, no longer prevented the juices flowing from the surface of the skin, the injured part was speedily regenerated.

These facts favour the idea of the simple juxta-position of a transfused matter: we observe, however, on the other hand, that the oyster and muscle adhere to the shell not only by their muscles, but by the whole border of their cloak; besides, the oyster has always between the two last strata of the convex valve, a considerable vacuity, which is filled with a fœtid acrid liquor, and which communicate with the interior of the body by a particular aperture. How is

this vacuity produced? and, above all, how is it removed upon the formation of each new stratum, if the arterial and absorbent vessels do not penetrate into the centre of the strata, to regulate its position, and to remove, from time to time, the particles of the shell?

Some observations seem to prove that there are testaceous animals, which, at certain periods, cast their old shells entirely off, and acquire new ones; but this re-production may also take place by developement, as in the horns of the deer. If the internal strata of those shells which are not cast off, be produced by a developement of this kind, it may be compared to that which forms the internal laminæ of the hollow horns of the ox, sheep, and other ruminating mammalia, and even to that by which the epidermis is produced in all animals; that is to say, there must take place a withering, or, as it were, the death of a membrane, which seems to preserve a sort of organization while it remains unexposed to external elements, or while it has not acquired its proper degree of solidity.

In this manner, it appears, are produced all the hard parts which may be regarded as the bones of animals that have no vertebræ. In cray fish, for example, the calcareous crust which, in them, is at once skin and skeleton, grows no more after it is completely indurated. The animal, however, continues to increase in all its soft parts; and when these become too much confined by
the

the envelope, the latter splits and is detached: but a new covering is found below the old one, which is formed while the latter loses its connection with the body, and as it were dies. The new envelope is at first soft, sensible, and even provided with vessels: but a quantity of calcareous particles, previously accumulated in the stomach, is soon deposited in this covering, hardens it, obstructs the pores and the vessels, and renders it in every respect similar to the shell it has replaced.

The induration of the covering of insects is not completed until they acquire their last form, after which they have no longer any occasion to change their skin: but all their skins they previously cast, though soft, are dead, and already replaced by others, which develope themselves underneath that which is destined to fall off.

All the hard parts therefore of white blooded animals, whatever may be their consistence and chemical nature, ought to be compared with respect to the manner of their growth to the epidermis, to nails, and to hollow horns, rather than to real bones. The same remark should perhaps be applied to certain external parts of fishes, though their substance is strictly osseous. I mean the bucklers of the *sturgeon* and *cyclopterus*, and the spinous tubercles of the *ray*.

Some white blooded animals have also hard parts internally; but they are not articulated in such a manner as to form the bases of moveable members,

members, and their texture differs considerably from that of ordinary bones. The most remarkable of those hard parts are, the teeth in the stomach of the lobster, the description of which, as well as that of the common teeth, we shall postpone until we come to treat particularly of digestion, and of the bones of cuttle fish, and calmars, of which we are now about to give an idea.

The common cuttle fish (*Sepia officinalis*), contains in the flesh of the back an oval substance, convex before and behind, white, solid, friable, and of a calcarious nature. This substance is not attached to the flesh, but has the appearance of a foreign body introduced into it. There is no indication of any vessel or nerve penetrating it, nor is any tendon affixed to it. It is composed of thin parallel lamellæ, which are not in immediate contact with each other. The intervals are occupied by an infinite number of small hollow columns standing perpendicular between one lamellæ and another, and arranged in a very regular quincunx.

As the superficies of the lamellæ are plane, and those of the bone itself convex, they necessarily intersect each other: the points of intersection are marked on the surfaces of the bone by regular curvilinear striæ. These bones have a kind of wings which are of a less opaque nature, less brittle, and have a greater resemblance to thin elastic horn, than the body of the bone.

To

To this last substance the part called the bone in the *calmars* (*sepia Loligo*) bear a resemblance; they are transparent, elastic, and very brittle; their shape is sometimes that of a leaf, and sometimes it is similar to a sword blade. Their connection with the soft parts is the same as the bone of the cuttle fish.

We also find a small semi-cornuous and semi-friable plate in the body of the fleshy lobe, which covers the branchiæ of the *aplysia*, and there is even one still smaller in the cloak of the *slug*.

Every thing tends to convince us that those hard parts which are found within molusca, grow by strata, like their external envelope, and that they are a kind of internal shells.

Two genera, which we place among the zoophytes, but which will perhaps acquire a higher place when their organization shall be completely known, *viz.* star fish (*asterias*), and sea urchins (*echinus*), have a kind of skeleton, the nature of which appear very much to resemble that of the shells of the molusca.

In the *urchins*, this skeleton is a solid calcareous envelope, frequently very hard. It has a number of little holes through which pass membranous feet, furnished with tubercles and points analogous to the substance of the shell which play freely on these tubercles.

In the star fish the calarious part forms a stalk composed of a number of small articulated vertebræ, which extend under the middle of each of
the

the branches of the body, and to which is attached a kind of osseous grating, which supports the remainder of the envelope of the branch to which it belongs, and which is rendered remarkable, even externally, by its projection, and by the tubercles of different forms that cover the whole of its surface.

Their osseous stalk cannot be regarded as completely external, since it is covered outwardly by an epidermis and other soft parts. This is perhaps the most striking exception to the general rule that white blooded animals have no internal articulated skeleton.

The mode of growth of the skeleton of the star fish has not yet been sufficiently investigated: that of the skeleton of some *holothuria* is exactly similar.

Finally corals, other zoophytes and lithophytes, have hard parts, which are sometimes corneous, sometimes calcareous, and sometimes spongy, but which grow by simple juxtaposition, or at least like shells, by the successive developement of several strata. In some, this growth takes place externally, and the sensible substance envelopes the old strata, by new ones, with which it again covers itself: Such is the case in *lithophyta* and *ceratophyta*.

In others, the parts which have once attained their proper hardness, no longer increase in thickness; but new shoots or branches are formed at their extremities: Such are all the jointed zoophytes.

All these productions contain, like bones and shells, a mixture of earthy matter and animal gluten.

ARTICLE III.

Of the Articulations of the Bones and their Motions.

IT is known that the bones are divided according to their forms, into long bones, flat bones, and bones of which all the dimensions are nearly equal.

We are also acquainted with the names given to their eminences and cavities, and those which indicate the state of their surfaces: these things belong merely to description, and might have been very well expressed without so great a parade of technical terms.

We shall at present only notice what relates to the articulations, because they determine the motions of which the bones are susceptible, and because some of them have a very great influence in the œconomy of different animals.

Some articulations admit of no motion whatever:—by some an obscure and very limited motion is performed; while others are disposed in such a manner that the bones of which they are composed move freely on each other, either in one or in several directions.

It not only happens that the corresponding bones are differently articulated, in different kinds of animals, but further, there are bones which, though they do not even touch each other in a great number, are however articulated, or ingrafted into one another, in some species. There are even some animals in which we observe particular kinds of articulation which do not exist in any other.

Articulation without motion, or *synarthrosis*, which takes place when two flat bones join each other immediately by their edges, is called *future*. It is *denticular* when those edges are notched and indented into one another; *harmonic* when they simply touch each other; and *squamous* when the thin edge of the one covers that of the other. The bones of the cranium and face of man afford examples of those different kinds of futures; these are the only bones that are united in this manner in the human body, but we find other examples in other animals. The ribs of the tortoise are very broad, and indented with one another, and with the vertebræ of the back to form the shell. These futures have even imposed upon several naturalists, who have imagined that fossil shells of the tortoise were parts of the human cranium. The parts of the sternum, or rather the breast-plate of the tortoise, are likewise joined by denticulated futures; the same kind of junction takes place in several of the bones that form the osseous girdle to which

which the pectoral fins of fishes are attached. The inferior and middle junction is a very perfect indented suture in the *siluri*; and in some other genera it is flattened horizontally in the fore part.

The junction of the bones of the head in mammiferous animals, resembles very much those we observe in the head of man; and in both they disappear with age in consequence of the progress of ossification. The bones of the heads of birds and fishes are almost all connected by harmonic and squamous sutures, and it appears that they unite more readily than those of quadrupeds.

In the lateral parts of the head of fishes, and in the flaps of their branchiæ, we observe a particular kind of articulation, which resembles the squamous suture, in this, that it consists of thin edges, of two flat bones overlapping each other, but which differs in admitting a motion by which the bones can bend or slide one upon the other.

Gomphosis is a second kind of articulation without motion, in which one bone is inserted as a wedge into a cavity in another bone, or in which it is contained, as a tree in the earth, by its roots. The teeth are the only example of this kind in man and in quadrupeds. The *saw fish* affords another instance in the hooks which are sunk into both sides of its long muzzle, and which suggested the name the animal bears.

Its real teeth, however, are not attached in this manner

manner more than those of *rays* and *sharks*; but are merely connected to the skin, while in other fishes they are intimately united with the jaw-bones; or these bones answer instead of teeth.

We ought to notice here a third kind of immoveable articulation, of which there is no example in the human skeleton. It is that in which a bone or other hard part inserted in one cavity, receives in a cavity, in its own base, an eminence arising from the bottom of that in which it is placed. The nails of *cats*, and of several other quadrupeds that have strong claws, are joined in this manner to the last phalanges of the toes. The tusks of the *morse* also receive a pivot from the basis of their alveoli.

Amphiarthrosis, or that kind of articulation which admits only of semi-motion, is not thus limited by the figure of the osseous parts which constitute it, but by the cartilaginous or ligamentous substance placed between the bones that form the articulation, and which firmly unites them. The bones of the pelvis are joined by this sort of intermediate cartilage in such a manner that without considerable efforts they can scarcely have any motion.

The bodies of the vertebræ act more freely upon one another, because the substance which unites them is thicker and more flexible. Their union takes place in quadrupeds and fishes in the same manner as in man: but in the neck of birds, and throughout the whole extent of the spine

spine of serpents, their articulation is completely moveable. They join by surfaces which are not united by any other substance, and which are held together, like the bones of our hand or foot, by a ligamentous capsule. This, in part, accounts for their great mobility.

We may also rank among the half-moveable articulations, those of the bones of the carpus and tarsus, which, though provided with few and smooth articular surfaces, are so confined by the surrounding ligaments, that they can only move upon each other with considerable difficulty, and within a very narrow space. But the disposition of their surfaces gives them a more important character, which should induce us to arrange articulations of this kind in the third class; that of the free articulations, or *diarthrosis*.

In the joints of the two preceding classes, the edges or surfaces of the bones which form an union, either come immediately in contact, or are bound one to the other by a substance which attaches itself throughout the whole of their surfaces or edges. The periosteum is continued from one bone to the other, and is more intimately connected at the place of their junction than to any other part. On the contrary, in the moveable articulations of which we have to speak, the opposite surfaces of the bones are free and distinct; each is covered with a smooth and polished cartilage; the interval is occupied by a liquor, and

sometimes by solid bodies, as glands, or a circular piece of cartilage. Both bones are attached to each other by a continuation of the periosteum, which does not cover the articular cartilages, but passes from the one bone to the other, and thus forms a kind of capsule, in which the articular substances are inclosed in such a manner that nothing can escape from or pass into the cavity. There are frequently other ligaments either within or without the capsule, which strengthen it, or limit the motions of the bones more than the capsule could of itself have done.

The number and rigidity of these ligaments, but still more the form of the depressions and eminences of the articular surfaces of the bones, govern the extent and direction of the motions.

A bone articulated with another by one of its extremities, can only move upon it in two ways, viz. by flexion or torsion: flexion takes place when the extremity of the bone moved, which is farthest from the joint, approaches the bone which is fixed; for when the two bones are in a straight line, that extremity is most distant from the latter. Torsion, or twisting, takes place when the bone moved turns round its own axis, or round an imaginary axis, passing through the articulation.

It will be readily perceived that torsion can only be performed when the articular surfaces are plane or spherical, and that the latter only are capable of flexion in every direction; but
when

when the surfaces are cylindrical, or each partly convex and partly concave, the motion must be confined to one direction; the bone will always remain in the same plane so long as that with which it is connected is not displaced, and will describe the segment of a circle, having its centre in the articulation.

That species of joint which admits of only one kind of flexion is called *ginglymus*, that which allows it in every direction *enarthrosis*, or *arthrodia*, according as the surfaces are more or less convex, and the flexions more or less complete.

When one bone is connected to another by two extremities, and is reduced to simply turning round, it forms a kind of *ginglymus*, which is called *rotation*.

The head is attached to the trunk, the lower jaw to the head, and all the parts of the extremities are attached to each other by these different kinds of moveable articulations; but each particular part is not always joined in the same manner in the different classes of animals. The head in mammalia is articulated by *ginglymus*; that of birds by *arthrodia*. The radius in man is connected by *arthrodia* with the humerus, and by rotation with the ulna. In the *rodentia*, *bogs*, &c. the radius is attached to the humerus by *ginglymus*, and is immoveable at its junction with the ulna; in some species it is even completely united.

Some fishes exhibit particular modes of moveable articulations, of which the skeleton of man, and other mammiferous animals, afford no examples.

The first, which may likewise be referred to ginglymus, is the annular articulation, in which a bone is, as it were, strung, like a bead, upon a branch, or at least upon a cylindrical eminence, and almost detached from other bones. The first spines of the anal fins of some *chætedons* are articulated in this manner.

The second is an articulation which can be rendered immoveable at the pleasure of the animal. The moveable bone has a small hook; and it is in the power of the animal, by turning that bone round, to insert the little hook in a hole in the immoveable bone. In this manner, by a slight flexion, the moveable bone is so linked, that its position cannot be changed except by a motion precisely contrary to that which fastened it to the other, and every effort in another direction is useless. It is thus that the *siluri* and *gasterostei* fix the first spines of their pectoral fins, when they wish to use them in combat.

We have already noticed the kind of moveable articulation which takes place between the thin edges of two flat bones, and which allows the one to slide over the other. In birds we find another kind of joint, which admits a similar motion, but which is produced between plane surfaces.

Surfaces. The palatine arch of the superior bill of the *duck* has this kind of surface, corresponding with others situated at the base of the cranium.

The *molusca* have no articulations except in their shells. Those of the bivalvular kind are, in general, articulated by ginglymus, more or less composed, in proportion to the number of indentations the shells form with one another. They have neither capsule nor articular cartilages. Externally there is an elastic ligament, which forces the valves to open when the muscles that ordinarily keep them shut are relaxed. The different pieces which form the multivalve shells, are either connected together by a common cartilaginous membrane, or they are immediately attached to the body of the animals. The *chitons* move their shells by making the edges slide one upon the other. In the *anatifæ* there is only one common motion for opening and shutting, which is performed by ginglymus, as in the bivalves. The opercula of some univalve shells, particularly the *neritæ*, are also articulated by ginglymus to the principal shell.

The crustacea and insects have a common system of articulation, which depends upon the position of their hard parts exterior to the muscles. As these hard parts form a kind of case, the interior of which is occupied by the muscles, they cannot be articulated by simple

and complete surfaces; they, therefore, can neither have arthrodia nor enarthrosis. All their moveable articulations are reducible to three kinds; ginglymus is the only one which exists in those parts that require a solid point of support, because, the scaly coverings of the members being tubular, they must be supported, at least, at two points of their circumference. This necessarily determines the articulation by ginglymus. With respect to the parts which require no solid point of support, they are either simply suspended by ligaments, or articulated by *inclusion*.

Inclusion occurs when one part enters and is enclosed in another. In this manner the limbs of insects are incased in the thorax, and the annular coverings of their abdomen into one another. As the part which receives, and that which is received, are each the segment of a spheroid, the last may perform the motion of turning; it may also penetrate more or less into the first, either by the whole of its circumference, or more on the one side than on the other; but what is properly called flexion, cannot be performed by this articulation.

The parts of insects which are articulated by ginglymus, and which are principally the different portions of their limbs, are very much hollowed on the side where the flexion must necessarily be most complete; the interval is supplied with a flexible membrane, and there is no other
ligament.

ligament. The articular tubercles and depressions are so arranged that they cannot be luxated without being broken: the slight curvatures, which form a kind of hooks, tend still further to produce this effect.

ARTICLE IV.

*Of the Tendons, of the Composition of the Muscles,
and of their Action.*

THE mode of articulation determines the number, kind, and direction, of the motions which the bones that form it are capable of performing.

The number and direction of the muscles attached to the bones, determine the number, kind, and direction of the motions they really do perform.

The muscles are attached to the bones by tendons. The tendon, like the muscle, is of a fibrous texture; but its fibres are closer, more firm, and of a silver whiteness. It is penetrated by fewer vessels, and no nerves. Its substance is almost entirely gelatinous; and it possesses neither sensibility nor irritability; it forms only a passive link, by which the muscle acts on the bone.

Portions of tendon are, however, found both in the inside and on the surface of several muscles. Even those tendons by which the muscles are inserted into the bones, penetrate a certain length into the fleshy substance, where they are interlaced in different manners. The form of the tendons varies as much as that of the muscles. Those tendons which are broad and thin are called *aponeuroses*.

In its gelatinous quality the tendon has a strong affinity to the osseous principle, or phosphat of lime: it receives it with facility, particularly when its action is frequently repeated, and when it is employed in violent motions. Heavy birds, that walk much, have the tendons of their limbs ossified at a very early period. The same thing happens to the *jerboa*, and other animals, that constantly leap with their posterior limbs.

The tendons of the crustacea and insects, in the muscles of the thigh and limbs, differ, in their nature, from the tendon of red-blooded animals; they are hard, elastic, and have no apparent fibres; they are covered by the fleshy fibres which are inserted into their surfaces. The tendon is frequently articulated with the scaly case which it has to move, in the same manner as one bone is articulated with another: it is connected with that case by a membranous ligament. This is particularly observable in the great claws of *cray-fish*.

The

The tendons of the molusca are not apparent ; but this is, doubtless, owing to the colour being the same in the tendinous and the fleshy parts. With respect to their chemical nature, it is certain that maceration and concoction completely detach the muscles from the hard parts, a circumstance which can only happen in consequence of the dissolution of their connecting medium ; that medium, therefore, does not consist of fibrine, as in the rest of the muscle, since, if it did, it would be indissoluble.

It is probable that the elementary muscular fibres all exercise an equal force at the moment of their contraction ; but the manner in which they are disposed in the muscle, and the situation of the muscle itself, with respect to the bone, or part it has to move, afford a more or less advantageous employment of that force. The action of a muscle, therefore, cannot be estimated by its mass only, nor by the number of the fibres that compose it. Two other circumstances are necessary to be considered ; the composition of the muscle, and its insertion.

The muscles are divided into simple and compound ; the *simple* are those in which all the fibres have a similar disposition ; the most common are the *ventriform* ; their fibres are nearly parallel, and form a long bundle, of a round shape ; their fleshy parts swell, more or less, in the middle, which is called their belly ; they become smaller towards the two extremities
where

where they terminate in the tendons. Another kind of simple muscle consists of those that are flat, and have parallel fibres; they form a sort of fleshy membrane, which, instead of ending in small tendons, is terminated by aponeuroses, or tendinous membranes. Both these kinds sometimes have tendons, or aponeuroses, in their middle, and at other points of their bodies. It is obvious that, in either, the total action is equal to the sum of all the particular actions of the fibres, and that, if the action experiences any disadvantage, it is owing to the mode of the insertion, and not to the composition of the muscle. This is not the case with the two other kinds of simple muscles—the *radiated* and the *penniform*.

Radiated muscles are those that have their fibres disposed like the radii of a circle, and which, proceeding from a base more or less extended, incline towards each other, and are inserted in a small tendon.

Penniform muscles have their fibres disposed in two rows, which unite in a middle line, and form, with each other, angles more or less obtuse, so that they resemble the feathers of a quill. The tendon is the continuation of this middle line.

It will be readily perceived that, in these two kinds of muscles, the total or resulting force is less than the sum total of the component forces, and that it is only equal to the sum of the
diagonals

diagonals of the parallelograms, which may be formed from every two fibres that unite in producing one angle.

A *compound* muscle is formed by the assemblage of several which unite in one common tendon. These muscles may be similar in their nature, but sometimes we find very different kinds, as the radiated, the ventriform, &c. uniting to form one compound muscle. The particular action of each may be estimated according to the preceding observations. Their total action must afterwards be calculated according to the degree of their inclination.

Lastly, there are some muscles which have only one belly, with divided tendons; others have several fleshy parts, and several tendons interlaced together in different ways. These last may be called *complicated muscles*.

From these different dispositions result the absolute force of the muscles; their insertion determines their real effect. The muscular insertions may be referred to eight distinct kinds.

Muscles may be destined to compress the soft parts contained in a certain cavity; they then envelope that cavity in different directions, in the form of membranes or bands. Such is the disposition of our abdominal muscles and diaphragm; such is that of the muscles of slugs, other molusca, and naked worms, which can contract themselves in every direction. When these muscles act together, it is for the purpose of
of

of expelling some matter from the body, as eggs, excrements, &c. but they usually act alternately, and then their effect is to enlarge one of the diameters of the cavity they surround, and to diminish the other. Thus, at each inspiration, the abdomen becomes wider and shorter, while the contrary happens on each expiration. In this manner *slugs* and *leeches* lengthen and shorten themselves, by moving, in the first case, their transverse or annular muscles, and, in the second, their longitudinal muscles.

In this manner, also, the muscles act which are destined to lengthen or shorten, to relax or compress, any soft part of the body, such as the tongue of man or quadrupeds, or the horns of snails.

The heart, the intestines, the arteries, &c. have likewise muscles of this kind.

Other muscles are calculated to widen or contract some soft aperture: some of these surround the orifice like rings, and are called *sphincters*; others are inserted in a manner more or less directly in the edges of the opening. When they are uniformly extended around the orifice, it preserves its figure, and is always dilated, or contracted, in the same manner. The eye-lid of the *moon fish*, and the anus of the *snail*, afford examples of this kind of motion. When, however, these muscles have different directions, and make different angles with the edges they have to move, the form of the aperture is very variable;

variable; such, for instance, are the lips of man. No animal comes near him with respect to the mobility of this part; and no one, therefore, possesses so expressive a physiognomy.

Another employment of the muscles is to extend and fold back, like curtains, membranes that are destined to cover certain parts, such as the eye-lids of man, quadrupeds, and birds. When these muscles are placed in the body of the membrane, their dispositions are similar to that of which we have just spoken; but, when they are situated externally, they have the form of very complicated pulleys. We shall explain them when we describe the eye of birds.

A fourth employment of the muscles may be that of turning, or rolling about, a globular mass, which is free, and supported on every side, as the eye in the orbit, or the mouth of the snail in its head. The muscles then surround this part as the portions of a hoop, which is turned to the side of the muscle that contracts most strongly.

These four modes of action are, in reality, all referable to that of the sphincters, or circular muscles. They are always performed by a girdle, or portions of a girdle, which contract, or close upon the parts they surround.

The following mode, in which the muscles act on the bones, and other hard parts, may be compared to the action of ropes, drawing a resisting object in a certain direction. The subject which is thus drawn, may be equally acted upon
in

in all its parts, so as to remain always parallel to itself. Such is the motion by which we elevate or depress our os hyoides and our larynx. The muscular fibres may then be regarded as ropes pulling in the direction in which the motion of the part acted upon is to be performed. This is the most advantageous manner in which they can be employed; and we find it exists in the *sterno-hyoides* and the *genio-hyoides*. If the muscles diverge, there is an equal quantity of action on both sides, and the resulting force is then employed in the most advantageous manner: this is what we observe in the *mylo-hyoides* and *scapulo-hyoides*.

But when the bone acted upon is articulated at any particular point, it cannot be elevated or depressed all at once: It must then be considered as a lever having its fulcrum in the articulation.

When the articulation is between the two extremities, and the muscles are placed at one of them, the bone forms a lever of the first rank. We have an example of this kind in the mandible of the *cray fish*. The muscles which are attached to the olecranon and os calcis, also furnish similar examples. The most remarkable is the tibia of the birds called *grebes* and *divers*, which has a long apophysis elevated above the knee, and which serves as a substitute for the patella.

But

But the most ordinary case is that in which the articulation is at one of the extremities of the bone, then the most favourable position for the muscle is when it rises from another bone parallel to that which it has to move, or which forms with it only a very small angle; such is the case with the muscles called *intercostales*, *interspinales*, and *intertransversi*: and the muscles which draw together certain bones that have a fan-like figure, as those of the membranes, which cover the branchiæ of fishes, and the wings of the *flying dragon*. Still, however, those muscles have an obliquity which is not rendered necessary by the position of the parts to which they are attached, and which considerably diminishes their power.

The muscles which close the mouth of man, and the bill of birds, may also be compared to the preceding, with respect to their advantageous position on account of their little obliquity; but they are inserted much nearer to the point of support than the former, a circumstance which also considerably diminishes their force.

The last mode of insertion, and the most common of all, is when a muscle attached to one bone is inserted into another, which last bone is articulated mediately or immediately with the first, and may be extended until they both form a right line, or inflected so as frequently to make a very small angle. This mode is the most disadvantageous of all, from the extreme

obliquity of the insertion, when the moveable bone is extended, and on account of its proximity to the fulcrum. The first of these inconveniences is partly corrected by what are called the heads of bones. Their articular extremities are usually enlarged, so that the tendons of the muscle, by turning round a convexity in order to be inserted below it, form more obtuse angles with the lever or body of the bone than would be practicable if the head did not exist; this diminishes and renders less variable the obliquity of their insertion.

As to the proximity of the fulcrum, that was necessary to prevent the members from being monstrously large in the state of flexion, but particularly for producing a prompt and complete flexion: for as the muscular fibre loses only a determinate fraction of its length in contraction, if the muscle were inserted at a greater distance from the joint, the moveable bone would only be approximated to the other by a small angular quantity: on the contrary, by inserting it near the apex of the angle, a very small contraction occasions a considerable approximation. This effect is produced by the muscular force; and in this manner these sort of muscles exercise a power which surpasses all imagination.

Comparative anatomy, however, affords examples of muscles inserted at a considerable distance from the fulcrum. Birds have one which extends from the top of the shoulder to the
the

the extremity of the fore-arm nearest the carpus : But this happens, because all the angle formed by the humerus and ulna, is in them occupied by a membrane intended to augment the surface of the wing.

It is also in consequence of the small contraction of the muscular fibre, that the short bones, which must be completely inflected, are moved by muscles attached to bones at a distance. The vertebræ and the phalanges of the fingers are in this situation. Muscles extended from the one to the other of those bones would not have produced a sufficient degree of flexion : besides, in the phalanges they would have made the fingers too thick. It is also necessary that the tendons of these muscles should be attached to the bones over which they pass : were not this the case, whenever the phalanges were bent so as to form an arch, the muscles and their tendons would remain in a straight line, and appear like its chord. Hence the necessity for the annular ligaments, the sheaths, and the perforations. This last organization, which occurs only in the flexions of the fingers and toes of man, quadrupeds, reptiles, and the toes of birds, consists in the muscles which have to extend farthest, being placed near to the bones, and their tendons, perforating those of the muscles, which are inserted at a shorter distance, and which lie over the first. When there is only three phalanges, there is but one perforation :

but birds, which have one toe with four, and another with five phalanges, have two perforations, and consequently three muscles; one perforated, one perforating and perforated, and one perforating.

The vertebræ which have to perform great motions; for example, those of the neck in birds, and the tail in quadrupeds, have also very distant muscles; but their long slender tendons are inclosed in sheaths, which they do not leave until they are opposite the points into which they are to be inserted.

ARTICLE V.

General Remarks on the Skeleton.

WE have already shewn that the skeleton is a collection of hard parts, supporting the body, of which it forms as it were the frame. In the invertebral, or white-blooded animals, it is external; and then its form is the same as that of the animal, since it incloses all the other parts. In the vertebral animals, it only determines the most important forms and proportions. Their skeletons, therefore, do not differ so much as their external figures; even amongst them all, there are resemblances which one would not suppose to exist, from the aspect of the parts they sustain.

The bones of which the skeletons are composed, are in general articulated in such a manner as to form a whole, all the parts of which are connected: there are, however, exceptions to this rule; the bones which support the tongue in quadrupeds, and birds, are not connected with the other bones, except by soft parts, though in fishes they are properly articulated with the rest of the skeleton. The whole of the anterior extremities are only attached to the body by muscles in quadrupeds that want the clavicles; but in other quadrupeds, they are joined to the sternum by single clavicles, and by double ones in birds.

In fishes they are strongly connected with the spine by a bony girdle.

On the other hand, their posterior extremities are generally free, and simply fixed in the flesh, while the other animals have them strongly attached to the rest of the skeleton by the medium of the pelvis.

The bones which compose the skeleton, present three principal divisions—the head, the trunk, and the extremities.

The head is never wanting: the extremities are totally wanting in serpents and some fishes; the posterior extremities are wanting in the apodes class of fishes, that is to say, in those that have no ventral fins, and in the cetacea amongst mammalia. The anterior extremities only are wanting in one species of lizard. No vertebral animal

has more than four extremities, unless we include in that number the kind of wing which belongs to the flying-dragon, a little animal next to our lizard.

The trunk is formed by vertebræ (the whole of which is called the spine of the back), the ribs and the sternum. The vertebræ are never entirely wanting, though their number is exceedingly variable. The sternum is absent in serpents and fishes; unless we should choose to give that name to the anterior part of the bony girdle which supports the pectoral fins, or anterior extremities of fishes. The ribs are wanting in *frogs, rays, sharks*, and a great number of cartilaginous fishes.

Those vertebræ which sustain the ribs are called *dorsal*. Those which are situated between the dorsal and the head, *cervical*; those which are posterior to the dorsal, *lumbar*; those which are joined to the pelvis or posterior extremities, *sacral* or *pelvic*; and those which form the tail, *coccygeal* or *caudal*. Only a very small number of mammalia, (the ternate bats,) and the frog kind, have no coccyx. Several fishes have no neck. It is obvious that in the animals that have no ribs, the distinction of the three first kinds of vertebræ cannot take place, and that the distinction of the three last disappear in those that have no posterior extremities, or where those extremities are not attached to the spine.

The ribs which proceed from the vertebræ and join the sternum are called true ribs: those
which

which do not extend so far, are called false ribs ; the latter are always posterior in quadrupeds. In birds, they are both before and behind : this distinction ceases to prevail in the animals that have no sternum. Particular denominations must be given to the ribs which proceed from the sternum, and do not join the vertebræ, of which the *crocodile* affords an example ; and those which, coming from the vertebræ, unite anteriorly with the corresponding ribs, without any sternum existing between them, as we find in the *camoleon*.

The head is always placed at the anterior extremity of the vertebral column, and that which is opposite to the tail. It is divided into three parts, which may vary in their relative proportions, but which are never wanting. These divisions are, (1) the cranium, which contains the brain, and in the partitions of which are situated the cavities of the internal ear, and frequently a part of those of the nose ; (2) the face, which contains the orbits of the eyes, the nasal cavities, and which is terminated inferiorly by the upper jaw ; (3) lastly, the lower jaw ; this last is always moveable even in the *crocodile*, though the contrary has been asserted. The upper jaw is immoveable in man, in quadrupeds, and in some reptiles, as the *tortoise*, the *crocodile*, &c. But it is more or less moveable in birds, serpents, and fishes.

The extremities, when perfect, are divided into four parts ; those which belong to the anterior extremities are, the shoulder, the arm, the

fore-arm, and the hand; those of the posterior are, the hip, the thigh, the leg, and the foot: these distinctions do not hold amongst fish whose extremities consist only of boney rays; that is to say, of bones constituted like a fan, and articulated to parts which correspond with the shoulder or hip: still, however, some analogy may be found between those parts and the division of the extremities in other animals.

The shoulder consists of the scapula, placed against the back, and the calvicule, attached to the sternum.—The last is wanting in some quadrupeds, and the cetacea, as will be seen hereafter, but is double in birds, tortoises, frogs, and many lizards:—the scapula is never wanting when the extremity exists. The arm is formed of one bone only. The fore-arm is almost always formed of two: even when the fore-arm has but one bone, there generally appears a furrow, or some other vestige of its ordinary composition. The hand varies with respect to the number of its bones; but those which exist in it always form a wrist or carpus, the body of the hand or metacarpus, and the fingers: this organization prevails even in birds which have their fingers enveloped in a skin covered with feathers; it likewise prevails in the cetacea, in which the whole of the anterior extremity is reduced to the figure of a *no* r or fin.

The *p r s* of the skeleton are usually disposed with a strict regard to symmetry; so that the two halves,

halves, formed by a longitudinal section, are counter-proofs of each other: In only one kind of fishes, called *pleuronectes*, which includes *soles*, *plaice*, *turbots*, &c. the head is so formed that the two eyes and the two nostrils are on the same side; but the symmetry of the remainder of the skeleton is preserved.

Each class and each order of animals have particular characters relative to their skeleton: they consist in the general form of the trunks and the extremities, in the presence or absence of the latter, and in the number of those different parts.

We shall explain all these particulars in detail in the following Lectures: it may be proper, however, to remark here, that though an animal of one class has some resemblance to those of another, in the form of its parts, and the use it makes of them, that resemblance is external, and affects the skeleton only in its proportions, but not in the number nor the arrangement of the bones: *bats*, for example, appear to have wings, but an attentive examination demonstrates that they are real hands, the fingers of which are merely somewhat lengthened: in the same manner, though the *dolphins* appear to have fins all of one piece, we find under the skin all the bones that compose the anterior extremities of the other mammalia, shortened and rendered almost immoveable. The wings of *penguins*, which likewise resemble fins in one piece, contain internally the same bones as those of other birds.

LECTURE THIRD.

OF THE BONES AND MUSCLES OF THE TRUNK.

ARTICLE I.

Of the Bones of the Spine.

A In Man.

THE spine of Man is divided into five regions, viz. (1) the *caudal*, or *coccygeal*; (2) the *sacral*, or *pelvic*; (3) the *lumbar*; (4) the *dorsal*; (5) the *cervical*, or *tracheal*.

The caudal region is of small extent; it consists of three or four little bones, articulated with each other, and supported by the point of the os sacrum, with which the first piece is frequently intimately united.

The sacral region is composed of five vertebræ, which are consolidated into one bone, called the os sacrum: it is parabolic, flat, and thin, at the lower end; concave before, and convex behind; its upper part is articulated with the body of the last vertebra of the loins by an oval surface, cut obliquely from the front backward, and forming,
with

with the loins, a sharp angle anteriorly. This angle is more acute in women than in men. Two other surfaces, directed backward, serve for its junction with the ossa ilii. The os sacrum is perforated by four pair of holes, which afford passage for the nerves. Posteriorly we observe eminences that correspond to all the processes of the vertebræ, which formerly composed this bone. The spinous processes, in particular, are very conspicuous: the two last are bifurcated.

There are five lumbar vertebræ; their bodies are more broad than the vertebræ above them; their spinous process is horizontal, compressed, and somewhat truncated at the point; their superior articular processes have their surfaces turned inward, the inferior have theirs turned outward; their transverse processes are long, flat, and pointed directly to the sides.

The dorsal vertebræ, which are twelve in number, diminish in size from the last to the fourth or fifth, and afterwards increase in size up to the first: their bodies are similar to those of the lumbar; their spinous processes are long, slope downward, and have the shape of a triangular prism; the three highest are more elevated, and become almost horizontal; the superior articular processes have their surfaces directed backward, and the inferior have theirs turned forward; the transverse processes are short, horizontal, and turned somewhat backward; anteriorly there is a small flat superficies, against
which

which the tubercle of the corresponding rib rests. These superficies are turned obliquely downward in the superior dorsal vertebræ, and upward in the inferior. There is, besides, at the lateral edge of each articulation of their bodies, a small cavity, common to every two vertebræ, which receives the head of the rib.

The lowest five of the cervical vertebræ are similar to those of the back, but smaller. The upper surface of each of their bodies is hollow, and receives the inferior surface of the preceding vertebra. The plane of these surfaces is inclined forward; their transverse processes are inclined somewhat forward and downward. They are remarkable for an excavation in the form of a semi-canal, and a small hole. The spinous processes are forked, except the two last.

The second vertebra of the neck, called *axis*, or *odontoides*, differs from the others in its spinous process, which is much broader, and more elevated; by the hole in its transverse process, which, instead of being perforated vertically, is directed transversely, and thus forms an oblique canal; by a pointed process, which rises from the upper surface of the body of the vertebra, and which has an articular surface anteriorly; finally, by its junction with the first vertebra, which is performed by the means of two flat surfaces corresponding to the articular processes of the other vertebræ.

The

The first cervical vertebra, which is still called the *atlas*, is merely a ring; it has hardly any spinous process, and no body; but it has two surfaces for articulation with the second vertebra, and two more which receive the condyles, by which it is connected with the head. The transverse processes are very long, and each has a foramen.

The length of the neck is nearly equal to one half of that of the back, and to two-thirds of that of the loins.

When man stands erect, the vertebral column has four curvatures. The region of the sacrum is concave before, the loins are convex, the back is concave, and the neck is convex.

The vertebræ of man are susceptible of a number of small motions with respect to each other; but these motions, though very conspicuous in the whole of the spine, are very obscure between any particular bones. Each vertebra can move a little forward, by resting on the anterior part of its body; backward, by inclining in the direction of the spinous processes; and, finally, sideways, by yielding a little in the direction of the oblique processes. These articulations are firmly supported by a number of strong ligaments; but to describe them in one vertebra is almost sufficient for a knowledge of the whole.

The body of each vertebra is covered, both above and below, by an elastic cartilaginous substance, the solidity of which gradually diminishes

minishes from the centre to the circumference. The articular processes have also each their capsules. All the anterior part of the bodies of the vertebræ is covered by a large and very solid coat, formed of tendinous or ligamentous fibres, which extends from the first cervical vertebra to the os sacrum. Behind the bodies in the interior of the vertebral canal, there is likewise another tendinous covering, which extends from the tooth-like process of the second vertebra to the os sacrum. Each process, whether spinous or transverse, has also a small ligament, which unites it to the preceding or the following process. The last vertebra is connected in the same manner with the os sacrum.

B *In other Mammiferous Animals.*

The spine of Quadrupeds may differ in the number of the vertebræ, in the respective proportions of the neck, back, loins, sacrum and coccyx, in the total curvature, and in the form of each vertebra.

1. *Number of the Vertebræ in Mammalia.*

The number of the cervical vertebræ is always seven, except in the *three-toed sloth*, which has nine. The *cetacea* have frequently two or more ossified together; for example, the two first in
the

the *dolphin* and *porpoise*, and the six last in the *cachalots*; but the parts are always perceptible; they are merely joined by anchylosis.

As to the other vertebræ, their different numbers, in the different species, have no constant relation with their natural families, as will appear from the table underneath.

In the cetacea there is, strictly speaking, no pelvis, and, consequently, no distinction can be established between the vertebræ of the loins, those of the sacrum, and those of the tail.

Only a very small number of mammalia want caudal vertebræ, among which are the *ternate bats*.

TABLE of the Number of the Vertebræ in
Mammiferous Animals.

Species.	Dorsal Vertebræ.	Lumbar Verteb.	Sacral Verteb.	Caudal Vertebræ.
Man	12	5	5	4
Orang-outang	12	4	3	4
Jocko	13	5	4	5
Long armed Ape	14	3	6	
Coaita, or 4 fingered Monkey	14	3	2	32
Weeping Monkey	14	7	4	25
Silky Monkey	12	7	1	26
Red Monkey	12	7	3	more than 16
Rib-nosed Ape	12	7	1	13
Hair-lipped Monkey	12	7	1	5
Chinese Monkey	11	7	3	20
Baboon	12	7	1	31
Magot, or Barbary Ape	12	7	1	3
Mandrill	12	7	3	13
Pongo	12	4	3	4
Howling Baboon	14	4	5	25

158 L.III. BONES AND MUSCLES OF THE SPINE.

Species.	Dorsal Vertebræ.	Lumbar Verteb.	Sacral Verteb.	Caudal Vertebræ.
Maucaco	12	7	3	18
Lori	15	9	1	9
Tarfier, or Woolley Jerboa ..	14	5	3	more than 17
Vampire, or Ternate Bat ..	12	4	1	0
Common Bat	11	5	4	12
Noctule, or Great Bat	12	7	3	6
Horse-shoe Bat	12	6	3	12
Flying Lemur	12	6	1	22
Hedge-hog	15	7	4	12
Tanrec	15	6	3	8
Shrew	12	7	3	17
Mole	13	6	7	11
White Bear	13	6	7	11
Brown Bear	14	6	5	more than 4
Badger	15	5	3	16
Glutton	16	5	3	18
Coati	14	6	1	more than 10
Raccoon	14	7	3	20
Otter	14	6	3	21
Martin	14	6	3	18
Weasel	14	6	3	14
Civet	13	6	3	20
Lion	13	6	3	23
Tiger	13	7	4	19
Panther	13	7	3	24
Couguar, or American Lion ..	13	7	3	22
Cat	13	7	3	22
Dog	13	6	3	22
Wolf	13	7	3	19
Fox	13	7	3	20
Hyena	16	4	2	more than 8
Cayenne Opossum, or Crab- eater	13	6	5	more than 16
Marmose, or Murine Opossum ..	13	6	1	29
Phalanger, or Surinam Opos- sum	13	6	1	30
Porcupine	14	5	4	more than 8
Hare	12	7	4	20
Rabbit	12	7	2	20
Cabiai	13	6	2	more than 4
Guinea Pig	13	6	4	6

Species.	Dorsal Vertebrae.	Lumbar Verteb.	Sacral Verteb.	Caudal Vertebrae.
Paca, or Spotted Cavy	13 . .	6 . .	5 . .	7 . . .
Agouti	12 . .	8 . .	4 . .	7 . . .
Beaver	15 . .	5 . .	3 . .	23 . . .
Flying Squirrel	12 . .	8 . .	3 . .	13 . . .
Marmotte	13 . .	7 . .	6 . .	22 . . .
Field Mouse	13 . .	7 . .	3 . .	15 . . .
Water Rat	13 . .	7 . .	4 . .	23 . . .
Black Rat	13 . .	7 . .	3 . .	26 . . .
Norway Rat	13 . .	7 . .	4 . .	23 . . .
Common Mouse	12 . .	7 . .	4 . .	24 . . .
Field, or Harvest Rat	12 . .	7 . .	3 . .	23 . . .
Hamster	13 . .	6 . .	4 . .	15 . . .
Fat Dormouse	13 . .	7 . .	2 . .	18 . . .
Garden Dormouse	13 . .	7 . .	4 . .	24 . . .
Ant-eater	16 . .	2 . .	4 . .	40 . . .
Pangolin	15 . .	5 . .	3 . .	28 . . .
Long-tailed Manis	13 . .	5 . .	2 . .	45 . . .
Armadillo	11 . .	4 . .	3 . .	30 . . .
Two-toed Sloth	13 . .	2 . .	4 . .	more than 7
Three-toed Sloth	14 . .	4 . .	3 . .	13 . . .
Elephant	20 . .	3 . .	4 . .	24 . . .
Hog	14 . .	5 . .	3 . .	more than 4
Tapir	20 . .	4 . .	3 . .	12 . . .
Rhinoceros	19 . .	3 . .	4 . .	22 . . .
Camel	12 . .	7 . .	4 . .	17 . . .
Dromedary	12 . .	7 . .	4 . .	18 . . .
Stag	13 . .	6 . .	3 . .	11 . . .
Camelopard	14 . .	5 . .	4 . .	18 . . .
Antelope	13 . .	6 . .	5 . .	15 . . .
Gazelle	13 . .	5 . .	5 . .	11 . . .
Chamois	13 . .	5 . .	4 . .	more than 7
Goat	13 . .	6 . .	4 . .	12 . . .
Sheep	13 . .	6 . .	4 . .	16 . . .
Ox	13 . .	6 . .	4 . .	16 . . .
Horse	18 . .	6 . .	2 . .	17 . . .
Couaga	18 . .	6 . .	7 . .	18 . . .
Seal	15 . .	5 . .	2 . .	12 . . .
Dolphin	13 . .	} In all 66		
Porpoise	13 . .			

2. *Proportions of the Spine in different Quadrupeds.*

The length of the neck does not depend on the number of the cervical vertebræ, for, as we have already observed, that number is almost always the same in all quadrupeds.

In general, the length of the neck is such, that, added to the head, the length of both is equal to the height of the animal's shoulders from the ground. Were not this the case, quadrupeds could not easily either reach the herbs on which they feed, or the water they drink. Among all those in which this rule is observed, the bulk of the head is in an inverse proportion to the length of the neck, otherwise the muscles would not be able to raise it up.

This rule, however, is not adhered to in the animals that lift food to the mouth by the means of hands, or feet constructed like hands; nor in the elephant, in which the proboscis is substituted for hands; nor in the cetacea, which live and obtain their food in water, and which, of all mammalia, have the shortest necks.

The shape of the body in animals, whether slender, or thick and short, is principally determined by the length of loins, which depends upon the number of the lumbar vertebræ. This is observable in the *lori*, &c.

TABLE

*TABLE of the Length in Metres * of the Regions of the Spine in Mammiferous Animals.*

NAMES.	Total.	Cervical.	Dorsal.	Lumbar.	Sacral.	Caudal.
Man	0,74	0,11	0,30	0,16	0,14	0,03
Orang	0,26	0,04	0,11	0,05	0,04	0,02
Pongo	0,66	0,12	0,29	0,13	0,10	0,02
Sai	0,66	0,03	0,09	0,09	0,03	0,42
Ternate Bat	0,19	0,05	0,07	0,03	0,04	
Common Bat	0,11	0,01	0,01	0,01	0,01	0,06
Mole	0,135	0,015	0,03	0,03	0,03	0,03
Hedge-hog	0,19	0,02	0,07	0,04	0,02	0,04
Sea Bear	0,39	0,31	0,44	0,28	0,17	0,19
Seal	0,72	0,12	0,24	0,15	0,06	0,15
Glutton	0,70	0,11	0,22	0,13	0,04	0,20
Racoon	0,64	0,06	0,14	0,10	0,04	0,30
Otter	0,98	0,11	0,24	0,13	0,03	0,47
Lion	1,51	0,27	0,44	0,35	0,09	0,36
Cat	0,71	0,08	0,15	0,13	0,03	0,32
Wolf	1,08	0,18	0,28	0,21	0,05	0,36
Opoffum	0,68	0,05	0,11	0,10	0,02	0,40
Hare	0,48	0,07	0,11	0,17	0,03	0,09
Guinea Pig	0,20	0,04	0,06	0,06	0,02	0,02
Three-toed Sloth	0,54	0,09	0,23	0,04	0,08	0,10
Long-tailed Manis	0,84	0,03	0,10	0,06	0,04	0,61
Elephant	2,85	0,32	1,05	0,25	0,21	1,02
Hog	1,25	0,17	0,42	0,25	0,11	0,30
Rhinoceros	1,85	0,45	1,40	0,20	0,22	0,69
Dromedary	2,98	1,00	0,85	0,49	0,20	0,44
Camelopard	4,22	1,82	0,88	0,35	0,24	0,93
Ox	2,12	0,39	0,58	0,35	0,20	0,60
Stag	1,50	0,47	0,46	0,30	0,12	0,15
Horse	2,01	0,49	0,64	0,24	0,17	0,47
Dolphin	1,26	0,04	0,26	0,96		
Porpoise	1,10	0,03	0,25	0,82		

* The Metre, which is the unit in this Table, is equal to 3 feet 11 lines of the old French measure, or about 3 feet 3 inches 6 lines English.—T.

3. *Form of the different Vertebrae in Mammiferous Animals.**α Vertebrae of the Neck.*

The cervical vertebrae of the genus *simia*, differs from ours only in their spinous process being stronger, and not forked. Their bodies, too, press more upon each other anteriorly, which serves the better to support the head.

In the *pongo*, in particular, their spinous processes are excessively long, doubtless in consequence of the largeness of the head and the length of the muzzle.

In the Carnivora, the transverse processes of the middle vertebrae of the neck assume a compressed shape, both on the anterior and posterior surfaces. The two last only form grooves; the holes are almost in the body of the vertebrae; the axis and atlas are much larger; the transverse processes of the atlas are very large and flat on the front and the back; the spinous process of the axis is very high, and is prolonged both upward, upon the atlas, and downward, upon the third vertebra: they thus furnish sufficient points of insertion for the muscles that move and support the head, which is very disadvantageously placed in these animals. The other spinous processes, except the last, are short: they are all directed, more or less, towards the head.

In

In the *moles* and in the *shrews* the vertebræ of the neck have no spinous processes at all. They form simple rings, which admit much freedom of motion.

Among the Edentata, the *ant-eaters* and the *armadillos* have the six last cervical vertebræ foldered or ossified together. The bodies of all these vertebræ are large, and compressed anteriorly. In all the species of this family they form a sort of groove, in which the œsophagus is lodged.

The bodies of the vertebræ of the Rodentia, as well as those of the *hog*, the *tapir*, and the *rhinoceros*, are disposed in a manner nearly similar. The transverse processes in the *hog* have the anterior part of their extremities so much enlarged and compressed that they seem double.

The *elephant*, whose neck is very short, has vertebræ like those of the Monkey tribe.

In the Ruminantia, the spinous processes diminish in proportion to the length of the neck. In the *camel*, the *camelopard*, &c. these processes are almost effaced, which is necessary, otherwise the neck could not be bent backward. The transverse processes are compressed, and form two angles, the superior of which is directed forward, and the inferior towards the side. In those which have short necks, such as the *ox*, the *goat*, and the *sheep*, these two angles form double transverse processes.

The cervical vertebræ of the *horse* have much

resemblance to those of the Ruminantia. In both, the bodies of the vertebræ have a sort of longitudinal ridge on their anterior part.

In quadrupeds, in general, the last but one of the cervical vertebræ has, upon the lateral parts of its body, two obtuse eminences, which form a kind of channel.

In the *dolphin*, the atlas has a considerable resemblance to that of *man*; the axis is very thin, and anchylosed with the atlas. The other five vertebræ are nearly as thin as paper.

In the *cachalot* the whole seven vertebræ are anchylosed; the five intermediate ones are extremely thin.

β Vertebræ of the Back.

The dorsal vertebræ of *monkeys* do not materially differ from those of *man*. The spinous processes in the *macacques* and *magots* are, however, elongated, and somewhat elevated.

The *bats* have no spinous processes on their dorsal vertebra; they are replaced by very small tubercles, and even these are wanting in some species, so that the spinal column presents no asperities on its posterior part. Their vertebral canal has a very great diameter in this region.

In the true quadrupeds, these processes are longer, straighter, and stronger, in proportion

as the head is heavy, or joined to a longer neck. It is necessary, indeed, that they should afford to the cervical ligament points of attachment proportioned to the weight it has to support; thus the *camelopard*, the *camel*, the *ox*, the *rhinoceros*, and the *elephant*, have these processes longest. It is a mistake to imagine that they sustain the hump of the camel, it being composed of fat only.

The *dolphin* has them of a moderate size, but straight, and less than those of the *lumbar vertebræ*, because the latter furnish insertions to the vast muscles of the tail.

γ *Vertebræ of the Loins.*

The lumbar vertebræ of *apes* have their spinous and transverse processes directed a little towards the head. This is still more apparent in the *dog* and *cat*, in which these processes are longer. In the *Quadrumana* and *Sarcophaga* there is commonly on the external side of each posterior articular process, a point directed backward, so that the anterior articular process of the next vertebra is received between two prominences. The motion is thus considerably limited. This point likewise exists in the *Rodentia*, but it is generally shorter: no such disposition is found in the other orders. The mag-

nitide of the transverse processes marks the strength of the loins, as is observable in the *ox*, the *horse*, the *porpoise*, &c.

δ *Vertebræ of the Sacrum.*

The os sacrum of quadrupeds is in general narrower than in man, and forms with the spine one straight line. It presents therefore no solid base for an erect posture, as we shall see more evidently in treating of the pelvis.

The form of the sacrum is generally that of a long triangle. In every genus, those species which sometimes stand erect, have it proportionably larger than others; such are, the *monkey*, the *bear*, and the *sloth*.

The spinous processes, which in man and the monkey are very short, are somewhat longer in the carnivorous animals: they almost touch and form a continued crest in the *rhinoceros*, and in most of the ruminating kind; but this disposition is most remarkable in the *mole*, which has the crest very long, as well as the bone itself.

In the *ternate bat*, the os sacrum forms a long compressed point, the extremity of which unites with the tuberosities of the os ischium, but has no os coccygis.

ε *The Vertebrae of the Tail.*

The caudal vertebrae in mammalia are of two sorts; those that preserve a canal for the passage of the spinal marrow, and those that do not: the latter are generally of a prismatic form; they diminish gradually in magnitude to the end of the tail; they have only slight protuberances for the insertions of the muscles.

The others are the nearest to the sacrum; they have articular and transverse processes, and also spinous processes, which are the more distinct in proportion as these animals move the tail with greater frequency and force.

Those animals in which the tail is prehensile, as the *sapajous*, have on the under side, and at the base of each body of the vertebrae, two little prominences between which the tendons of the flexor muscles pass.

The mammalia, in which the tail is long, and much accustomed to motion, have often two or three little supernumerary bones, situated at the inferior surface upon the joints of some of the vertebrae: these bones commonly extend from the third or fourth vertebrae, to the seventh or eighth: it has been observed that their shape resembles a V; they afford points of insertion for muscles.

The *beaver*, which uses his tail as a trowel, has the caudal vertebrae remarkable both for

the magnitude of the transverse processes, and because the inferior spinous processes are larger than the superior. To this he is indebted for the force with which he strikes his tail downward when forming the earth into mortar.

The spine of the *cetacea* differs widely from that of quadrupeds in its form, which more nearly resembles that of fishes: it may be useful, briefly to notice, in this place, its peculiarities.

Of the seven cervical vertebræ the first alone is quite distinct, and bears a well defined spinous process.

The dorsal vertebræ have at first the articular processes at the root of the transverse; but towards the ninth vertebra there are only the superior ones; for at this height these articular processes turn backward to the basis of the spinous processes next the head, and form a kind of groove which receives the preceding spinous process.

The vertebræ of the loins and tail admit of no distinction, as there is no pelvis. It may be observed, however, that the transverse processes, which are very long in the first lumbar vertebra, become shorter as they approach the tail, and are totally effaced in the last of those vertebræ.

C. *In Birds.*

The number of the vertebræ that compose
the

the different regions of the spine, varies as much in birds as in quadrupeds. This will appear from the following Table ;

TABLE of the Number of the Vertebrae in Birds.

SPECIES.	Ver. of the neck.	Ver. of the back.	Ver. of the sacrum.	Ver. of the coccygis.
Vulture.....	13	7	11	7
Eagle.....	13	8	11	8
Bald-Buzzard.....	14	8	11	7
Sparrow-Hawk.....	11	8	11	8
Common Buzzard.....	11	7	10	8
Kite.....	12	8	11	8
Great Horned Owl.....	13	7	12	8
Common Owl.....	11	8	11	8
Fly-Catcher.....	10	8	10	8
Blackbird.....	11	8	10	7
Tanager.....	10	8	9	8
Crow.....	13	8	13	7
Magpie.....	13	8	13	8
Jay.....	12	7	11	8
Starling.....	10	8	10	9
Gros-beak.....	10	7	12	7
Bull-finch.....	10	6	11	6
Sparrow.....	9	9	10	
Gold-finch.....	11	8	11	8
Titmouse.....	11	8	11	7
Lark.....	11	9	10	7
Red-breast.....	10	8	10	8
Swallow.....	11	8	11	9
Goat-fucker.....	11	8	11	8
Humming Bird.....	12	9	9	8
Hoopoe.....	12	7	10	7
King's-fisher.....	12	7	8	7
Wood-pecker.....	12	8	10	9
Toucan.....	12	8	12	more than 7
Parrot.....	11	9	11	8
Pigeon.....	13	7	13	7
Peacock.....	14	7	12	8

170 L.III. BONES AND MUSCLES OF THE TRUNK.

SPECIES.	Ver. of the neck.	Ver. of the back.	Ver. of the sacrum.	Ver. of the coccygis.
Pheasant.....	13..	7..	15..	5..
Turkey.....	15..	7..	10..	5..
Curlew Bird.....	15..	8..	10..	7..
Ostrich.....	18..	8..	20..	9..
Cassowary.....	15..	11..	19..	7..
Flamingo.....	18..	7..	12..	7..
Heron.....	18..	7..	10..	7..
Stork.....	19..	7..	11..	8..
Crane.....	19..	9..	12..	7..
Spoonbill.....	17..	7..	14..	8..
Avocet.....	14..	9..	10..	8..
Plover.....	15..	8..	10..	7..
Lapwing.....	14..	8..	10..	7..
Woodcock.....	18..	7..	13..	8..
Curlew.....	13..	8..	10..	8..
Oyster-catcher.....	12..	9..	15..	8..
Rail.....	13..	8..	13..	8..
Coot.....	15..	9..	7..	8..
Jacana.....	14..	8..	12?	7..
Pelican.....	16..	7..	14..	7..
Cormorant.....	16..	9..	14..	8..
Sea swallow.....	14..	8..	10..	8..
Gull.....	12..	8..	11..	8..
Petrel.....	14..	8..	??	8..
Swan.....	23..	11..	14..	8..
Goose.....	15..	10..	14..	7..
Barnacle.....	18..	10..	14..	9..
Duck.....	14..	8..	15..	8..
Sheldrake.....	16..	11..	11..	9..
Scoter, or Black Diver.....	15..	9..	14..	7..
Merganser.....	15..	8..	13..	7..
Grebe.....	14..	10..	13..	7..

The vertebræ of the neck of birds, are in general very numerous; they vary from ten to twenty-three; the number of the dorsal vertebræ varies from seven to eleven. There are no lumbar vertebræ, properly so called; all those which

which extend from the thorax to the tail being ossified in one piece with the two ossa ilii. The tail is short, and has but a few joints ; from seven to eleven.

The part which varies most in point of length is the neck : its length is proportioned to the height of the legs, except in some water-fowls, where it greatly exceeds that proportion. This is necessary to enable them to seek their food below the surface of the water in which they swim.

The bodies of the vertebræ of the neck are not articulated by flat surfaces, which only admit of an obscure motion, but by surfaces forming portions of a cylinder, which allow great flexion. The three, four, or five uppermost vertebræ can only bend forward, and the rest only backward. This makes the necks of birds resemble the letter S ; and it is by contracting or widening the two arches which form this curve, that they shorten and stretch out the neck.

The articular processes of these vertebræ point upward and downward ; the others forward and backward.

Instead of transverse process, the cervical vertebræ of birds have only an eminence upon the upper part. The anterior extremity is furnished with a styloid process, which descends parallel to the body of the vertebra.

The uppermost and lowermost, only, have distinct

tinged spinous processes, and these have them both on the anterior and the posterior part. The intermediate vertebræ have anteriorly two ridges, which form a semi-canal; and posteriorly, a protuberance which is often bifid, and which, when prolonged, presents two scabrous lines.

This structure was necessary for lodging the tendons of the muscles that produce the complicated motions we observe in the necks of birds.

The *atlas* is shaped like a little ring; it is only connected with the head by one surface.

The back of birds is as remarkable for its want of motion, as their neck is for its flexibility. The vertebræ which compose the back have spinous processes, touching each other, and tied together by strong ligaments. The greater part of these processes are often united into a solid piece, which runs, like a ridge, along the whole length of the back. The transverse processes send off from their extremities two points; the one directed forward, the other backward: they join those of the other vertebræ, and sometimes are foldered to them in the same manner as the spinous processes are to each other. This disposition was necessary, that the trunk might remain firm amidst the violent efforts which the motion of flying requires: indeed, the birds which do not fly, such as the *ostrich* and the *casowary*, retain the motion in their spine.

The last dorsal vertebræ are frequently placed
under

under the crista of the ilium, and there, like the lumbar vertebræ, they are often anchylosed with the large bone of the haunches; on this account the number of holes which give passage to the nerves is commonly the only criterion of the number of these vertebræ.

The vertebræ of the tail are most numerous in those birds that move it with the greatest force, such as the *magpie*, *swallow*, &c. They have spinous processes both above and below, and very long transverse processes. The last of all (to which the quills are attached) is largest, and has the form of a ploughshare, or a compressed disque. In the *casowary*, which has no visible tail, the last bone has a conical shape. In the *peacock*, on the contrary, it has the figure of an oval plate situated horizontally.

D. In Reptiles.

The number of vertebræ, and every other attribute of the spine, are more varied in this class of animals than in any other.

In the *tortoises* seven vertebræ are assigned to the neck; the first is only a simple tubercle, the annular portion of which is very distinct. The surface, by which it is articulated with the head, is formed of three planes, one anterior and two lateral. The point in which they unite is the most prominent, and to this is attached a strong
6
ligament.

ligament. The surface which unites it to the next vertebræ is a glenoid cavity; the second and the following vertebræ have a prominent longitudinal ridge upon the fore-part of their body. The articular processes descend below the body; there are no spinous processes except one to the second vertebra, which points forward, and one to the third in the form of a simple tubercle. The two last vertebræ, at a certain age, become anchylosed.

There are eight dorsal vertebræ, but they are all anchylosed together with the ribs and the back shell in one immoveable piece. They have, therefore, neither processes nor articular surfaces. They are all narrower in the middle than at the ends.

The lumbar and sacral vertebræ are likewise consolidated with the back shell, but those of the tail are free and moveable.

The condyle, which forms the body of these vertebræ at its articulation with the others, inclines backward, and not towards the head, as those of the neck do. There are likewise upon the fore-part of the body, at its base, two small tubercles; but all the processes of these vertebræ resemble those of the mammalia.

In the family of *lizards*, the *crocodile* has seven cervical vertebræ, the five last of which have their processes so closely pressed together that the neck cannot be bent towards the side. The same number (seven) is found in most lizards, though

though the *cameleon* has only two. The sacral vertebræ are few in every species, and none of them have a large os sacrum.

As *frogs* have no ribs, no distinction can be formed with respect to the three first orders of vertebræ in them.

They have, in general, eight between the neck and the pelvis, all furnished with pretty long transverse processes. The last are the longest, and touch the ossa ilii. In the *toads* the transverse processes are very large, and shaped like hatchet blades. The os sacrum consists of a single bone only; it is long, pointed, compressed, and has no coccyx. In the *pipa*, which has the transverse processes of the second and third vertebræ much longer than the others, and almost like ribs; this bone is ossified with the last vertebræ.

The *salamanders* have fourteen vertebræ between the head and the sacrum; they have all nearly the same shape except the first, which receives the head, and the last, which is articulated to the sacrum. The two extremes of the spine alone want the vestiges of the ribs, which consist of small oblong moveable bones, actually articulated to the transverse processes, which here take a posterior direction. The articular processes are large, and wedged together. The posterior rest upon the anterior, so as to impede the motion of the spine backward. The sacrum con-

sists only of a single vertebra, but there are twenty-seven in the tail.

In *serpents*, the vertebræ alone constitute almost the whole skeleton, and they are nearly of the same form from the head to the tail: the body, as well as the spinous, articular, and transverse processes, are easily distinguished. In certain kinds, for instance the *boa*, the spinous processes, which are continued throughout the whole length of the back, are separated from each other, and allow reciprocally a motion sufficiently conspicuous. Wherever this disposition of the spinous processes prevails, the body of the vertebræ, on the side next the belly, presents only an obscure projecting line.

In other kinds of serpents, as for example the *rattlesnake*, the spinous processes are long, and so large as to touch each other. They have, for their basis, the articular processes, which lie on each other like tiles. In consequence of this structure, the motion of the spine towards the back is very circumscribed, but its motion towards the belly and sides much augmented. The bodies of the vertebræ play very easily in these directions upon one another, and are armed with a sharp spine tending towards the tail, which only obstructs their motion when it might produce a luxation.

The first vertebræ differ from those of the rest of the body, only in having the rudiments
of

of the ribs much smaller: there is no neck in these animals.

The vertebræ of the tail differ no farther than in having no ribs, and that their spines, both ventral and dorsal, are double, or form two ranges of tubercles. The articulation of the bodies of the vertebræ with each other is very remarkable: the anterior part of the body of the vertebra presents a smooth hemispherical tubercle, and the posterior part a corresponding cavity; so that each vertebra becomes connected to those next it by a sort of knee joint: this mode of articulation fully explains the motion of reptiles, which is performed winding from side to side, and not up and down, as it is represented by painters.

TABLE of the Number of the Vertebræ in Reptiles.

1. Oviparous Quadrupeds.

SPECIES.	Ver. of the neck	Ver. of the back.	Ver. of the loins.	V. of the sacrum.	Ver. of the tail.
Turtle.....	8..	11..	0..	3..	20..
Crocodile.....	8..	11..	5..	2..	36..
Tupinambis.....	7..	18..	4..	2..	104..
Iguana.....	5..	11..	9..	2..	72..
Cameleon.....	3..	17..	3..	1..	69..
Salamander.....	1..	12..	1..	1..	26..
Frog.....	10 in all.....				
Pipa, or Sarinam toad.....	8 in all.....				

2. *Serpents.*

SPECIES.	Vertebræ to which ribs are joined.	Vertebræ of the tail.
Viper (<i>berus</i>)	139	55
Spectacle Snake (<i>naia</i>)	192	63
Garter Snake (<i>natrix</i>)	204	112
Amphisbæna	54	7
Boa (<i>constrictor</i>)	252	52
Common Snake	244	more than 60
Rattlesnake	175	26
Slow-worm (<i>anguis fragilis</i>)	32	17

E. *In Fishes.*

The vertebræ of osseous fishes have their bodies sometimes cylindrical, sometimes angular, and sometimes compressed. They are joined by their bodies only. The annular portions do not touch each other, and they have no articular processes: they may be divided into two classes, the *caudal*, which have a spinous process above and another below; and the *abdominal* or *dorsal*, which have the spinous process upon the upper part only. These last have generally, on the sides, transverse processes, to which the ribs are attached.

The spinous processes both inferior and superior are very long, particularly in those which are flat, as the *pleuronectes*, *chaetodons*, &c. The canal for the passage of the spinal marrow is formed in the vacancy of the superior processes. In the inferior there is a similar passage for the blood vessels. The structure of cartilaginous fishes is nearly similar; but as all the cartilages are

consolidated together, the spinous processes can only be distinguished.

The vertebra of a fish may be easily known from that of any other animal, by the configuration of its body, which presents, both anteriorly and posteriorly, cavities that are united to similar depressions in the adjoining vertebra, and form, throughout the whole vertebral column, cavities composed of two cones joined at the base. These hollow cones contain a cartilaginous substance, formed of concentric fibres, of which those next the centre are much the softest. Upon this cartilage all the vertebræ perform their motions.

The last vertebra of the tail is, for the most part, of a triangular form, flat, and placed vertically; upon its posterior extremity it bears articular impressions, which correspond to the small and delicate bones of the fin of the tail. Besides the hard parts which support the bodies of fishes, there are certain small bones quite detached and unarticulated, which serve as fulcra to the muscles of the body. There are others which take the same direction as the spinous processes, and support the dorsal and anal fins. These last vary much in their form in the different kinds of fish; sometimes they are triangular, and sometimes compressed, rounded, or serrated, on one or more of their angles. The little bones are retained in their positions by a ligament which connects them to the processes of the vertebræ. Each supports one or more of the radii of the fins.

180 L.III. BONES AND MUSCLES OF THE TRUNK.

TABLE of the Number of the Vertebrae of Fishes.

SPECIES.	Cervical vertebræ	Dorsal ver- tebræ	Lumbar verteb.	Caudal verte- bræ.
Ray	{ ossified into one piece. }	4 ..	.....	more than 80
Shark.....	207 in all.....			
Sturgeon.....	28 in all.....			
Syngnathus acus	more than 50 in all.....			
Syngnathus Hippocampus	62 in all.....			
Balistes .....	.....	7 ..	.....	10 ..
Ostracion quadricornis.....	13 in all.....			
Eel.....	115 in all.....			
Sea Wolfe	2 ..	24 ..	.....	50 ..
Sea Dragon.....	2 ..	13 ..	.....	30 ..
Uranoscope.....	1 ..	9 ..	.....	15 ..
Whiting.....	2 ..	17 ..	4 ..	32 ..
Sea Scorpion .....	.....	8 ..	2 ..	15 ..
Armed Trigla .....	.....	12 ..	.....	23 ..
Red Gurnard.....	.....	13 ..	.....	21 ..
Small flying Trigla.....	3 ..	8 ..	.....	12 ..
Remora.....	.....	12 ..	.....	15 ..
Plaice.....	.....	13 ..	.....	30 ..
Stickleback .....	.....	17 ..	.....	22 ..
Perch.....	.....	21 ..	.....	20 ..
Dorée	4 ..	9 ..	2 ..	16 ..
Zeus Vomer.....	.....	10 ..	.....	13 ..
Horned Chætodon.....	.....	9 ..	.....	12 ..
Stripped Chætodon.....	.....	9 ..	.....	12 ..
Carp.....	1 ..	15 ..	9 ..	16 ..
Cyprinus Nafus.....	1 ..	19 ..	5 ..	19 ..
Herring.....	4 ..	38 ..	.....	18 ..
Rhomboid Salmon (Salmo Rhombus)	1 ..	12 ..	.....	20 ..
Pike (Lucius).....	4 ..	35 ..	.....	20 ..
Brazilian Pike .....	.....	34 ..	3 ..	15 ..

SPECIES.	Cervical vertebra.	Dorsal ver- tebræ.	Lumbar vertebra.	Caudal verte- bræ.
Silurus Felis .....	.. 1 ..	.. 12 ..	.. 1 ..	.. 30 ..
Armour-fish (Loricaria) .....	.. 1 ..	.. 6 ..	.. 1 ..	.. 28 ..
Tobacco-pipe-fish (Fistularia Tobacaria) .....	.....	.. 59 ..	.....	.. 22 ..

ARTICLE II.

*Of the Muscles of the Spine.*A. *In Man.*

IN the lumbar and dorsal region of the human spine, the motion of each vertebra upon those next to it is very obscure: the total power of flexion is, however, considerable. In the cervical region, the motion is greater, and considered as a whole; the vertebral column is capable to a certain degree of being turned round.

The muscles of the spine are numerous and complicated; posteriorly there are:—

1. THE INTERSPINALES.

These muscles are disposed in two rows between the spinous processes of all the vertebræ: there are twenty-three on each; they serve to bend the spine backward.

2. THE INTERTRANSVERSALES,

Which have nearly the same shape as the preceding : these are situated between the transverse processes ; when the muscles of one side only act, they bend the spine towards that side ; when those of each side act together, they maintain the spine in an erect position.

3. THE TRANSVERSO-SPINALES.

These muscles extend obliquely from the inferior transverse processes, and from the tubercles of the sacrum to the superior spinous processes. They form a compact mass, which covers the whole spine ; and is called *transverso-spinalis magnus*, or *multifidus spinæ*.

4. THE SPINALIS COLLI

Is attached to the spinous processes of the cervical vertebræ from the second to the sixth ; the superior slips covering the inferior. Below it is attached to the transverse processes of the seven first dorsal vertebræ by distinct tendinous slips.

5. THE SEMISPINALIS DORSI.

This muscle is situated transversely upon the spine, and lower than the preceding. It is inserted

serted into the spinous processes of the two last cervical, and the five first dorsal vertebræ, and arises from the transverse processes of the seventh, eighth, ninth, and tenth vertebræ of the back.

6. THE SPINALIS DORSI.

This muscle is also situated transversely, but partly higher and partly lower than the preceding. It is formed of concentric bundles of fibres. The superior part is inserted into the spinous processes of the dorsal vertebræ from the second to the eighth. The inferior part is attached to the spinous processes of the three lowest dorsal, and the two first lumbar vertebræ.

7. THE LONGISSIMUS DORSI

Is more superficial, and is placed above the preceding muscles: the direction of its fibres is, however, the reverse of theirs. It is connected by a strong tendon to the os sacrum, and is also attached to all the spinous processes of the lumbar vertebræ: hence it ascends to the seventh vertebra of the neck. In its passage it affixes itself by separate portions internally to the transverse processes of all the dorsal vertebræ, and externally to the eight lowest ribs.

8. THE TRANSVERSALIS COLLI, OR TRANSVERSALIS MAGNUS,

Is between the *longissimus dorsi* and the preceding muscles. It extends from five or six of the first processes of the dorsal vertebræ, to the third, fourth and fifth transverse processes of the vertebræ of the neck. It is considered as an accessory to the *longissimus dorsi*.

9. THE SACROLUMBALIS

Is situated more externally, and rises along with the *longissimus dorsi*, with which it is confounded at the inferior part. The superior part is inserted into the angles of all the ribs, and the transverse process of the last vertebra of the neck by an equal number of tendinous slips.

10. CERVICALIS DESCENDENS, OR TRANSVERSALIS TENUIS.

This muscle is placed between the *longissimus dorsi* and the *sacro-lumbalis*. It is attached at the upper part to the transverse processes of all the cervical vertebræ after the third, and is inserted by tendinous slips, which cross the tendon of the *sacro-lumbalis* into the angles of all the ribs. This muscle is an auxiliary of the *sacro-lumbalis*.

To form a clear idea of the action of the different

ferent muscles of the spine, they should be considered together.

The mass of fleshy and aponeurotic fibres which occupies the posterior part of the spine, and seems to arise from the os sacrum, may be looked upon as a single muscle, and called *SACRO-SPINALIS*. It is composed of three principal branches.

The first, which is the most internal, and next to the spinous processes, corresponds to the *spinalis colli* and *spinalis dorsi*. It keeps the spine straight, and draws it backward when it has been inclined forward.

The second portion, which is external, forms what anatomists have named the *sacro-lumbalis*, and its accessory the *cervicalis descendens*. It acts like the preceding.

The third portion is intermediate; it is formed by the *longissimus dorsi* and its accessory, or *transversalis magnus colli*, and has precisely the same use as the two others.

We next observe the small muscles situated between each pair of vertebræ: these form three series.

1. *The Transversospinales.*
2. *The Interspinales.*
3. *The Intertransversales.*

There is only one muscle situated upon the anterior part of the spine, which acts exclusively upon it: this is called

LONGUS

LONGUS COLLI, *or* PRÆ-DORSO-
ATLOIDEUS.

It is attached to the three first dorsal vertebræ, and to the anterior tubercle of the atlas ; it bends the neck forward.

The vertebræ of the tail or coccyx are capable of a small degree of motion backward and forward, which is performed by means of two pair of muscles, named,

1. THE ISCHIO-COCCYGEUS, *or* ISCHIO-
CAUDALIS,

Is attached to the spine of the os-ischium and the lateral parts of the bones of the coccyx. When both muscles act, they pull the bones somewhat backward.

2. THE SACRO-COCCYGEUS, *or* SACRO-
CAUDALIS.

It comes from the internal surface of the os sacrum ; and it is inserted into the internal surface of the os-coccygis, which it elevates by its contraction.

B. *In other Mammiferous Animals.*

The muscles of the spine of *monkeys* nearly resemble those of man ; they differ only with respect to the strength of the tendons.

Those

Those of the *bat* are so thin, that a few tendinous fibres alone are perceivable on the part near the spine.

The other mammalia differ only in the number of attachments, which depends upon that of the vertebræ. In the *bog*, for instance, the *spinalis dorsi* arises distinctly from the first spinous process of the back by a fleshy slip: similar portions come from each succeeding spinous process, and they all unite to tendons which are inserted into the spinous processes of each lumbar vertebra.

The motions of the tail are much more visible in the rest of the mammalia than in man. It is an additional member granted to them by nature, since many of them use it to fasten themselves to trees, or to suspend themselves from them. The greatest part use it as a whip to drive away parasitical insects; others, as the *cetacea*, direct their course in the water by its motion. The *beaver* employs it as a trowel to build his habitation, &c. It is evident, therefore, that, to execute these various operations, more muscles are required in these animals than in man.

The tail of mammiferous animals is susceptible of three sorts of motion: one by which it is turned backward, or raised up; another, by which it is inflected, or lowered; and a third, by which it is directed towards the sides.

The combination of these motions produce others of a secondary kind: thus the tail may be turned upon its own axis, or rolled into a spiral form

form in the same plane, or like a screw, as in those animals which have it prehensile.

These motions are effected by three classes of muscles very different from those of the human body, as we shall presently see.

a. The Muscles that raise or throw back the Tail.

These are always situated on the superior or spinal surface.

1. THE SACRO-COCCYGEI SUPERIORES, or
LUMBO-SUPRA-CADUALES.

These arise from the articular processes of the three or four last vertebræ of the loins, those of the sacrum, and from such of the vertebræ of the tail as have processes by fleshy slips, which gradually diminish in their thickness. Small tendons proceed from the common mass opposite to the fleshy digitations. The first tendon is the shortest; it proceeds from the internal side, and is inserted into the base of the first of the caudal vertebræ, which have no articular processes. The second tendon proceeds to the next, and so on to the end. There are generally thirteen of these tendons; they enter a ligamentous groove, which serves as a sheath to them; all these sheaths are joined together by a ligamentous plexus, which encloses them as it were in a kind of case.

When these two muscles act together, they raise the tail, or reflect it upwards.

2. INTER-

2. INTERSPINALES, SPINALIS OBLIQUUS, or LUMBO-SACRO-COCCYGEUS of *Vicq. D'Azyr*.

These muscles are the continuation of the *interspinales* of the trunk; but as the spinous processes of the tail are short, and often replaced by two tubercles which answer to the oblique processes, the insertions are somewhat different. This, perhaps, is the reason why those muscles have been regarded as distinct by many anatomists.

b. *The Muscles which depress or bend the Tail downward.*

These arise within the pelvis, and extend more or less along the inferior surface of the tail. They consist of four pair.

1. THE ILEO-SUBCAUDALIS, or ILEO-COCCYGEUS of *Vicq. D'Azyr*.

This muscle arises from the internal part of the os ilium, forms a long fleshy mass within the pelvis, and is inserted into one of the bones shaped like a V, which are situated under the tail; sometimes, as in the *raccoon*, the insertion takes place between the fifth and sixth bone; and sometimes between the seventh and eighth, as in the *opossum*: This muscle depresses the tail, and applies it close to the anus.

2. THE

2. THE SACRO-SUBCAUDALIS, *or* SACRO-COC-
CYGEUS INFERIOR *of* Vicq. D'Azyr.

This muscle is the antagonist of the *sacro-coccygeus* or *lumbo-supra-caudalis*, which it exactly resembles in structure. It arises from the inferior part of the os sacrum, and the transverse processes of such of the caudal vertebræ as possess those processes by a fleshy portion, which becomes gradually smaller, and forms as many tendons as there are caudal vertebræ unfurnished with transverse processes: These tendons are received into a sheath like those of the *lumbo-supra-caudalis*, and are inserted into the base of each of the vertebræ on the under side, beginning usually at the seventh.

3. THE SUB-CAUDALES, *or* INTER-COCCYGEI
of Vicq. D'Azyr.

These are situated under the inferior middle line of the tail. They arise at the articulation of the first and second caudal vertebræ, and form an elongated portion, which is first inserted into the V shaped bone of the fourth, fifth, and sixth vertebræ. They likewise receive little fleshy slips, which gradually diminish in thickness and, go on to be inserted into the inferior surface of the base of each bone of the tail.

4. THE PUBO-SUB-CAUDALIS, *or* PUBO-COC-
CYGEUS of *Vicq. D'Azyr*.

This muscle is wanting in the *raccoon*, but is very distinct in the dog and opossum. It is thin, and arises fleshy and expanded from the upper part of the pelvis, from whence it proceeds to terminate in a point, and is affixed under the tail to the processes or tubercle at the base of the fourth and fifth vertebræ. Its action is the same as that of the Ileo-sub-caudalis.

c. *The Muscles which bend the Tail sideways.*

These are only two, *viz.*

1. THE ISCHIO-CAUDALIS, *or* ISCHIO-COC-
CYGEUS-EXTERNUS of *Vicq. D'Azyr*,

Arises from the internal surface of the os-ischium, below and behind the cotyloid cavity, and passes backward over the transverse processes of the vertebræ of the tail.

In the *dog*, it is only a fleshy slip, which is inserted into the fourth vertebra.

In the *raccoon*, which wants the *pubo-sub-caudalis*, it is inserted into the seven vertebræ of the tail that follow the third by an equal number of fleshy digitations.

In the *opossum* it terminates upon the four first vertebræ of the tail.

2. THE INTERTRANSVERSALES.

These muscles extend as a single band, partly muscular, partly aponeurotic, between all the transverse processes. Their tendons are most visible on the upper part of the tail.

It appears, from the above enumeration, that there are eight pair of muscles belonging to the tail.

C. *In Birds.*

Birds have no muscles for the dorsal part of the spine. The neck only is moveable. It is furnished with a number of muscles, which are—

The *intertransversales*; these are disposed nearly in the same manner as in the mammiferous animals.

The *transverso-spinales*, which proceed obliquely from the transverse processes of each inferior vertebra, to the spinal process of its immediate superior; but on that side only towards which the vertebra moves. Thus the upper vertebræ have them only on the anterior, and the lower ones only on the posterior side.

There is also a muscle analogous to the *cervicalis descendens*, or *sacro-lumbalis*.

This muscle arises from the spinous processes of the back, and is inserted by a very long tendon into the transverse process of the second vertebra. It detaches five or six slips accord-

ing to the different species, which are inserted into the inferior transverse processes of the neck. Each of these at its insertion receives two or three little bundles of muscular fibres from as many of the inferior spinous processes.

In the *buzzard*, for instance, the tendon inserted into the second vertebra receives five slips from the spinous processes of the five vertebræ next to the third: the second tendon, which is inserted into the transverse process of the fifth vertebra, receives three fasciculi from the spinous processes of the three following cervical vertebræ. In like manner, the third tendon, which is inserted into the sixth transverse process, receives four fasciculi from the spines of the cervical vertebræ, from the seventh to the tenth, and so on; but different numbers occur in the different species. All the small auxiliary slips are situated between the two grand *cervicalis descendentes*.

The *longus colli* is a very complicated muscle in birds: each style of the transverse processes of the vertebræ that admit of motion backward, receives a tendon from it, and this tendon, as it descends, receives muscular fasciculi from several of the subjacent vertebræ.

In the *buzzard*, which we shall again take as an example, the tendons of the superior styles receive their fasciculi from the vertebra above them.

In the *heron*, the tendons of the superior styles have their fleshy part or bellies attached to the

lowest of the vertebræ, and partly enveloping the tendons of the inferior styles. We must, however, except those of the three last cervical vertebræ, which are the same as in the *buzzard*.

The muscles of the tails of birds are very distinct, and easily dissected; some are employed in raising or lowering the tail; others in turning it towards the side.

The muscles which elevate the tail are only two in number, one for each side.

THE SACRO-SUPRA-CAUDALES, or LEVATORES
COCCYGIS of *Vicq. D'Azyr*,

Arise from the posterior and superior part of the pelvis and sacrum, and extend to the external surface of the transverse processes of the vertebræ of the tail, by tendinous slips: these descend obliquely to the superior spinous process of the same vertebræ, and to the last bone of the tail, into which they are inserted. When only one of these muscles acts, it not only raises the tail, but also directs it to one side.

The muscles employed in depressing the tail form likewise only one pair. They are

THE SACRO-SUB-CAUDALES, or DEPRESSORES
COCCYGIS of *Vicq. D'Azyr*.

These are situated within the pelvis, and their
form

form is pyramidal. They arise from the posterior depressions of the ilium and the point of the sacrum. They also arise in part from the transverse processes of the first vertebræ of the tail, and are inserted by tendinous slips into the spinous processes of the same vertebræ, and into the rhomboidal process of the last bone that supports the quills. They act precisely like the preceding muscles, but in the opposite direction.

The lateral flexors of the tail are all removed from the middle line. There are four of them on each side.

The first, which is also the longest, is

THE FEMORO-CAUDALIS, *or* CRURO-COCCYGEUS
of Vicq. D'Azyr.

It arises from the femur, to which it is attached towards the uppermost third of its posterior surface, and is inserted into the superior side of the rhomboidal process of the last bone of the tail. It directs the tail towards the side when it acts separately: when both muscles act at the same time, the tail is bent downward, or lowered. That powerful inflexion of the tail which takes place when birds run, is to be attributed to the operation of this muscle.

The second of these muscles is partly inserted into the ligament which fastens the external quill

of the tail to the last bone, and it arises from the posterior edge of the branch of the os pubis: when both muscles act together, they spread out the feathers in the form of a fan, and enable the *peacock*, the *turkey*, and the *pheasant*, to display the variegated plumage of their tails.

The third is nearly parallel to the preceding, and situated on its internal side: it also takes its origin from the pubis, but somewhat towards the branch of the ischium; it is inserted into the lateral angle of the rhomboidal process, situated, as we have already stated, beneath the last bone of the tail.

The fourth muscle is the shortest of all. It is

THE MOTOR LATERALIS COCCYGIS

of Vicq. D'Azyr.

It arises from the external point of the spinous process of the four vertebræ of the tail, which follow the first, and is inserted into the lateral edge of the ligament which unites the quills of the tail: it spreads the quills, but with less force than the second, to which it may be considered an accessory muscle.

D. *In Reptiles.*

There are few spinal muscles in *frogs*.

The muscle which is analogous to the ischio-coccygeus is large and thin, and occupies all
the

the space comprised between the long bone of the coccyx and the ilea. Its fibres are oblique, and it serves to draw the coccyx into the direction of the spine.

That which is analogous to the *lumbo-costalis*, arises above the last by a sort of point attached to the coccyx. It extends quite to the head, into which it is inserted, and detaches fibres in its progress to each of the transverse processes, which form a kind of intersection upon its surface.

The *obliquus superior* arises from the head at the margin of the foramen magnum, and is inserted into the transverse processes of the first dorsal vertebra.

There is only one small *rectus anterior*.

It arises from the base of the cranium, below the foramen magnum, and is inserted into the first of the transverse processes.

The *intertransversales* are like the human.

The spinal muscles of the *salamander* much resemble those of the *frog*. Those of the tail are very similar to the muscles of *fishes*.

The spine of the *tortoise* has no motion except in the parts belonging to the neck and tail. Those of the back and loins, which are ossified together, have no muscles.

The muscles of the neck are very different from those of man. The motions they produce are those of elongation, by which the head is

protruded from the shell; and those of retraction, by which it is withdrawn, the neck being bent in the form of a Z.

The first of the muscles proper to the neck is attached to the under part of the anterior lateral border of the back shell, and into the transverse process of the first vertebra; it raises the neck and draws it back.

Another proceeds from the anterior and middle part of the shell: it is inserted by four fleshy slips, which are separate throughout a considerable portion of their extent, into the articular processes of the third, fourth, fifth and sixth vertebræ of the neck. It draws the neck back when the head is much extended, and pushes it out when it is retracted.

A muscle also arises from the articular processes of the third, fourth and fifth vertebræ of the neck, by three fleshy portions, that afterwards unite, and terminate in two tendons; one of which is inserted into the transverse process of the first, and the other into the spinous process of the second vertebra. This muscle bends the neck upon itself, making it describe a curve, which is convex downwards; this motion brings the head under the shell.

A muscle analogous to the *longus colli*, arises from the under part of the body of the second dorsal vertebra, beneath the shell; it ascends along the neck, and furnishes aponeurotic slips

to all the transverse processes, as far as the second vertebra, where it is inserted. This also is one of the retractors of the head.

There are very distinct *interarticulares*, which, by their action, elevate each of the vertebræ, and consequently extend the neck.

The *transverso-spinalis* is situated on the posterior part of the neck: It arises from all the superior transverse processes, and is inserted into all the spinous processes, as far as the sixth.

Finally, a short muscle proceeds from the upper part of the first dorsal vertebra below the shell, and is inserted into the articular processes of the sixth and seventh cervical vertebræ. This muscle is peculiar to the *tortoise*, and begins the extension of the neck when the head is concealed within the shell.

E. In Fishes.

The muscles of the spine in fishes are very different from those of other red-blooded animals; their situation and actions are totally changed.

In mammalia, in birds, and in reptiles, these muscles are situated before or behind the vertebræ. In fishes, on the contrary, they are placed upon the side. From this difference of position results that of the motion produced; in the former, the vertebral column principally bends forwards, or erects itself, and the motion to either

sive is less sensible; but the lateral movement is much more remarkable in fishes, as in them it produces the action of swimming, while the motion of the spine towards the belly and the back scarcely exists.

The fleshy fibres which determine the motion of the vertebral column, are interwoven in such a manner that they are hardly to be distinguished unless as layers, and in this manner we shall proceed to consider them.

When the scales and skin are removed, we find underneath a fleshy mass composed,

1. Of fibres collected into little bundles, longitudinal and parallel, disposed in arches with the convexity towards the head. All these arches are received one into another, and the intersecting line which distinguishes them seems the production of an aponeurosis, in the substance of which are often found spines, or little flexible ossified parts. This is easily observed in the *carp*, the *pike*, the *whiting*, &c.

2. Of other muscular fibres, which, proceeding from the back and the belly, have a different course, and unite at the extremities of these arches. The superior, or dorsal, take two directions, forming a V, or angle, open towards the head. Their surface furnishes aponeurotic filaments, which terminate in small tendons; they are inserted and lost in the skin.

The inferior or costal layer of fibres is composed of little intercostal muscles, the length of each

each of which is equal to the respective distance of each rib, or inferior spinous process.

These three layers of fibres are so connected together, that they can only be considered as one and the same muscle, attached to the bodies and processes of all the vertebræ, and to the head. It has received the name of

MUSCULUS LATERALIS.

It produces all the lateral motions of the body, and more especially those of the tail. The manner in which it acts is easily explained: the contraction of the fibres of one side of the body causes the tail to approach the head in the same direction. When the tail is in this state of lateral flexion, it can only be restored to its natural position by the contraction of the fibres of the opposite side; but when this contraction carries the tail beyond a right line, a motion opposite to the first is produced. It is by the repetition of these lateral and alternate motions that the action of swimming, or the progression proper to fish, is performed.

The *ostracions*, the bodies of which, with the exception of the jaws and members, are inclosed in a horny case nearly as hard as bone, have the lateral muscles somewhat different. They are found under the parietes of the skin. They are nearly of equal magnitude, but they are attached to the head and tail only. Insertions
into

into the vertebræ of the body would have been useless, since only the part of the tail which is situated without the case is capable of motion. The texture of these lateral muscles is also much more simple, as almost all their fibres are longitudinal.

As the ribs and muscles are wanting, there is substituted for those parts an aponeurosis of a brilliant silver colour, which constitutes the integuments of the abdomen, and lines the internal surface of the case.

The tail of these fishes has a pair of muscles peculiar to it, and seemingly assistant to the lateral. Their form is pyramidal; they are placed in the abdominal or inferior part of the body, and extend from about its middle to that part of the tail which is without the case. They arise from the inner surface of the ventral parietes of the case, and are inserted by small tendons into the inferior part of the sides of the three last vertebræ of the tail, which they somewhat depress at the same time that they move it to one side.

In the interval which is left between the two lateral muscles of the body in fishes, and towards the dorsal ridge, there appear some long and thin muscles; their number is various, as it depends upon the existence or number of the back fins. They are called *musculi dorsales*.

There is only one pair in those that have no dorsal fin, as in some species of the *gymnotus*. They proceed from the neck, and terminate in the caudal

caudal fin. They are composed of small and very short fleshy bellies, with long tendinous interfections.

In those fishes that have only a single dorsal fin, such as the *loaches*, *carp*, *tench*, &c. there are two pairs of these muscles; the first between the back of the neck and the dorsal fin, and the other between that fin and the caudal fin.

When there are two dorsal fins, as in the *mullet*, *zeus*, &c. we meet with three pairs of muscles, one between the neck and the first fin, another between the two fins, and the third between the second dorsal fin and the caudal fin.

All these muscles are inserted into the first rays of each of the fins, which they move by raising or unfolding them. There are muscles perfectly analogous to these under the ridge of the belly.

In the *carp*, for example, there are two pairs; the one arises from the symphysis of those bones of a girdle form which receive the pectoral fins, and is inserted on each side into the ligamentous tissue which unites the two ventral fins. The little fleshy bellies of which this pair is composed, are four or five in number: they are placed at a distance from each other, and resemble beads.

The other pair extends from the junction of the anal fins to the first rays of the caudal fin. Their fleshy bellies are still thinner, and the tendons much longer than those of the former.

The

The fins of the back, belly, anus and tail, have little muscles peculiar to themselves, appropriated to fold and unfold them.

The direction and attachments of the little muscles of the caudal fin are various. The longest usually arise from the three vertebræ preceding the last of the tail: they are the outermost, and are inserted into the five or six external, or longest rays on each side.

Others arise from the two last vertebræ: they spread, like the preceding, in the manner of a fan, and are inserted into the intermediate rays.

Finally, there are, at the basis of the rays themselves, two muscles with short oblique fibres, which are inserted into each of the rays by an equal number of digitations. These are designed to compress the fin, while the former serve to open or unfold it.

The muscles of the dorsal fins are disposed nearly in the same manner; those that extend them arise from the spinous processes of the dorsal vertebræ; those that bend them are short, and stretched obliquely across the little bones or rays that compose these fins.

The extensor muscles of the anal fin arise from certain particular spinous processes on the abdominal surface of the vertebræ: the flexors are short, and situated at the base of the rays.

We shall finish this article on the muscles of the spine of fishes by a particular explanation of those of the *ray*.

The

The spinal muscles in this fish approach nearly to the form of those which we have already described in the tails of certain quadrupeds.

They are disposed in two layers, and are four in number; two *laterales superiores*, and two *laterales inferiores*.

The *laterales superiores* arise from the middle of the vertebral column above the abdomen, by a fleshy head covered with strong aponeuroses: this portion extends as far as the pelvis, and there detaches little tendinous branches which pass through parallel sheaths, and proceed successively towards the middle line, where they are inserted into the upper part of each of the vertebræ of the tail. Fleshy fibres accompany these tendons to some distance after their separation from the common fasciculus.

In the inferior part of the tail the superior lateral muscles receive accessaries from each side; but these are simple tendons, which seem only intended to guard against too violent an extension either to one side or the other.

Each tendon of the lateral muscles pulls that vertebra of the tail into which it is inserted in the direction of its own action, and the flexion or general curvature of the tail upwards is the result of their common contraction.

The *laterales inferiores* of the tail arise also from the lumbar vertebræ like the preceding, but more externally. Their arrangement is nearly the same, with this difference, that their tendons

make a kind of turn, and run under the tail, where they are inserted into each of the vertebræ. They also receive tendinous accessaries, and produce motions in a direction opposite to the former, that is to say, they bend the tail downward: their tendons are more slender than those of the superior laterales; they divide into two branches at their extremities, and each bifurcation affords a passage for that of the next vertebra, so that they mutually serve as sheaths, and are all, except the last, both perforating and perforated.

ARTICLE III.

Of the Ribs and Sternum.

A. *In Man.*

THE human thorax is shaped like a compressed cone, with the base downward, and the apex truncated. It is formed posteriorly by the dorsal portion of the vertebral column which we have already described, anteriorly by a flat bone called the *sternum*, and on the sides by twenty-four osseous arches called the *ribs*.

The *sternum* is a long flat bone: its superior extremity is articulated with the clavicles; the other is free, and supports a cartilage which sometimes ossifies, and which is named the *xyphoid*, or *ensiform* cartilage, and in the new nomenclature

appendix sternalis. The two long sides of this bone receive the cartilages of the seven first ribs into small depressions. The sternum is often found of two parts, but these generally become ankylosed with age. This bone is covered on each side, both within and without the thorax, by a very solid ligamentous tunic. Its abdominal appendix is also supported by a strong ligament, which passes from its external surface obliquely to the cartilage of the last *sterno-vertebral* or true rib. This ligament prevents the appendix from being displaced by violent actions of the chest.

The *ribs* are twelve in number on each side. They are long bones, somewhat compressed, curvated throughout the whole of their length, and have their concave sides turned towards the inner part of the thorax. One of their extremities terminates in two little articular surfaces, divided by a projecting line. It is received by the lateral part of the bodies of two vertebræ. This vertebral extremity of the rib becomes somewhat narrowed, and then presents a new articular surface at the posterior part, which corresponds with the transverse process of the more inferior of the two vertebræ to which the rib is articulated. The rib continues to bend backward in the same manner, but suddenly deviates from this direction and comes forward. The point where this change takes place is different in every rib. In the superior ribs it is very near the vertebræ, but in the inferior removed to a considerable

siderable distance from them. This point, which receives the tendons of some muscles, is called the *angle of the rib*. The sternal extremity has a little depression, into which the intermediate cartilage that unites it to the *sternum* is received. Only seven ribs extend directly to the sternum; they are called *true ribs*, or, with more propriety, *sterno-vertebral*: the other five ribs have cartilaginous elongations, by which they are united with one another: they are called *false ribs*, or simply *vertebral*.

The human ribs are bent in such a manner, with respect to their axis, that when laid upon an horizontal plane, one end is always elevated.

The ribs have only a limited motion upward and downward. Their articulations are strengthened by a great number of ligaments. The articular surfaces of the vertebral extremity have capsules, which retain them upon the bodies and transverse processes of the vertebræ. The space included between these surfaces is also made secure by two ligaments, one inserted into the transverse process of the superior vertebra on the inside, and the other into the inferior articular process of the same vertebra, but on the external side. The sternal extremity is also surrounded by a little capsule, which joins it to the prolonged cartilage. There is, besides, in all the spaces between the ribs, a ligamentous expansion, which unites the inferior edge of one rib to the superior edge of the next.

The

The last vertebral rib has a small ligament peculiar to itself, which attaches it inferiorly to the transverse processes of the first and second vertebræ of the loins.

B. *In other Mammiferous Animals.*

The figure of the thorax in the inferior mammalia is liable to variation. In those that have no clavicles, it is commonly compressed on the sides, and the sternum forms an anterior projection more or less conspicuous: the breast is most elongated in the *sarcophaga*.

The number and form of the ribs vary also considerably in different families. In the *Quadruped* they are always from twelve to fifteen. In the vermiform *sarcophaga* they sometimes amount to seventeen, which are generally very close. They differ but little with respect to number in the other families. In the herbivorous quadrupeds they are broad and thick. The *horse* has eighteen, the *rhinoceros* nineteen, and the *elephant* twenty. The *two-toed sloth*, in which there are twenty-three on each side, has of all animals the most. The *armadillo* has the two first ribs exceedingly large in proportion to the rest. The *two-toed ant-eater* has the ribs so broad, that they overlap each other like the tiles of a house. This construction renders the sides of the thorax very strong in that animal.

The sternum of the *orang* and *pongo* is broad. In every other species of ape it is narrow, and formed of seven or eight pieces.

All the *bats* have the sternum narrow, but it exhibits on its front part a ridge; and the anterior extremity, which is enlarged on the sides like a T, passes over the ribs to receive the clavicles.

In the *mole*, the clavicular extremity of the *sternum* is prolonged before the ribs: it is compressed laterally, and receives the two short clavicles under the neck.

The *hog* has the sternum much enlarged behind, and narrow before.

In the *rhinoceros*, the *horse*, and the *elephant*, the sternum is prolonged anteriorly, and flattened on the sides.

The Cetacea have the sternum broad, but of no great thickness, especially at the anterior part.

TABLE of the Number of Ribs in Mammiferous Animals.

SPECIES.	Total.	True.	False.
Man	12	7	5
Sai, or Weeping Monkey	13	9	4
Orang	12	7	5
Pongo	12	7	5
Ternate Bat	13	7	6
Common Bat	12	7	5
Mole	13	8	5
Hedge-hog	15	7	8
Bear	14	9	5

SPECIES.	Total.	True.	False.
Seal	15	10	5
Glutton	14	9	5
Racoon	14	9	5
Otter	14	9	5
Lion	13	9	4
Cat	12	9	4
Wolf	13	9	4
Opoffum	13	7	6
Hare	12	7	5
Guinea Pig	13	6	7
Three-toed Sloth	16	8	8
Long tailed Manis	13	6	7
Elephant	20	7	13
Hog	14	7	7
Rhinoceros	19	7	12
Dromedary	12	7	5
Girafe	14	8	6
Ox	13	8	5
Stag	13	8	5
Horse	18	8	10
Dolphin	13	6	7
Porpoise	13	6	7

C. In Birds.

The thorax of birds is in general very large; it is, however, formed by the ribs and the sternum only; but this last bone differs both as to figure and dimensions from the sternum of the mammalia.

The ribs exhibit many peculiarities. They may be distinguished into *sterno-vertebral*, and *vertebral*, properly so called; but they are not situated as in mammiferous animals. The vertebral ribs are most commonly the anterior, but sometimes ribs of this kind are also situated

posteriorly. The vertebral extremity is bifurcated; one of the branches rests upon the body of the vertebra, and the other upon its transverse processes. The sternal extremity receives an osseous appendage, which supplies the place of the sterno-costal cartilage: with this bone it forms an obtuse angle, the open part of which is turned forward.

The middle part of the rib presents likewise another peculiar characteristic. On its posterior edge is a flat process, directed obliquely towards the back, above the succeeding rib, so that all the ribs have points of support on each other.

The sternum of birds is very broad, and almost square, but not thick. It covers not only the thorax, but the greater part of the abdomen. Its internal or posterior surface is concave. The exterior convex, and in all those that fly, it bears upon its middle line a projecting crest resembling the keel of a ship. The clavicular extremity of this bone is truncated to receive on each side the two great clavicles. The abdominal extremity is thinner, and frequently perforated with holes to increase its levity. It is likewise sometimes truncated, and only forms two angles more or less extended; at other times it forms three angles on each side very distinct, as in *jacana* and *king's-fisher*.

The magnitude of the sternum, and the shape of its keel, seem intended to give very extensive origins to the muscle that depresses the wing.

They

They are various as the habits of the bird with respect to its mode of flight, whether it be high or low, swift or slow, or continued during a longer or shorter period.

The sternum of the *ostrich* and *cassowary*, which do not fly, has no crest; but it is large, and rounded like a buckler.

It is the narrowness of the sternum which gives to *rails* and *water hens* that compressed shape which characterizes their habits.

It is likewise very narrow, and entirely osseous, in the common *crane* and *demoiselles de Numidie*, and the males have the prominence of the crest hollowed to lodge the convolutions of the trachea.

In the gallinaceous tribe, the crest of the sternum begins very low, and its elevation is marked by two projecting lines, which rise gradually, in a concave curve, to form that crest. These double lines are likewise found, though much smaller, in the *owl* and *spoon-bill*.

The *herons*, the *swan*, the *sparrows*, and the *raven*, have only one elevated line at the origin of the crest. In the *heron* it has a very prominent and convex edge. In the *swan* and *duck* it forms a straight line.

D. In Reptiles.

The thorax of reptiles is very various in its structure. *Frogs* have a sternum, but no ribs;

serpents have ribs, but no sternum; *tortoises* have the ribs ossified to the back shell, and the sternum included in the breast-plate; the *crocodile* and *lizard* have perfect ribs, but their sternum is almost entirely cartilaginous.

In the *crocodile*, the first portion of the sternum is ossified and elongated. It receives the two clavicles. The remaining part is entirely cartilaginous. It is united with the os pubis, and sends off eight cylindrical cartilages to the parietes of the abdomen. The ribs are twelve in number; the two first and two last of which are not attached to the sternum. The intermediate ribs have upon their posterior edges cartilages partly ossified, which supply the place of the angles of the ribs in birds. All the posterior ribs, beginning at the fifth, are only articulated to the transverse processes of the vertebræ, which are of great length. The five first articulate with the vertebræ at two points, one on its body, and the other on the transverse process.

The *iguana* and the *tupinambis* have only the upper part of the sternum ossified. It is broad, and receives six ribs and the clavicles. The other ribs are free.

The *camoleon* possesses likewise the upper portion of the sternum; but almost all the ribs have cartilages which extend to the middle line, and are there united to the opposite ones.

Frogs, though they have no ribs, have nevertheless a very conspicuous sternum. It forms
on

on the anterior part a cartilaginous appendix, furnished by a disk situated below the larynx. It next receives the clavicles, and then expanding, it terminates at last in another disk situated under the abdomen, and which affords an origin for muscles.

The *salamander* has ribs so short that they seem to be the transverse processes of the vertebræ; they have only one point of articulation, upon which they have but little motion. These rudiments of ribs are twelve in number on each side. This reptile has, properly speaking, no sternum, but its place is partly supplied by the bones of the shoulder, as we shall presently see.

The back shell of the *tortoise* is formed by the expansion of eight ribs or osseous staves, which arise from the joints of the vertebræ, and terminate in a border that surrounds the whole shell: these bones are united together by real sutures, situated transversely.

Above and all along the middle part we observe a row of little osseous plates, almost square, intimately connected by synarthrosis, and equal in number to the vertebræ, of which they constitute a part.

The osseous margin is made up of a great number of pieces soldered together, which, by their union, form an edge or border with three surfaces, viz. the superior, which belongs to the back shell; the inferior, which is joined to the breast-plate by a very thick leather-like skin;

and the internal, which presents a groove for the reception of the extremities of the ribs. But this margin assumes a different appearance at its anterior part; it is there a square piece of bone, convex above and concave below, which sustains a spine for the attachment of muscles. Its anterior edge has more the form of a crescent; there are also some little peculiar pieces above the tail.

The breast-plate of the *tortoise*, when deprived of the thick skin that covers it, exhibits, in some species, only one solid plate, formed of several pieces, united by synarthrosis: in others, this plate is perforated quite through, and formed of several bones, some of which are situated in the middle line between the anterior and posterior part, while others are placed laterally, and fastened together by the help of the former, which support them.

E. *In Fishes.*

Fishes have, properly speaking, no thorax; all the cavity of the trunk being occupied by the abdominal viscera. This cavity varies very much in extent and figure; it is compressed at the sides, and flattened or somewhat rounded horizontally. In different species, its length constitutes a greater or less portion of the whole length of the body. In general, fishes of the order *abdominales* have this cavity proportionably

ably longer ; but this rule is not constant. The cavity is bounded posteriorly by the inferior process of the first caudal vertebræ, which is often very large, and has almost always a peculiar shape. In the *pleuronectes*, for instance, it is large, round in the fore-part, and terminated below by a sort of spine.

The abdominal cavity is enclosed laterally by the ribs when they exist : For example, the *rays*, the *sharks*, the *pipe-fish*, the *sun-fish*, the *porcupine-fish*, the *lump-fish*, the *fistularia*, &c. have no ribs. — The *sturgeons*, the *balistes*, the *eels*, the *uranoscopes*, the *pleuronectes*, the *sea-wolves*, and the *dorées* have them very short. The *gurnards*, the *loricariæ*, the *uranoscopes*, and the *bull-heads*, &c. have their ribs somewhat horizontal. They surround the cavity almost to its top in the *perch*, *carps*, *pikes*, *chetodons*, &c. Finally, they unite in a sort of sternum in the *zeus vomer* ; the *herrings* or *clupeæ*, the *salmorhomboides*, &c. The *syngnathus hippocampus*, or little sea-horse, has a sort of false ribs produced by the osseous tubercles of his skin, which furrounds his body like belts.

Only a very few fish can be properly said to have a sternum : besides those just enumerated, there are some in which the sternum does not furnish attachment to the ribs : such is the *doree* (*zeus faber*) ; if indeed that can be called a sternum, which is only a series of small bones, without

out articulation, running along the whole inferior edge of the abdomen.

The number and size of the ribs are likewise extremely various. The *siluri*, the *carps*, and the *chetodons* have them proportionably larger. In the herring, on the contrary, they are as small as hairs: many fishes have them forked; others have them double, or, in other words, two ribs proceed from each side of every vertebra.

ARTICLE IV.

Of the Muscles of the Ribs and Sternum.

A. In Man.

THE ribs, by their motion, do little more than serve the purposes of inspiration and expiration. The muscles acting upon these bones either elevate or depress them.

The following are those which elevate the ribs:

THE SCALENUS, or TRACHELO COSTALIS,

Arises from the transverse processes of the five lower vertebræ of the neck, and is inserted into the posterior part of the three first ribs, by four digitations.

THE

THE INTERCOSTALES INTERNI *and* EXTERNI.

These muscles form two layers, and occupy all the intervals between the ribs. Their fibres are oblique, and in opposite directions; those of the external layer tend from a superior rib towards the cartilage of the next rib; those of the internal are directed from the cartilage of the inferior rib towards the angle of the superior, or backward.

THE LEVATORES COSTARUM, *or* TRANSVERSO-COSTALES,

Extend from the transverse process of the last cervical, and from those of the eleven first dorsal vertebræ to the angle of the ribs.

THE SERRATUS POSTICUS SUPERIOR, *or* DORSO-COSTALIS,

Arises from the spinous processes of the two last cervical, and the two first dorsal vertebræ, and is inserted into three or four of the uppermost true ribs, the first rib excepted.

The muscles that lower or depress the ribs are—

THE SERRATUS POSTICUS INFERIOR, *or* LUMBO-COSTALIS.

This muscle arises from the spinous processes of the three last vertebræ of the back, and the
two

two first of the loins, and is inserted by digitations into the four last false ribs. It pulls them outward and downward.

The sternum has only one muscle, and this manifestly acts in depressing the ribs: it is called

TRIANGULARIS STERNI, *or* STERNO-COSTALIS.

It arises from the inferior and middle part of the sternum, and ascends to the cartilages of the five lowest true ribs.

Other muscles are likewise attached to the ribs; but their action upon those bones, which seem only intended to give them firm insertions, is less conspicuous. These are the *diaphragm* and the muscles of the abdomen, which serve for respiration, and for the formation of the moveable parietes of the abdomen.

THE DIAPHRAGM.

Is a fleshy and tendinous partition, which divides the cavity of the thorax from that of the lower belly. It is situated obliquely between the appendix sternalis, and the bodies of the lumbar vertebræ. This muscle is attached to the sternal appendix, the two lowest true ribs, and the edge of the cartilages of all the false ribs: posteriorly it is inserted into the lumbar vertebræ, by two columns of flesh, called *crura*. This muscle is tendinous in the middle, and fleshy about the edges. It is covered above by the pleura,

pleura, and below by the peritoneum: its uses will be more particularly explained when we treat of Respiration. It has three perforations in its posterior part; that on the right gives passage to the vena cava; the œsophagus passes through that on the left; and the aorta, vena azygos, and thoracic duct pass through the posterior foramen.

The parietes of the abdomen are formed by five pairs of muscles: these are —

THE OBLIQUUS EXTERNUS, OBLIQUUS MAGNUS,
or COSTO-ABDOMINALIS.

This muscle arises from the eight last ribs by as many digitations, and is inserted into the crest of the os ilium and os pubis. Its fibres descend from without inwards.

THE OBLIQUUS INTERNUS, OBLIQUUS PARVUS,
or ILIO ABDOMINALIS,

Arises from the crest of the os ilium and os pubis. It is inserted into the edges of all the false ribs, and even the last true one, and the sternal appendix. Its fibres descend from within outwardly.

THE RECTUS ABDOMINIS, or PUBO-STERNALIS,

Is attached to the superior part of the pubis. It is inserted into the three last sterno-vertebral

bral ribs, into the first vertebral rib, and the appendix sternalis, by four digitations. This muscle in its passage is covered with an aponeurotic sheath produced from the oblique muscles. It is even inserted into some points of that sheath. This occasions the formation of several tendinous transverse lines, which are generally four in number.

THE PYRAMIDALIS, *or* PUBO-UMBILICALIS,

Arises likewise from the superior part of the pubis, and, diminishing much in breadth as it ascends, is inserted into the linea alba, near the umbilical ring.

THE TRANSVERSALIS ABDOMINIS, *or* LUMBO-
ABDOMINALIS,

Is affixed at one part by a broad, thin, and almost aponeurotic tendon, to the transverse and spinous processes of the four superior lumbar vertebræ, and extends its fibres almost transversely to the linea alba.

The recti and pyramidales bend the trunk forward. The obliqui have the power of inclining it laterally; finally, the transverse muscles act upon the parietes of the abdomen like a girth, and compress it on every side.

B. In other Mammiferous Animals.

The muscles of the ribs exhibit no remarkable difference in the other orders of mammalia.

Those

Those of the lower belly differ somewhat from the same muscles in man as to their proportional length. This difference, however, is more perceptible in the *recti* and *pyramidales*; for in the *scarcophaga* the *recti* often extend to the anterior extremity of the sternum, and then the *pyramidales* are generally wanting.

The *diaphragm*, in *bats*, has two very strong crura, which form a kind of fleshy septum, placed longitudinally on the spine within the abdomen.

In the article on Generation, we shall describe the muscles peculiar to the abdominal bag of the *didelphis* or *opossum*.

C. In Birds.

The *scalenus* differs in no respect from the *levator costarum*, which extend from the transverse processes of each vertebra, to the anterior edge of each rib. The superior layers are the thickest, and they become very thin at the last ribs.

The *internal* and *external intercostals* have also an opposite direction in their fibres, but they occupy only the intervals between the bend of the articulations and the angular processes, except in the last ribs, which have no processes, and where those muscles are found both on the anterior and posterior parts.

The *triangularis sterni* comes from the superior
7 and

and lateral part of the sternum, and proceeds to the edge of the second articulation of the first sterno-vertebral rib. It there sends off other fibres, which are inserted in the second and following ribs. These fibres become gradually thinner, and their direction is nearly parallel to the axis of the body of the bird.

There is no *diaphragm* in birds.

Their abdomen is covered with three layers of muscles, which are all transverse, though their fibres have different obliquities.

That which is analogous to the *obliquus externus* has its fibres transverse. It is attached to the crest of the ilium, covers the elongations of the sternum, and is inserted into the second or third rib. Its posterior aponeurosis is very thin; that which unites it to its fellow is very strong.

The *obliquus internus* is entirely fleshy, and is not quite so broad as the preceding. It arises from the posterior edge of the last rib, and is inserted into the anterior edge of the *os ilium*.

The muscle analogous to the *transversalis* forms the third layer. Its transverse fibres are somewhat divided, and as it were fasciculated; it has the same insertions as the preceding.

Both the *musculi recti* and *pyramidales* are wanting.

D. In Reptiles.

In the *frog*, which wants ribs, and the *tortoise*, where they are immoveable, the muscles which

usually have their insertions in them, are in those animals extended to other parts.

Thus, in the *tortoise*, whose *breast-plate* occupies the place of the abdominal muscles, they are inserted into the *pelvis*, which they move.

With respect to those animals, one very remarkable observation may, in general, be made:—It appears that the very singular shape of the muscles and bones depend upon each other. Indeed, as the muscles are not placed upon the bones, they have not, if we may be allowed the expression, fashioned them; and the want of motion in the bones, which has given an unnatural figure to the trunk, has also given to the muscles other forms and other uses.

The abdominal muscles of the *frog* present nothing peculiar, except that the skin does not adhere to their surfaces, and that, instead of being inserted into the rib, they are fastened to the sternum by a strong aponeurosis.

The same observations may be made with respect to the *salamanders*.

E. In Fishes.

The spaces between the ribs are filled up by short oblique fibrous muscles, analogous to the intercostals; but the great lateral muscles, which are inserted also into the ribs, move them all at once, somewhat in the same manner as they act upon the vertebræ of the tail.

ARTICLE V.

Of the Motions of the Head upon the Spine.

THE head may be considered under two points of view. 1st. As an osseous cavity, which contains and preserves the brain and the principal organs of sense: this is the view we shall have to take of it in the second part of the course.

2d. As a mass more or less weighty, articulated with the neck, and capable of being moved upon it in different directions. In this latter respect it now claims our attention.

A. *In Man.*

The human head is composed of two parts: first, an oval case, called the *cranium*, the top and sides of which have almost the same convexity, but the inferior surface is more plain, and tends obliquely forward, the position of the body being supposed erect. Beneath the anterior portion of this division of the cranium, is placed the second part of the head, which we call the *face*. The form of this part is nearly prismatic; the base, where the palate is situated, is parabolical; the face is directly crossed from the anterior to the posterior part by the *canal of the nostrils*; and in front, towards the upper part, it is enlarged to make room for the *orbits*. A kind
of

of branch, which springs from each side, and which, running backward, rejoins the cranium, is called the *zygomatic process*. Beneath the place where this joins the cranium, is the articulation of the *lower jaw*, which, with the cylindrical part above mentioned, completes the face. One of the characteristics peculiar to man is, that the jaws project very little before the superior and anterior part of the cranium, which we call the *forehead*.

We shall not here enter into a minute detail of the holes, futures, eminences and depressions of all the different parts of the head, but return to them in a subsequent article.

The part of the inferior surface of the cranium, situated farther back than the face, is called the *occiput*, or, more particularly, the basis of the cranium. The occiput has an irregular convexity, of a different curvature from that of the cranium, and is separated from it behind by a projecting line, representing two arches of circles, which are called the *occipital arches*.

The lateral extremities of this line exhibit each a large tuberosity, called the *mastoid process*, which is situated behind the hole of the ear, but somewhat lower. At the internal part of its base is a depression called the *mastoid groove*. Exactly between the two mastoid processes is the *foramen magnum*, which affords a passage to the spinal marrow, in its progress from

the cranium into the common canal of the vertebræ.

The osseous part, situated before this foramen, and at the posterior base of the semi-cylinder, which forms the face, is called the *cuneiform* or *basilary process*.

A straight projecting line extends from the middle of the occipital arch to the edge of the foramen. It is called the *spine of the occiput*, and its posterior extremity forms an eminence called the *occipital tuberosity*.

The head is articulated to the top of the first vertebra, in such a manner that the canal of the latter corresponds with the foramen magnum.

This articulation is formed by two prominent surfaces, situated on the anterior edges of the foramen magnum, and turned somewhat forward and outward.

These eminences are called the *occipital condyles*; they are received by two correspondent cavities of the *atlas*, and with it form a ginglymus, that permits no perceptible motion of the head, except forward and backward.

The *atlas* is articulated in the same manner by two lateral, and somewhat anterior surfaces, to the *axis* or *dentata*. These surfaces being, however, more plain, permit a rotatory motion to the atlas and head, upon the *axis*, whence that vertebra derives its name.

The anterior part of this second vertebra produces a process which rises behind the anterior
part

part of the atlas, and joins it by an articular surface. It has been compared to a tooth, and called *odontoid*.

The rest of the rotatory motion of the head is performed by the twisting of the cervical part of the spine.

Finally, the motion which inclines the head to the right and left, though partly performed by the articulation of the occiput to the atlas, is principally effected by the five lower cervical vertebræ, the articular surfaces of which, being turned directly backward, admit of much freedom in the lateral direction.

Several ligaments strengthen this articulation, and facilitate its movements. Some unite the arches of the atlas to the occiput, and form two strong membranes; others surround the condyles at their articulation with the atlas, and form a capsular ligament. Besides, a ligament proceeds from the top of the odontoid process, and is inserted into the anterior border of the foramen magnum, determining the axis of motion. There are also lateral ligaments; and finally, lest this process should injure the spinal marrow contained in the vertebral canal, there is a ligament situated transversely in the interior part of the ring of the atlas, which retains it in its place.

The position of the two condyles, upon which the head rests, is such that they nearly bisect a line drawn from the most projecting part of the occiput to the dentes incisores. The con-

sequence of this disposition is, that, in the erect position, the head is in equilibrium upon the spine.

The plane of the foramen magnum is nearly perpendicular to that of the eyes, and parallel to that of the palate; on which account the eyes and mouth are both directed forward when we stand upright.

These two dispositions take place completely in the human species alone. Even the Negroes have the anterior part of the line above mentioned longer than the posterior, because their jaws are somewhat elongated.

B. *In other Mammiferous Animals.*

In the *orang-outang*, the jaws are not only more elongated, but the occipital hole seems to retire backward, and ascend along the posterior surface of the cranium, so that its plane forms an angle of 60° only, with that of the orbits.

This elongation increases, in quadrupeds, in proportion as they recede from man. The jaws, at last, not only constitute three-fourths of the head, but the cuneiform process being prolonged, the foramen and the surface of the occiput are gradually removed backward and upward: at last their position is no longer below, but behind the head; and the plane of the foramen, forming angles, more and more acute, with
the

the plane of the orbits, becomes parallel to it, and at length no longer intersects it below, but above the head.

This accounts for the difference of the direction of the head in quadrupeds, which is so great, that, were the spine vertical, the head could not be preserved in equilibrio, unless the eyes were turned backward, and the mouth upward.

When standing upon the four feet, the head of a quadruped is not retained upon the spine by its own proper weight, but by the muscles and ligaments only; particularly that ligament called the *cervical*, which rises from the spinous processes of the vertebræ of the neck and back, and is inserted into the spine of the occiput.

As man has no need of this ligament in his ordinary position, it is in him so weak that many anatomists have denied its existence.

Quadrupeds, on the contrary, have it stronger in proportion as the head is larger or longer. In the *horse*, its insertion into the vertebra of the back is as broad as two hands, and it is fastened by straps to three or four of the vertebræ of the neck. The *Carnivora* have it somewhat less; but in the *elephant* it is largest of all, and is there inserted into a particular depression of the occiput. The *mole* has this ligament ossified in a great measure, as it is employed not only in raising the head, but also considerable masses of earth.

In the inferior mammalia, the occipital surface of the cranium making a much more acute angle

with the vertex than it does in man, the occipital arches become more distinct and pointed; and they assume different figures in different species. The mastoid processes always preserving the same inclination to the plane of the palate, gradually diminish the angle which they make with the occipital surface, till they finally arrive at the same plane.

In *monkeys* in general the mastoid processes are nearly obliterated. In all these species which have the jaw elongated, and strong canine teeth, the occipital arches form a projecting ridge. Such in particular is the case with the *Chinese-ape*, *Barbary-ape*, *cynocephalus*, *bare-lipped-ape*, *baboon*, *mandril* and *pongo*.

The *bat* has the basis of the cranium, as it were, curved, and the great foramen situated on the posterior part. The transverse processes of the first vertebra are flat on the sides. The processes enclosing the organs of hearing, which are very large, and as it were inflated, exhibit a large projection at the base of the skull.

The base of the cranium and the occiput are deprived of processes in the *mole*.

The *bear*, and in general all the large *Sarcophaga*, have, at the posterior surface of the head, projecting ridges, in a direction almost perpendicular to the foramen magnum; the transverse processes of the atlas are also very large.

The *lion*, the *tiger*, the *wolf*, and the *fox*, have the

the occipital protuberance very prominent; their heads are almost triangular behind.

In the Rodentia the face is very long: the cranium is also elongated, and rounded above, and flat below; the articulation behind, and the transverse processes of the atlas, are enlarged.

The cranium of the *ant-eater* is round, and has no projecting processes, though the face is conical, and very long.

The *elephant* has the head truncated almost vertically behind. The occiput is, as it were, square, and the condyles are at the posterior extremity. The place of the occipital protuberance is occupied by a considerable depression, in which there is a longitudinal ridge for the insertion of the cervical ligament.

In the *bog*, the occipital tuberosity is large, with depressions, and almost perpendicular to the condyles.

The *rhinoceros* has the occiput more oblique, and the atlas as broad as the head.

The Solipeda and Ruminantia have the transverse processes of the atlas flattened, and turned forward, and the mastoid processes elongated. The motion of the head forwards and to the side is therefore much circumscribed by this conformation.

Finally, the Cetacea have a broad atlas ankylosed with the axis. Two articular depressions correspond with the large condyles of the occiput. The articulation is formed at its posterior extremity.

C. In

C. *In Birds.*

The head of birds is so constructed as to perform very evident motions upon the vertebral column. It is always articulated behind, by a single condyle, or hemispherical tubercle, situated at the lower part of the foramen magnum. This tubercle is received into a correspondent depression in the body of the first vertebra.

Hence there is not only a more extensive vertical motion, but likewise a horizontal rotatory motion. Indeed we often see birds, when they wish to sleep, turn their heads so as to place their bill between their wings; but no quadruped can put his snout in that position.

The mastoid processes is prolonged in a prominent ridge, running downward and forward towards the middle line, where it joins that from the opposite side.

The occiput is round in those that have short bills, but it is flattish, and exhibits a kind of crest in those that have the beak long.

In the *cormorant*, the occipital protuberance supports a long triangular bone, which seems to be produced by the ossification of the cervical ligament.

The first vertebra in birds is a simple osseous ring, a little more thick on the anterior part. It articulates above with the occipital condyle, and below by a flat surface with the second vertebra.

The second vertebra in birds bears a tooth-like process

process on the upper side, but it is very short, and proportioned to the height of the ring of the atlas.

D. *In Reptiles.*

The articulation of the head of reptiles is considerably behind; but the motions vary in different species.

In the *crocodile* there is only one condyle, situated at the under side of the foramen magnum: the atlas is formed of two portions; the posterior is shaped like the segment of a ring: the anterior, which is thicker, receives the condyle, and is articulated to the second vertebra: there are two lateral processes, long, flat, and turned backward, which supply the place of transverse processes.

The odontoid process of the second vertebra is short and thick; it is articulated within a cavity in the body of the atlas. This second vertebra has transverse processes similar to those of the first.

All other *lizards* have nearly the same conformation; but the condyle seems divided in two by a longitudinal superficial furrow.

The *tortoises* have likewise only one condyle. In the land sort it is prolonged, and divided into two, as it is in the lizards. In the marine species it presents three articular faces, like a trefoil leaf. As this condyle penetrates deep into the correspondent cavity of the atlas, the lateral motion of the head is much confined. The other motions of the head of the tortoise are those of projection and retraction; they depend
upon

upon the flexion and extension of the cervical vertebræ, and have been described already.

The *frog*, the *toad*, and the *salamander*, have the head articulated by two condyles upon the first vertebra, which is almost immoveable.

Serpents have three surfaces, in the manner of a trefoil, close together, upon one condyle, beneath the occipital foramen. The head is not more moveable on the atlas, than the rest of the vertebræ are upon each other.

E. In Fishes.

The occiput of fishes appears like a vertical truncation of the cranium. The tubercle by which it is united to the vertebræ is single, and placed below the occipital foramen. This union is effected by the intervention of cartilages with flat or concave surfaces, so that the motion is much confined on every side. The superior part of the occiput in some species presents flat and very prominent lateral processes, and, in particular, a longitudinal spine, which terminates above the foramen magnum.

The basis of the cranium, in most kinds, is only formed by a longitudinal ridge, more or less round.

In some species, such as the *whiting*, the *perch*, the *salmon*, &c. the occipital protuberance is very long, and sharp-edged.

The

The *sparks* and *rays* have their heads articulated with the vertebral column, by two condyles; but this articulation is almost immoveable, and is made secure by ligamentous fibres.

ARTICLE VI.

Of the Muscles of the Head.

A. In Man.

THE muscles which move the human head arise from the first, the second, or from several other cervical vertebræ.

Those that arise from the atlas are,

1. THE RECTUS CAPITIS POSTICUS MINOR, or
ATLOIDO-OCCIPITALIS,

Rises from the spinous process of the first vertebra, and is inserted into the middle of the posterior edge of the foramen magnum. It draws the occiput directly backward, and moves the head upon the atlas.

2. THE RECTUS CAPITIS ANTICUS MINOR, or
TRACHELO-SUB-OCCIPITALIS.

This little muscle arises from the anterior annular part of the atlas, and is inserted into the cuneiform process. The motion it produces is
directly

directly the opposite of the preceding: it bends the head forward and downward.

3. THE RECTUS CAPITIS LATERALIS, *or*
MASTOIDO-ATLOIDEUS.

This muscle arises from the transverse process of the atlas, and is inserted into the mastoid process of the same side: it bends the head a little towards the shoulder.

4. THE OBLIQUUS CAPITIS SUPERIOR, *or*
ATLOIDO-SUB-MASTOIDEUS.

This muscle arises from the same process as the preceding, and ascends, internally, towards the posterior edge of the foramen magnum, just by the mastoid process. Its action produces a slight rotation of the head upon the axis, at the same time that it brings it backward.

The muscles which originate from the second vertebra, are only two.

1. THE RECTUS CAPITIS POSTICUS MAJOR,
or AXOIDO-OCCIPITALIS.

This muscle arises from the spinous processes of the axis, and is inserted into the occiput over the *rectus capitis posticus minor*. It covers that muscle, and participates in its operation, causing however a more decided motion of the head backwards.

2. THE

2. THE OBLIQUUS CAPITIS INFERIOR, *or*
AXOIDO-ATLOIDEUS,

Arises from the same spinous process, and proceeds outwardly towards the transverse process of the atlas, into which it is inserted; this is, therefore, rather a muscle of the spine than of the head. It turns the atlas upon the axis, thus producing the lateral motion of the first cervical vertebra.

There are five muscles of the head, proceeding from the other cervical vertebræ.

1. THE COMPLEXUS MAGNUS, *or* TRACHELO-
OCCIPITALIS,

Arises by digitations from the transverse processes of the four last cervical and three first dorsal vertebræ. It passes over the back of the neck, in its way to its insertion in the occiput, above all the preceding. It is closely united, by its lower surface, with another called the biventer. This muscle is evidently an extension, or a flexor of the head backward.

2. THE BIVENTER CERVICIS, *or* TRACHELO-
DORSALIS.

This muscle arises, in like manner, by digitations from the transverse processes of five vertebræ of the back, from the second to the sixth, and from the spinous process of the first. It is
inserted

inserted into the occiput, above the preceding muscle, to which it is similar in use. Its middle being narrow and tendinous, it has, from that circumstance, obtained the name of *biventer*.

3. THE COMPLEXUS MINOR, *or* TRACHELO- MASTOIDEUS,

Arises by digitations from the transverse processes of the six last cervical vertebræ, and three first dorsal, and ascends along the neck to the mastoid process, into which it is inserted. It receives, near its insertion, a long slip of muscle from the longissimus dorsi. It bends the head backward, turning it at the same time a little upon its axis, when it acts without the correspondent muscle of the opposite side; but when these muscles act together, they keep the head upright. They are antagonists of the sternocleido-mastoideus.

These three muscles are covered by,

4. THE SPLENIUS CAPITIS, *or* CERVICO- MASTOIDEUS.

This muscle arises from the spinous processes of the five last cervical and two first dorsal vertebræ. It is inserted into the occipital arch near the mastoid process. It has the same use as the complexus minor. Its external part, which rises from the two next dorsal vertebræ, and is inserted into the transverse processes of the two upper cervical vertebræ, is regarded as

a muscle of the spine, and has been named *splenius colli*.

5. THE RECTUS CAPITIS ANTICUS MAJOR, *or*
TRACHELO-SUB-OCCIPITALIS,

Extends along the cervical vertebræ, on the fore part, from the second to the sixth, and is inserted into the cuneiform process of the occiput. It bends the head forward.

Certain muscles upon the shoulder, which are inserted into the head, such as the *trapezius*, *sterno-cleido-mastoideus*, the muscles of the *larynx*, *os hyoides*, and *jaw*, all act upon the head, and might be demonstrated here.

B. *In other Mammiferous Animals.*

The small muscles of the head are found in quadrupeds as well as in man, and with the same attachments; the only difference is, that they increase in magnitude proportionally with the two first vertebræ. Except, therefore, in the *monkey* and *cetaceous animals*, the *obliquus capitis inferior*, and *rectus capitis posticus major*, are of very considerable magnitude.

In general the *biventer cervicis* is not divided into two portions by an intermediate tendon. In the *Carnivora* there are, throughout its whole length, transverse tendinous intersections. It lies upon the *complexus magnus*, from which it is, however, very distinct; so much so, indeed,

that these animals appear to have three complexi: but in the *horse* it is completely united to the complexus on the upper parts.

The *splenius* is inserted into the cervical ligament, in those animals which have this ligament considerably elevated above the vertebræ. It is always larger than in man, but is strongest in the *mole*. No part of this muscle is attached to the transverse processes of the cervical vertebræ in the Carnivora. Such of its fibres as go to the mastoid process, are inserted there by a tendon common to them and the complexus minor. In the *horse*, the part of the *splenius* which belongs to the head is entirely inserted into the mastoid process by a thin tendon common to it and the complexus minor, which receives no slips, except from the third cervical and the two first dorsal vertebræ. The *splenius* furnishes besides three slips to the transverse processes of the three cervical vertebræ next to the atlas. The tendon of the first is common to it and the *transversalis colli*.

E. In Birds.

Birds have no *splenius*.—The *Biventer Cervicis* is completely separated from the complexus. It extends from the middle of the back to the occipital arch. Its two bellies are simple and without processes. Its middle tendon is very slender.

It

It seems to be wanting in those birds which have very long necks, as the *heron*.

The *complexus magnus* is only inserted into the articular processes and lateral surfaces of a few of the cervical vertebræ; for instance, the third or fourth, or perhaps the second or third.

The *complexus minor* rises from the anterior spines of the third, fourth and fifth vertebræ, or sometimes from the second and third. It is inserted into the occiput more outwardly than the preceding. These three pairs of muscles occupy the whole arch.

The *recti postici* are three in number in birds.

The *minor* and *major* are analogous to those of the human species; and the *rectus posticus maximus*, which in them proceeds likewise from the spinous process of the axis, covers the other two.

The *obliquus inferior, seu magnus*, is to be found, but not the *superior*.

The *rectus lateralis* also exists in birds. Finally, the two *recti antici* are likewise present; but the *rectus major* arises only from the three or four first vertebræ.

D. In Reptiles.

The muscles of the head of the *tortoise* cannot be described under names similar to those of mammiferous animals and birds, because the

shell affords insertions to the greater number of them. We will therefore only distinguish them by their points of attachment. Thus, on viewing the back part of the neck, we remark—

1st. At the anterior part of the back-shell, near the angle of the lunula, a broad muscle, which extends to the lateral and posterior parts of the head into which it is inserted. It pulls the head backward.

2d. Beneath, and from the middle of the anterior lunula of the back-shell, there arises another muscle, which is thin and round, and which, in separating from that of the opposite side, forms an angle like the letter V; it is inserted on the outside of the preceding muscle, and has the same use.

3d. A muscle analogous to the *splenius capitis* rises from the spinous processes of the fourth and fifth cervical vertebræ, by distinct slips, and is inserted into the occipital arch. Its use is to raise the head.

4th. A muscle analogous to the *rectus major anticus*, rises from the inferior tubercles of the four vertebræ next to the atlas, and is inserted, fleshy and thick, into the depression of the cuneiform process below the condyle.

5th. The *trachelo-mastoideus* rises from the inferior tubercles of the second and third cervical vertebræ, by two thin aponeurotic tendons. It is

is inserted, by a very thick and entirely fleshy portion, into the protuberance that answers to the mastoid process. Its use is to bend the head laterally.

6th. Lastly, at the superior part of the cervical spine there is a short muscle which proceeds from the inferior part of the foramen, formed by the temporal fossa, and is inserted into the spinous processes of the first, second and third vertebræ of the neck.

On viewing the neck in front, we observe the muscle analogous to the *sterno-cleido-mastoideus*, attached to the strong aponeuroses that surround the humerus at its articulation with the scapula. The lower part of it, for one-third of its length, can only be seen, the remainder being concealed by a muscle composed of transverse fibres, which supplies the place of the *mylo-hyoideus*, and *platysma-myoides*. It is inserted into a process corresponding to the mastoid. Its use is to draw the head inwardly, and to produce a small elevation of the shoulder.

The *longus capitis* arises from the third vertebra of the back, and is inserted by a slender tendon into the cuneiform process of the occiput.

The *frogs* have very few of the muscles of the head: most of those which are inserted in it are employed in moving the superior extremities, or are proper to the vertebral column.

The muscle analogous to the *obliquus superior*

arises from the first transverse processes of the spine, and is inserted into the superior part of the occiput: its direction is oblique from without inwards.

That which is analogous to the *rectus capitis anticus minor*, arises from the transverse process of the first vertebra, and is inserted into the basis of the cranium, below the foramen magnum.

These are the only two muscles proper to the head in frogs: They are similar in the *land salamander*.

E. In Fishes.

Osseous fishes have no particular muscle destined to move the head. The lateral muscles of the body inserted there occasion but little sensible motion; but the *rays* have three muscles assigned to that purpose, which we think necessary to point out in this place. One serves to move the head upon the trunk, the others to raise and lower the extremity of the muzzle. The first is situated above the body and the cavity of the branchiæ. It is fastened to the spinal column, and to the anterior portion of the bony arch that supports the large wings; it is inserted into the posterior extremity of the head, which it moves upward upon the spine.

With respect to the two muscles of the muzzle, the superior arises from the anterior part of the girdle, which supports the wings or fins by a short fleshy portion, the small cylindrical tendon
of

of which is received into a mucous sheath: this sheath passes with the tendon above the branchiæ, and extends to its insertion at the base of the muzzle, which this muscle moves upward.

The inferior is situated on the lower part of the body, and in the cavity of the branchiæ, whence it arises from the first cartilages of the vertebral column. It extends obliquely outward, and then inward, describing a curve, the convexity of which is external. It is inserted, almost entirely fleshy, into the base of the snout, which it incurvates or bends towards the belly.

LECTURE FOURTH.

OF THE ANTERIOR EXTREMITY, OR PECTORAL MEMBER.

ARTICLE I.

Of the Bones of the Shoulder.

A. *In Man.*

THE human shoulder is formed of two bones called the *scapula* and *clavicle*.

The *scapula*, or *omoplate*, has nearly the form of a right-angled triangle; and its situation, when at rest, is such that one of the sides is parallel to the spine.

The longest side points obliquely outward and downward: it is called the *costal* margin. The shortest side is uppermost, and is called the *cervical* or *superior* margin. The superior, anterior, or external angle, is truncated, and forms an oval articular surface, on which the head of the bone of the arm moves; it is therefore called the *humeral* angle. Above this articulation there is a projection of the superior margin, which is
first

first directed forward, and then backward. This is called the *coracoid* process.

On the convex surface, at about one-third of its length from the superior margin downward, a process is produced: this process intersects the scapula transversely, and is called the *spine*. It is elongated, and forms a flat detached projection, which extends over the humeral angle, and is called the *acromion*. The part of the surface which is above the spine is called *supra-spinal*, and that below it *infra-spinal*.

The *clavicle* is a long and strong bone, with a double curvature, supported at one extremity on the top of the sternum, and at the other on the acromion. The latter obeys the motions of the scapula, which slides in every direction upon the posterior part of the ribs, to which it is not articulated, but only attached by the muscles. Each of its margins, and each of its angles, is therefore capable of being elevated, or applied closer to the ribs.

The human shoulder, and consequently all the rest of the superior extremity, is only articulated to the other parts of the skeleton, by that end of the clavical which joins the sternum.

Certain ligaments join the scapula to the clavicle, and the latter to the sternum. The first proceed from the coracoid process, and are inserted into the end of the clavicle next the acromion. The next are (1st.) the *inter-clavicular*, which connects the extremities of both clavicles

clavicles behind the sternum, and (2d.) others which arise from the inferior surface and passing obliquely, are inserted into the cartilage of the first rib. Finally, each extremity of the clavicle is furnished with a capsular ligament, one attached to the acromion, and the other to the sternum, at their articulations.

B. *In other Mammiferous Animals.*

The shoulder in the inferior mammalia differs from that of man, by the absence or proportion of the clavicle, and the form of the scapula.

The clavicle of the *Quadruman*a resembles that of man: it is entirely wanting in all animals that have hoofs, such as the *Pachydermata*, *Ruminantia* and *Solipeda*. In animals with nails, there is nothing general to be remarked. Amongst the *Sarcophaga*, the *Cheiroptera*, (particularly the *bats*, in which this bone is very large and strong,) the *Pedimana*, and the greater part of the *Plantigrada*, namely the *moles*, *shrews*, and *bedge-hogs*, have it perfect; the others, that is to say the *Carnivora*, as *dogs*, *cats*, *weasels*, *bears*, *coatis*, *racoons*, *otters*, *seals*, &c. have only clavicular bones suspended in the flesh, neither touching the acromion nor sternum; and even these are entirely wanting in some individuals.

The clavicle of the *mole* is particularly remarkable on account of its thickness, which exceeds its length; this gives it a very singular shape,

shape. It is connected with the acromion by a ligament, and is articulated with the humerus by a broad surface.

With respect to the Rodentia, the clavicle is perfect in the *squirrels*, the *rats*, the *beavers*, and the *porcupines*; but is wanting in the *damans* and *cavys*. *Hares* have the clavicle suspended in the flesh.

This bone is found in several of the Edentata, such as the *armadillos*, the *ant-eaters*, and the *sloths*. In the last, at the sternal extremity it is furnished with a process which forms nearly a right angle with the axis of the bone. But the clavicle is quite wanting in the *pangolins*.

The Cetacea have no vestige of the clavicle.

We see, by this investigation, that the clavicle is found in all animals that often extend their arms or anterior feet forward, either to seize things, as the *monkey*, or to fly, as the *bat*, &c. That it is wanting in those quadrupeds that use the anterior extremities for progressive motion only, and that there are rudiments of it in such as hold a middle state between these two orders.

Indeed the clavicle is a very strong arch, which represses the arm, and prevents it from being moved too far forward; it is, therefore, found double in birds.

The scapula of the *monkeys* has the spinal angle (which answers to the posterior superior,) more obtuse, and consequently the opposite side longer than in man. This renders the side next the spine

spine shorter. The same conformation is observed in the *makis*.

In the *Sarcophaga* the spinal margin, or that next to the spine, is rounded off, which conformation also renders the posterior angle very obtuse. The supra-spinal fossa becomes likewise nearly as large, and sometimes even larger than the infra-spinal. In those which have no clavicles the acromion does not project so far, and there is another eminence pointing backwards almost perpendicular to the spine. It is also found in the *hedge-hogs* and *Pedimana*. The coracoid process is, for the most part, wanting; it is, however, found in the *hedge-hog*, the *Cheiroptera*, and the *Pedimana*. The body of the scapula is elongated in the *hedge-hog*, and much more so in the *mole*; in the latter it appears to be a long bone, with no mark of a spine, except towards the posterior margin, and before the tubercle, which corresponds to the acromion. This bone is so placed that it is longitudinally parallel to the spinal column.

The *Cheiroptera* alone have the spinal margin very long, and the posterior angle acute.

In the *Rodentia*, the scapula has generally the same shape as in the *Sarcophaga*; for in them the length of the acromion depends upon the presence of the clavicle. The same rule prevails with respect to the length of the coracoid process.—The *bares* have, upon the acromion, another long projection rising at a right angle,
and

and turning backward. This recurrent process is very long, and rather slender. Towards the posterior part it forms a very conspicuous projecting angle.

The Ruminantia and Solipeda have the scapula narrow towards the back, and elongated towards the neck, like the preceding animals. The spine is nearer to the anterior margin, which we have named cervical or superior in man. It appears truncated, and has neither acromion nor recurrent process. It is likewise destitute of any coracoid process.

The *bog* and the *rhinoceros* exhibit a striking peculiarity in the spine of the scapula. This spine is almost effaced near the humeral angle, but about its middle there arises a very bold projecting process, inclined towards the costal margin.

The scapula of the *elephant* is rhomboidal; the spine terminates in two large processes, one of which turns forward and forms the acromion, and the other, which is much larger, turns backward. The latter resembles the recurrent process which we remarked in certain Rodentia, especially in the *bare*.

Among the Cetacea, the *dolphin* and *porpoise* have the spinal margin of the scapula rounded, and very large: the spine is very near the cervical margin, and cannot be distinguished from the plane of the infra-spinal fossa. The supra-spinal fossa has a deep hollow, that seems to
proceed

proceed from a defect in the ossification. Above the humeral angle there is a projecting plate, which is continued with the spine, and seems to correspond to the acromion. In the other mammalia of this family the fossa supra-spinalis is still less distinct.

We find that the extent of the scapula, in the direction parallel to the spine, is in proportion to the violence of the efforts the animal has to make with the anterior members; because this configuration affords more extensive attachments for the muscles that connect it with the trunk. Thus, in *man*, in *monkeys*, and more particularly in *bats* and *moles*, it approaches nearest to that extreme elongation which prevails in birds.

C. In Birds.

In birds the shoulder is composed of three bones, the *clavicle*, the *fork*, and the *scapula*.

The *clavicle* is a straight large bone, flat before and behind. It is articulated by a large and sharp head, with the anterior edge of the sternum in a corresponding hollow, in which it has but little motion. It advances forward, and somewhat laterally; it is then enlarged, and divided into short processes. The first process, which is anterior, inferior, and internal, is connected to the fork; the second, which is posterior, superior, and external, is articulated to the scapula,

scapula, and with it forms a cavity into which the head of the humerus is received.

The *scapula* is elongated in the direction parallel to the spine, and is very narrow on the opposite side. It is often pointed, but sometimes truncated on the posterior part, and always flat and destitute of a spine. The head, or humeral extremity, becomes thicker at its junction with the clavicle. Outwards we observe the surface which these bones in common present to the head of the humerus, and inwardly a little point which answers to the extremity of the fork. Between these three bones, however, there is still left a small vacancy or free space.

The *fork*, or *os furciforme*, is single, and common to both shoulders. It is elastic, and shaped like a V. Its point is turned backwards, and its two branches support the humeral heads of the two clavicles. By its elasticity it hinders them from closing together in the violent efforts of flying.

Birds of prey that fly by day have the fork very short, with crooked branches; their convexity is forward, and the angle of union round, and separate from the sternum.

Nocturnal birds of prey have the fork weak, with almost straight branches, the angle obtuse and close to the sternum.

In *parrots* it is also weak; the branches are convex outward, and the angle of union obtuse, and removed from the sternum.

-In

In the *Passer*es the bone is nearly of a parabolic figure, with the angle close to the sternum. However, the *swallow* and the *goat-sucker* must be excepted, as they have it small, like birds of prey.

The *Gallinæ* have it also nearly parabolic. The angle is prolonged in a process from which a ligament proceeds to fasten it to the keel of the sternum, which in these birds is very low.

The *ducks*, *mergansers*, and *flamingos*, have the fork resembling birds of prey.

In the *herons* and *cormorants*, the angle of the fork is articulated with the summit of the keel of the sternum. It is united to it by ossification in the *cranes* and *stork*, the *jabiru* and *pelican*.

The two branches of the fork are separate in the *ostrich*, and each anchylosed with the clavicle and scapula of the same side. These three, therefore, form only one very flat bone, with an opening near the extremity, by which it is joined to the sternum.

In the *cassowary* no fork can be found except a sort of process at the internal border of the head of the clavicle, which is merely a rudiment.

Thus we see that the *os furciforme* is the more detached, stronger, and more elastic in proportion to the activity of the bird in flying, and the necessity of the functions of that bone. But in those birds which never fly it can scarcely be said to exist, and, at best, it is far from being
able

able to separate, by its resistance, the heads of the clavicles: in fact, there remains, in birds of this kind, only the vestige of it.

D. *In Reptiles.*

In oviparous quadrupeds the glenoid cavity of the shoulder is partly composed of the scapula, and partly of the clavicle.

The scapula, which is elongated, has no spine: it contracts, and becomes thicker towards the neck.

The clavicle is simple, short, and flat, and united to the sternum in the *crocodile* and *lizards*. It is broad, and almost square, in the *iguana* and *camelion*. In the *tupinambis* it is oval, and very large and long between the front and back, and has two unossified parts.

The *frog* and *toad* have two clavicles to each shoulder, attached to the two extremities of the sternum. The scapula is bent, and composed of two articulated pieces, with the superior one inclining towards the spine. The same conformation obtains in the *Surinam toad*. The anterior clavicles appear to correspond to the os furciforme of birds. The clavicle, the sternum, and the first piece of the scapula, are anchylosed together.

The *salamanders* have the shoulder formed in a most singular manner. The scapula, clavicle,

and sternum consist only of a single bone, which receives the head of the humerus. The shoulder is almost all cartilaginous; but the part answering to the scapula is more distinct than the rest. It inclines towards the spine, where it receives the muscles by which it is moved. The clavicular part is directed towards the head; that which supplies the place of the sternum turns towards the breast, but without uniting with the bone of the opposite side: the part on the right side slides over that on the left. This conformation allows a greater dilatation of the breast in respiration.

The *tortoise* has also these three bones, which unite to form the glenoid cavity, and correspond with the scapula fork and clavicle. But as their respective disposition is very remarkable, it appears necessary to give a particular description of them.

One of the bones extends from the base of the rudiment of the first rib, to which it is fixed by a ligament, as high as the humeral cavity, where it is intimately connected with the other two.

The second bone may be considered as the continuation of the first, which it joins at the humeral cavity, of which it forms part. Its other extremity is attached to the breast-plate, and strong ligaments likewise unite this extremity to that of the posterior bone.

These two bones, thus united, are slightly bent outwards, so as to leave between them and those

those of the opposite side, an oval space, through which the œsophagus, the trachea, and several muscles, pass.

The first seems to correspond to the clavicle, and the second to the os furciforme.

Finally, the third bone of the shoulder is situated below the abdominal and thoracic viscera, nearer the breast-plate. It is long, and extends from the humeral cavity, of which it forms the lower part, as far as the abdomen. It seems to supply the place of the scapula, by the number of muscles inserted into it; but its situation is just the reverse of that bone. A very strong ligament unites this bone to the second.

N. B. As the pectoral member in fishes cannot, in any manner, be compared to that of the other vertebral animals, it seemed necessary to give a particular description of it, which will be found at the end of this Lecture.

ARTICLE II.

Of the Muscles of the Shoulder.

A. In Man.

THE human shoulder is moved by several muscles, which give to it four principal motions that are often combined together. In one of

these motions the shoulder is brought forward towards the breast. In the second, which is the reverse of the former, it is drawn back in the contrary direction, and the back becomes covered. In the third, the shoulders are pulled downward, and retained in that position. The neck is then at ease. By the fourth, the shoulders are raised towards the head, or elevated.

These muscles are eight in number.

1. THE SERRATUS MAJOR ANTICUS, *or* COSTO-SCAPULARIS,

Is attached inferiorly to the spinal margin of the scapula. It then expands, and is inserted by digitations into the external surface of the ribs from the first to the ninth. By its inferior digitations, this muscle pulls the shoulder, at the same time, downward and forward; by the superior digitations, it draws it upward, or towards the head; and finally, by its middle portions, it holds the shoulder fixed in a forward position.

2. THE PECTORALIS MINOR, SERRATUS MINOR ANTICUS, *or* COSTO-CORACOIDEUS.

This muscle is inserted, at one end, into the coracoid process, and at the other, by three digitations, into the anterior surface of the three ribs, from the third to the fifth. The obliquity of its fibres determines the motion of the humeral angle

ART. II. MUSCLES OF THE SHOULDER. 261

angle of the scapula downward, and at the same time moves it forward.

3. THE LEVATOR SCAPULÆ, ANGULARIS SCAPULÆ, *or* TRACHELO-SCAPULARIS,

Is inserted into the posterior and superior angle of the scapula. It proceeds towards the neck, where it is inserted, by fleshy slips, into the transverse processes of the vertebra, from the second to the fifth. It raises the scapula behind, while at the same time it somewhat depresses the humeral angle, as this bone then becomes a kind of lever.

4. THE OMO-HYOIDEUS, CORACO-HYOIDEUS, *or* SCAPULO-HYOIDEUS,

Extends from the superior costa of the scapula, near the coracoid process, to the base, and up to the horns of the os hyoides, into which it is inserted. Its use is to pull down the os hyoides a little. It assists deglutition, more than it contributes to the motion of the shoulder.

5. THE TRAPEZIUS, CUCULARIS, *or* DORSO-SUB-ACROMIALIS,

Has its insertions, on one part, in the occipital arch, and all the spinous processes, as well cervical as dorsal; and, on the other, is inserted into the whole length of the spine of the scapula, and part of the clavicle. This muscle, like the serratus magnus, acts in opposite directions in its

partial contractions: thus the superior portion raises the shoulder, the middle draws it backward, and the lower pulls it downward.

6. THE RHOMBOIDES, *or* DORSO-SCAPULARIS.

This is situated under the preceding muscle. It arises from the spinous processes of the fifth, sixth, and seventh cervical, and the four first dorsal vertebræ; it is then inserted into the spinal edge of the scapula below its spine. Its direction is oblique, and it tends outward as it descends. This muscle seems calculated for moving the scapula backward, while at the same time it raises it a little, in consequence of the ascending obliquity of its fibres.

7. THE SUBCLAVIUS, *or* COSTO-CLAVIUS,

Is situated below the clavicle, occupying, in an oblique direction only, the space between that bone and the first rib. It fixes the clavicle to the breast in the violent exertions of the shoulder.

8. THE STERNO-CLEIDO-MASTOIDEUS.

This muscle, which we have already described in treating of the motions of the head, may likewise be included in those of the shoulder, on account of the action of that part which is inserted into the clavicle; but the motion it produces is very confined.

B. *In*

B. *In other Mammiferous Animals.*

The *serratus major* is more extensive in the inferior mammalia than in man; for it is attached, by digitations, not only to the ribs, but to the transverse processes of the cervical vertebræ. This is necessary in animals which walk upon all fours, to prevent, more effectually, the scapula from being pressed towards the spine. This muscle, with its correspondent one, forms a species of girth that supports the thorax. As it has the same extent in *monkeys*, it is one proof that nature intended them to use all the four feet in walking. The *serratus major* in them even furnishes digitations to all the cervical vertebræ; while, in some of the carnivora, the digitations extend only to a part of these vertebræ. In the *cat*, for instance, there are four digitations; the *dog*, the *bear*, and the *rabbit*, have five. In the *dolphin*, (which does not walk,) the *serratus major* has no insertions in the vertebræ of the neck.

The *pectoralis minor* is wanting in the carnivorous and hoofed animals. The *horse* has a muscle which supplies its place; it rises, by digitations, from the ribs; it then passes to the anterior edge of the scapula, but in its way it unites itself with the fibres of the *pectoralis major*, so as to be inserted partly into the humerus. In the

dolphin, its place is supplied by a muscle, which has only one digitation inserted into the sternum, near to the anterior extremity; above, it is attached to the humeral cavity of the scapula.

The *levator scapulæ* presents many varieties in the number and insertions of its tendons. For instance, in *monkeys* it is not inserted into the angle, but into the spine of the scapula, near the acromion, and it is then covered by the trapezius which is not divided. In the *Carnivora*, and the *Rodentia*, it occupies a larger compass. It approaches still nearer to the humeral extremity of the spine of the scapula, and the trapezius being bifid, it passes between the two parts. In the *cat*, it has only two superior attachments, one into the transverse process of the first vertebra of the neck, and the other into the cuneiform process of the occipital bone.

In the *dog* and the *bear*, it is inserted only into the first vertebra of the neck; in the *rabbit*, it is attached to the cuneiform, or basilar process of the occiput only. *Vicq. D'Azyr* has considered this as a distinct muscle, and has called it ACROMIO-BASILARIS.

In the *sheep*, it rises from the first cervical vertebra, and is inserted into the posterior part of the spine of the scapula. It is entirely wanting in the *horse*.

In the *dolphin*, it is fastened to the transverse process of the first vertebra, but its tendon is expanded

expanded over the whole external surface of the scapula.

The *trapezius*, and *sterno-cleido mastoideus* of the monkey, very much resemble those of man, but in the other mammiferous animals they are so complicated, that we are obliged to describe them together.

In such of the Sarcophaga, and the Rodentia, as have not the clavicle perfect, the *cleido-mastoid-eus* (which is very distinct from the *sterno-mastoid-eus*), and the clavicular portion of the *deltoides*, not being separated by a fixed bone, form together only one muscle, acting upon the humerus; this might be named MASTO-HUMERALIS. The clavicular portion of the *trapezius* likewise joins them at their point of union, and these three portions form one muscle, called by anatomists COMMUNIS CAPITIS, PECTORIS, et BRACHII. This clavicular portion of the *trapezius* is very distinct from its scapular part. It is even separated from it by the levator scapulæ, which passes between them. It is more or less extended according to the species.

Thus we find that in the *dog* and the *cat* its fibres proceed partly from the cervical ligament. In the *rabbit*, there are none but what come from the occiput. In the *bear*, the anterior portion of the *trapezius* is again subdivided into two muscles. The fibres, which come from the occiput, form a tendon which is inserted into the sternum,

sternum, at the same place as the *sterno mastoideus*.

In the *sheep*, one tendon only proceeds from the mastoid process, which presently divides into two muscular fasciuli: one of these goes to the sternum; and the other, which corresponds with the *cleido mastoideus*, is confounded with the clavicular part of the *trapezius*, almost opposite to the middle of the neck, and forms, with that and the clavicular portion of the *deltoides*, a single muscle, extending to the humerus, as in the preceding species.

In the *horse*, there is only what is called in man, the ascendant portion of the *trapezius*, which is inserted into the posterior part of the spine of the scapula. There is also a *sterno-mastoideus*; but instead of the *levator*, the *cleido-mastoideus*, and the clavicular portions of the *trapezius* and *deltoides*, we only find a single muscle attached to the mastoid process, and the transverse processes of some of the superior cervical vertebræ, which passes before the head of the humerus. This muscle descends along the internal surface of the arm, to be inserted inferiorly.

The *dolphin* has not the clavicular portion of the *trapezius*. This muscle which is itself very thin, covers all the scapula, and is inserted near its neck. The *sterno-mastoideus* is very thick, with a large belly; and on the outside of it there is another muscle, much similar, which rises from

from the mastoid process, and is inserted below the head of the humerus.

We have still to describe a thin muscle belonging to this part in the *rabbit*. It arises from the spine of the scapula, covering the supraspinalis, and is inserted into the clavicle.

The *rhomboides* in *apès* extends as far as the occiput. Its occipital fibres, which in them are sometimes divided from each other, are always separate in carnivorous animals, and then form a particular muscle, named by anatomists OCCIPITO-SCAPULARIS, OR LEVATOR SCAPULÆ MAGNUS.

In the *horse*, this anterior portion of the *rhomboides* is inserted into the cervical ligament only. This is the LEVATOR SCAPULÆ PROPRIUS of hip-potomists.

The *rhomboides* is small in *dolphins*, and has no distinct anterior portion.

The *coraco-byoideus* has nothing remarkable in *monkeys*. It is wanting in animals that have no clavicle or coracoid processes: even in dogs there is none.

The *subclavius* also exhibits nothing remarkable in *monkeys*; it is wanting in the mammalia that have no clavicles.

It is necessary to give a particular description of the muscles of the shoulder in the *mole*, on account of their singularity.

The cervical portion of the *serratus major* is simple, excessively large and turgid, and is only
attached

attached to the last vertebra. Instead of the whole *trapezius*, there are only two bundles of fibres, which proceed from the loins, and are inserted into the posterior extremities of the scapula. These two fasciculi being almost parallel, would rather pull the extremities asunder than bring them together, were they not connected by a very strong transverse ligament. The use, therefore, of these two muscular fasciculi is to give to the whole anterior part of the body a kind of balance-like motion in an upward direction.

The *rhomboides* has almost all its scapular attachments at the same transverse ligament which is common to the two scapulæ. Its other insertion is in the cervical ligament, which is always ossified. Its use is, therefore, to raise the head with much force.

This renders the muscle which is analogous to the occipital portion more effectual. Its fibres are parallel to the spine; they pass through those of the *rhomboides*, properly so called, to be attached to the transverse ligament; the anterior extremity is inserted into the middle of the cranium.

The *sterno* and *cleido mastoidei* have nothing particular, and the *levator scapulæ* is wanting.

The *pectoralis minor* is very thin; it is inserted into the anterior part of the first ribs, and into the ligament that connects the clavicle to the scapula.

The

The clavicle has two muscles: one, which may be called *superclavius*, arises from the first bone of the sternum, at the anterior angle of the great head of the clavicle; the other also arises from the sternum, but lower down, and is inserted near the first.

We shall likewise particularly describe the motion of the shoulder in the *bat*, since it widely differs from that of the other mammalia.

The *serratus major* is situated before the pectoralis minor: it is attached to all the ribs, but not to the neck, and is inserted into the external and inferior border of the scapula.

The *subclavius* is only remarkable for its bulk, which is comparatively very considerable.

The *pectoralis minor* has three digitations; it is inserted into the coracoid process, which is very strong, by a broad tendon.

The *trapezius* is neither attached to the spine nor the processes of the neck, but to the eleven first dorsal vertebræ; it is inserted into the triangular surface of the cervical angle of the scapula.

The *rhomboides* has no peculiarity.

The *levator scapulæ* arises from the fifth and sixth vertebræ of the neck.

The *sterno-mastoideus* is not attached to the clavicle.

C. *In Birds.*

The scapula of birds is moved by four muscles analogous to those of the mammalia: but in general those of the upper part are very small and slender; they are neither attached to the head nor the neck. This conformation is probably connected with the length and flexibility of the neck.

The *ferratus major*, or SUBSCAPULARIS of *Vicq. D'Azyr* is divided into four or five flat slips, which arise from the one half of the inferior costa of the scapula next its free extremity, and which are inserted into the five first ribs. The first is almost parallel to the spine; the second is more oblique; the three last are thick, and pass directly towards the spine, or, in other words, are perpendicular to it.

The COSTO-SCAPULARIS of *Vicq. D'Azyr* is a muscle which might be taken for a slip proceeding from the *ferratus major*; but it arises from the lower costa of the scapula more forward, and descends to be inserted into the first ribs.

The *trapezius* is composed of two portions; one arises from the spinous processes of the last vertebra of the neck and the first of the back, and passes on towards the inferior and interior branch of the fork. The other part is much longer, it adheres to all the spinous processes of
the

the back except the first, and, passing obliquely forwards, is inserted into the superior, or spinal edge of the scapula.

The *rhomboides* is partly covered by the trapezius, and immediately by the latissimus dorsi: it likewise rises from the spinous processes of the dorsal vertebra, and is inserted into the most posterior part of the spinal margin of the scapula.

D. In Reptiles.

In the *frog* (which has no ribs) the *serratus major* has an extraordinary shape, which appears to be occasioned in part by the want of the cervical vertebræ: it forms three distinct muscles.

The first arises from the occiput, near to the foramen magnum. It divides into two bellies, which are inserted into the superior spinal angle of the scapula; one on the internal, and the other on the external side.

The second proceeds from the second transverse process, and passes under the dorsal portion of the scapula, towards its spinal edge.

The third proceeds from the third transverse process, and passes underneath the preceding, keeping still nearer to the edge.

There is besides another muscle proper to the scapula, situated upon its internal surface, between the two constituent parts, which make it
appear

appear broken. It appears to draw these two parts closer together, and by its contraction renders the angle they form with each other more acute.

There is no muscle analogous to the *pectoralis minor*.

The place of the *levator*, or *angularis scapulae*, is supplied by a very considerable muscle which rises from the base of the occiput; it becomes perceptibly smaller as it approaches the shoulder, and is inserted into the posterior edge of the cartilaginous part of the scapula.

The *omo-hyoideus* is long and thin; it comes from the great inferior horn of the os hyoides, and is inserted under the neck of the scapula.

The *trapezius* is wanting.

The muscle analogous to the *rhomboides* is very thin. It arises from the dorsal processes, and is inserted into the spinal edge of the scapula.

There is no *subclavius* muscle.

The *sterno-mastoideus* has only one belly, which extends obliquely from the posterior part of the head, behind the ear, to the neck of the osseous part of the scapula. Its action is evidently that of pulling the shoulder towards the head, and raising it up.

We shall describe the muscles of the *tortoise* separately, as they differ considerably from those of other red-blooded animals. They are only three in number.

One of them, though very unlike the *trapezius*, is similar in its use. It rises from the lower
surface

surface of the back-shell among the ribs, from the second to the fifth. It is very thin, and passes to the external margin of the third bone of the shoulder, which seems to correspond with the scapula.

A muscle analogous to the *levator scapula*, is inserted into the curve, formed by the joint of the two first bones of the shoulder. It arises by seven fleshy heads from the transverse processes of the seven vertebræ of the neck.

Another little long muscle arises from the inner surface of the back-shell near the sternal extremity of the first rib, and is inserted into the dorsal extremity of the first bone of the shoulder. It is perhaps analogous to the *costo-clavius*.

ARTICLE III.

Of the Bone of the Arm.

A. In Man.

THE arm is formed of a single bone, called the *humerus*, which is joined to the shoulder and forearm. It is received, at one end, into an articular cup belonging to the scapula, in which it moves in every direction. It is a long bone, but we shall only here consider its superior articulation, or scapular extremity. It terminates

nates in a rounded convex and oblique portion, called the *head* of the humerus. This part is distinguished from the rest of the bone by a little circular depression called the *neck*. There may be likewise observed two processes, but not very prominent. The posterior one, on account of its being larger, is called the *great tuberosity*, (*trochiter*;) the anterior, being less, is called the *little tuberosity*, (*trochin*.) The seeminences are separated by a sort of canal, or longitudinal groove, in which the tendon of the *biceps*, or *scapulo-radialis* muscle, slides. The head of the humerus is retained in the articular cavity of the scapula by a ligamentous capsule, which rises from the bony and cartilaginous edges of the cavity, and extends to the neck of the humerus. The tendon of the biceps muscle, which penetrates into this articulation, produces, likewise, the effect of a ligament. The middle part of the bone is nearly cylindrical; but there are some eminences towards the scapular extremity, for the insertion of muscles. The bone becomes longer and flatter toward the cubital extremity, which we shall explain in treating of the articulation of the fore-arm.

B. In other Mammiferous Animals.

In all classes of animals whatsoever the humerus is simple. It varies little in its form;
and

and as to its proportion with the rest of the anterior extremity, we may remark, that, in the mammalia, it is shorter according as the metacarpus is longer. In the animals that have *cannon bones*, or a cylindrical metacarpus, the humerus is almost entirely concealed under the skin of the thorax. It is very long, in proportion to the body, in *bats* and *flotbs*.

The *guenons* have the humerus more arched towards the back part than man. Its spines are so sharp that its superior part becomes a triangular prism. The great tuberosity rises much above the head of the bone.

In the *pongo* and the other *monkies*, it resembles the same bone in man, but is sometimes longer or shorter.

The large *Sarcophaga* have the humerus arched, with the head elevated considerably above the axis of the bone. The great tuberosity is very broad, flat, and rises above the head.

The rest, and the Rodentia, and Edentata, also exhibit no difference that is very perceptible, except in the proportional length of the bone, and the elevation of its spines. In the *beaver*, for example, it is much enlarged at the cubital extremity, and bears, at about one third from the top, a large transverse process. Its figure is triangular.

In the *bog*, the *tapir*, and the *rhinoceros*, the great tuberosity is divided into two parts. The

linea aspera in the last, is terminated below by a very high tubercle.

It is likewise found, though smaller, in the *borse*, in which the little tubercle has also a channel.

The Ruminantia, in general, have the great tuberosity very high, and the linea aspera very prominent. In the *camel* the little tuberosity is the highest, and hollowed out into a canal.

In the Cetacea the humerus is extremely short, rounded at the top, and has, on its external surface, a small tuberosity.

The Mole has the most singular humerus of all mammiferous animals. It is not only articulated to the scapula by a little head, but by another, which seems to appertain to the great tuberosity, with a surface upon the clavicle. Between the latter and the head of the bone there is a deep hollow. The crest of the little tuberosity is so large that it resembles a square placed vertically, with the linea aspera at top. The rest of the body of the bone, which is very short, is bent towards the top, so that the part which articulates with the fore-arm points directly upward. From this construction it follows that the elbow is elevated above the shoulder, and the palm of the hand turned outward, which is necessary for the mode of life of this animal,

C. In

C. *In Birds.*

The humerus in birds is articulated at once with the scapula and clavicle by an eminence resembling a portion of a wheel, which is situated almost in the plane of the two spines. Behind the internal spine, under the head of the bone, there is a deep cavity. The external spine is thin, and very prominent; the internal is shorter, and more obtuse.

In general, the humerus is cylindrical in birds, towards its middle part, except in the *manchot*, which has it so singularly compressed from left to right, that, at its radial extremity, the two bones of the fore-arm are articulated one over the other in the same line.

In the *ostrich* the humerus is very long, and curved in the direction of the curvature of the sides. It is very short in the *cassowary*.

D. *In Reptiles.*

The humerus of the *tortoise* has a very remarkable shape. As in birds, it is articulated at once to the scapula, clavicle, and os furciforme, by a large oval head, the greatest diameter of which lies in the direction of the flatness of the bone. A considerable eminence rises above this large head, which, by its curvature and its uses, has some relation to the olecranon—a process which, in this animal, the bone of the fore-

arm wants. Below the head there is another eminence, less projecting, but more rough, which likewise serves as a point of insertion to some muscles, and supplies the place of the little tuberosity. The rest of the body of the bone is flattened and narrowed towards the middle.

In the *crocodile*, the humerus is round, but a little bent like an S in its whole length. At the extremity that joins the scapula, it resembles the *tibia*: Its head, instead of being round, is flat; and its tuberosity, which is single, is anterior, in the form of a ridge, and somewhat inclined inwards.

In the other *lizards*, and in *frogs*, the humerus exhibits nothing peculiar.

Serpents, having no limbs, have consequently no humerus.

ARTICLE IV.

Of the Muscles of the Arm.

A. In Man.

THE human humerus is put in motion by muscles, of which some arise from the trunk, and others are attached to the scapula.

The former are:

I. THE PECTORALIS MAJOR, or STERNO-HUMERALIS.

It rises from the sternum, the sternal portion of the clavicle, and the seven first ribs. It covers
the

the breast in front, and is inserted into that part of the *linea aspera* which forms the exterior border of the bicipital groove. It brings the humerus forwards and inwards in whatever position it may be. It also turns it round upon its own axis.

2. THE LATISSIMUS DORSI, *or* LUMBO-HUMERALIS.

This muscle extends from the *os sacrum*, the crest of the *os ilium*, the spinous processes of the lumbar vertebræ, the seven last dorsal vertebræ, and the four last vertebral ribs, to the posterior and inferior part of the small tuberosity of the humerus, below which its tendon is inserted, broad and thin. This muscle covers the back part of the trunk; its use is to move the humerus backward, and somewhat downward.

The latter are divided into two kinds.

a. Those which arise from the surface of the scapula.

1. THE SUPRA-SPINATUS, *or* SUPRA-SCAPULOTROCHITERUS,

Is situated in the supra-spinal fossa. Its tendon passes above the articulation, and is inserted into the great tuberosity of the humerus, which it elevates.

2. THE INFRA-SPINATUS, *or* SUB-SCAPULOTROCHITERUS.

This muscle occupies the fossa below the spine. Its tendon is inserted into the anterior

surface of the head of the humerus, which it rolls outward upon its axis.

3. THE SUB-SCAPULARIS, *or* SCAPULO-TROCHINEUS,

Is attached to the whole costal surface of the scapula, and its tendon is inserted into the little tuberosity of the humerus, which it rolls inward upon its axis, and draws it at the same time towards the body.

b. Those which arise from the eminences of the scapula :

1. THE DELTOIDES, *or* SUB-ACROMIO-HUMERALIS.

This muscle arises from the whole inferior edge of that half of the clavicle next to the scapula, from the acromion, and part of the spine of the scapula. It is composed of several penniform and radiated bellies, uniting in one common tendon, which is inserted into the internal linea aspera of the humerus, about one-third of its length from the scapula, and more outwardly than the pectoralis major. It is the most powerful elevator of the arm.

2. THE TERES MINOR.

This seems to be a portion of the infra-spina-tus. It rises from the inferior edge of the scapula, and is inserted into the external surface of the head of the humerus.

3. THE

3. THE TERES MAJOR, *or* SCAPULO-HUMERALIS,

Arises from the inferior or costal angle of the scapula, and passes somewhat below the head of the humerus to its internal surface. Its actions accord with those of the preceding muscles.

4. THE CORACO-BRACHIALIS, *or* CORACO-HUMERALIS,

Extends from the coracoid process, where it rises by a tendon common to it and the coracoid head of the biceps, to the middle of the humerus, in the direction of which it passes along its internal surface. This muscle raises the arm towards the shoulder, and in some cases may move the scapula upon the arm.

B. *In other Mammiferous Animals.*

All the muscles of the humerus are found in the mammalia, but with some modifications.

The *pectoralis major* is generally more fleshy than in man, and composed of more distinct fasciculi.

In *monkeys* the clavicular portion extends to the linea aspera, and also lower down. The fibres of the sternal portion pass in three divisions.

There are besides two costal portions; one anterior and greater, which is inserted into the great tuberosity; the other posterior and less, which is inserted into the neck of the bone

below the head. This muscle, therefore, seems to be composed of three, four, or five others.

In the mammalia that have not the clavicle perfect, and in the *dolphin* also, there is first a sternal portion, which runs perpendicularly to the linea aspera, forming with its fellow on the opposite side a muscle common to both arms; it is this which produces the crossing of the four legs: it may be called, *AMBIBRACHIALIS COMMUNIS*.

In the Carnivora, in general, this muscle is subdivided into several portions, part of which is extended to the lower part of the humerus, tending very obliquely backward. This common muscle is also found in the Ruminantia. The *sheep* has, besides, a second *musculus communis*, totally different, which extends from the sternal region to the cubitus, and thus completely encloses the humerus in the trunk. It seems to have more relation to the panniculus carnosus than to the pectoralis major. In the *horse*, this latter is called by hippotomists the *ambibrachialis communis*, and produces a kind of crossing of the fore legs.

A second portion of the *pectoralis major* is much larger, and more deeply seated than the common muscle, arises from the whole length of the sternum, and passing obliquely, is inserted near the humerus; even this is sometimes divided into several fasciculi.

The *latissimus dorsi* of quadrupeds differs but little

little from the human, but those animals have one muscle more; for the *panniculus carnosus*, or *cutano-humeralis*, produces a very remarkable tendon, which is inserted into the humerus, close by that of the *latissimus dorsi*. It unites with the tendon of the *teres major*, and affords an attachment to one of the portions of the *extensor cubiti*.

In the *dolphin*, there is a little muscle, the direction and use of which appears to be the same with those of the *latissimus dorsi*; but it arises by digitations from the ribs. It is entirely covered by the dorsal part of the *panniculus carnosus*.

The *supraspinatus*, *infraspinatus*, *subscapularis*, *teres major* and *teres minor* muscles, differ from those of mankind no otherwise than in their proportion, which corresponds with the figure of the scapula.

The *supraspinatus* is generally larger than the *infraspinatus*; the contrary occurs in man.

In the *dolphin*, these muscles, except the *subscapularis*, are indistinct and nearly obliterated.

It has already been shewn, that in animals which have not the clavicle perfect, the clavicular portion of the *deltoid* is united to that of the *trapezius*. We have now, therefore, only its scapular portion to describe.

This scapular portion seems itself divided into two parts; one proceeding from the acromion, and the other from the spine, or, more frequently,

ly, from the infra-spinous portion of the scapula. They unite, intermix crossways, and form a common tendon, which is inserted into the linea aspera of the humerus.

In the *sheep* the acromial part is very small, and there is none at all in the *horse*. The *deltoides*, therefore, which in this animal takes the same direction as the infra-spinatus, is called the AEDUCTOR LONGUS BRACHII.

The *coraco-brachialis* exists even in those animals that have no coracoid process, and arises from a little eminence of the superior border of the scapula. Its tendon is common with that of the head of the biceps, which rises from the coracoid process in those which have the biceps really with two heads.

Monkeys have the *coraco-brachialis* divided into two portions, the inferior of which extends the whole length of the posterior and internal surface of the humerus.

In the *bear* the inferior portion is slender, and proceeds to be inserted at the external condyle. It sends off, from its middle, a slip which joins the biceps, and resembles its coracoid head.

In the *dog*, the *cat*, the *rabbit*, and the *horse*, the *biceps* has only one head, and the *coraco-brachialis* consists only of one part, which is totally unconnected with the biceps.

In the *mole*, the *pectoralis major* is of an extraordinary thickness, and almost as large as in birds. It is composed of six portions, all inserted
into

into the anterior surface of the square part of the humerus. Four of these portions arise from the sternum, and are inserted into different edges and angles of this square surface; the fifth rises from the sternum, and covers the whole surface; and finally, the sixth proceeds transversely from one humerus to the other.

The *latissimus dorsi* is considerable. It is divided into two portions, and inserted into the posterior surface of the square part of the humerus. The *teres major*, which is inserted at the same place, is of an enormous bulk. It is by the means of these three muscles that the animal is enabled to dig and push the earth backward. The other muscles of the humerus exhibit nothing singular in the *mole*, except what arises from the peculiar figure of the bones.

In the *bat*, the muscle analogous to the *pectoralis major* is composed of three portions, or rather of three distinct muscles.

One, situated as usual, extends from the salient line of the sternum to the head of the humerus, which it covers, and is inserted into the great anterior tubercle.

The second rises from the whole length of the clavicle and the anterior part of the spine of the sternum. It is inserted behind the great tubercle, above the preceding, and assists its action in the motions of the wing.

The third is partly covered by the first: it arises from the last ribs, near their sternal cartilages.

tilages. Its fibres ascend almost perpendicularly below the arm-pit, to be inserted into the spine of the humerus, which is, in this animal, very long.

The *latissimus dorsi* is only a fleshy band, which arises from the spinous tubercles of the two last dorsal vertebræ. It has some connection with the *trapezius*, and uniting its tendon to that of the *teres major*, it is inserted into the humerus in the hollow of the arm-pit.

The *supra* and *infra-spinati*, as well as the *sub-scapularis*, present no variety worthy of notice.

The *deltoides* has no connection with the clavicle, unless, indeed, we consider the second portion of the *pectoralis major* as making a part of it: it extends over the whole external surface of the scapula, where it forms two portions: the inferior is more thin than the other. They reunite in a tendon, which passes over the joint, and is inserted into the spine of the humerus.

There is no *teres minor*. The *teres major* has nothing remarkable. Its tendon unites with that of the *latissimus dorsi*.

The *coraco-brachialis* is wanting.

C. In Birds.

Birds have three pectoral muscles, all attached to their very large sternum, and acting upon the head of the humerus.

1. THE PECTORALIS MAXIMUS.

This weighs more than all the other muscles of a bird's body together. It rises from the os furciforme, the keel of the sternum, and from the last ribs, and is inserted into the very prominent linea aspera of the humerus. It is by means of this muscle that birds exert the sudden and violent motions of the wings which are necessary for flight.

2. THE PECTORALIS MEDIUS of *Vicq. D'Azyr*.

This muscle is situated in the angle formed by the body and keel of the sternum, and in the interval between the fork and the clavicle. Its tendon passes through the hole formed by the union of the fork, clavicle, and scapula, as if it went over a pulley, and is inserted into the humerus, which it raises. By this pulley nature has been enabled to place a levator at the lower part of the trunk, and thus bring the centre of gravity farther down, without which the bird would have been liable to overset in the air.

3. THE PECTORALIS MINIMUS of *Vicq. D'Azyr*,

Arises from the lateral angle of the sternum, and the base of the clavicle: it is inserted under the head of the humerus, and brings this bone close to the body.

There are, besides, two little muscles attached to the internal surface of the top of the clavicle.

They

They are inserted into the great inferior tubercle of the head of the humerus, which they draw towards the trunk.

The *latissimus dorsi* of birds is formed of two parts. The anterior extends directly to its insertion in the posterior surface of the middle of the linea aspera. The posterior ascends obliquely, to be inserted under the head of the bone. Both are very thin.

Although the scapula has neither spine nor coracoid process, we see muscles analogous to the *supra* and *infra-spinati*, and the *teres major*.

The *deltoides* may be distinguished as divided into a clavicular and scapular part. The latter arises only from about the neck of the scapula. Their insertion is very low down in the humerus.

D. In Reptiles.

The pectoralis major of the *frog* is composed of two portions, placed one above the other. They produce two tendons, which are inserted on each side of the humeral groove.

The *latissimus dorsi* arises from the inferior part of the back, where it is thin. It becomes thicker, and is attached to the broad part of the scapula, which it entirely covers. It is inserted, by a strong tendon, into the internal surface of the
the

the humerus, above one-third of its length from its superior end.

In the *frog* there is neither the *supra* nor *infra-spinatus*.

The *subscapularis*, or *coraco-brachialis*, (for the muscle of which we now speak supplies the place of both,) arises from the internal surface of the scapula, at its junction with the clavicle, and is inserted into the interior part of the humerus, about one-third from the head.

The *deltoid* is formed of three portions. The first, which is the longest, and very slender, proceeds from the anterior part of the sternum. The second arises from the union of the clavicle with the scapula, at the internal surface, runs over the bone above the joint, then sends a thin tendon to the first, in its passage, and is partly inserted in the linea aspera, and partly in the inferior portion of the humerus. The third is distinct: it rises partly from both the scapula and clavicle, and is inserted into the scapular extremity of the humerus.

The *teres major* and *teres minor* are wanting.

Besides these muscles, in which we discover an analogy to those of mammiferous animals, there is one which arises from the second transverse branch of the sternum, and is inserted into the inner edge of the groove of the humerus by a broad tendon. It may be regarded as an *assistant to the pectoralis major*.

This conformation appears to prevail in the *salamander*.

If the *tortoise* has fewer muscles proper to the shoulder than common, it has an extraordinary number inserted into the humerus.

That which corresponds to the *pectoralis major* is composed of five portions.

Two are superficial; one arises from the edge of the anterior part of the breast-plate, and proceeds to its insertion in the lesser tubercle of the humerus. The other is much more extensive: it rises from a great part of the internal surface of the breast-plate, and is also inserted, by a flat tendon, into the lesser tubercle of the humerus; but it is prolonged, by a fan-like aponeurosis, which extends over the inferior surface of the arm, and even the fore-arm.

One of the three deeper portions of the *pectoralis major* arises from the greater part of the second bone of the shoulder, and is inserted into the humerus, below its scapular articulation; another rises from the expansion of the interosseous ligament, which unites the second bone of the shoulder to the third, and proceeds to join its tendon intimately with that of the preceding portion. Lastly, the third, which is the most deep seated of all, arises from the superior surface of the third bone of the shoulder, or that which is next the back-shell. Its tendon is conjoined with those of the preceding.

The

The muscle analogous to the *deltoides* is also composed of two portions; one arises from a ridge on the anterior part of the breast-plate; the other, which is its accessory, is placed more deeply, and united to its corresponding muscle. They are inserted, by one common tendon, into the lesser tubercle of the humerus, which they draw towards the neck in the action of swimming.

There is another muscle much deeper seated, which seems likewise an assistant to the *deltoides*. It rises from the dorsal extremity, and all the internal edge of that bone of the shoulder which corresponds with the clavicle, and proceeds to be inserted in the humerus below the lesser tuberosity.

On the internal surface of the humerus we find a muscle rising from the loose extremity of the sternal face of the third bone of the shoulder: it is inserted in the humerus, about one-third from its lower end, by a thin tendon. It bears some relation to the *sterno-radialis* of the *frog*, and performs the same office.

The *levator brachii* is a very thick muscle, which arises from the third bone of the shoulder, the exterior edge of which it surrounds, and is inserted into the process of the humerus, resembling the olecranon, which it pulls upward and outward.

A muscle analogous to the *teres major*, arises from the neck of the third bone of the shoulder,

externally, and is inserted into the humerus, between the two tuberosities. It pulls the humerus backward.

Another muscle, which seems a substitute for the *latissimus dorsi*, rises from the interior part of the back-shell, to which it is attached obliquely, in the interval between the two first ribs. It is inserted into the body of the humerus, behind the greater tubercle, by a flat tendon. It pulls the humerus toward the upper shell, when the animal stands upon all its four feet.

A muscle, the use of which seems the same as that of the *levator brachii*, rises from the whole internal surface of that bone of the shoulder which answers to the clavicle, and is inserted into the whole length of the olecraniform process, or great tuberosity of the humerus. It is very fleshy, and appears to be formed of two portions.

Finally, the muscle analogous to the *scapulo-radialis*, or *biceps flexor cubiti*, arises from the anterior border of the humeral cavity, and is inserted into the external and superior surface of the humerus by a small tendon, which reaches as far as the base of the radius. It extends the member, and brings it toward the head.

ARTICLE V.

*Of the Bones of the Fore-Arm.*A. *In Man.*

IN Man the lower quarter of the humerus is gradually enlarged by two projecting lines arising from its two sides, which diverge to form considerable tuberosities, named condyles; the internal (*épitrochlée*) and the external (*épicondyle*.) The line on the internal side is the shortest, but its condyle projects most. This portion of the humerus is compressed behind and before; the anterior surface being convex, the posterior flat. The inferior part between the condyles has two eminences which round off this end. The internal, which has the form of a pulley, that is to say, of a circular channel slightly concave, is somewhat oblique, and its posterior extremity larger, and turned more outward: above there is a large depression to receive the olecranon.

The second eminence is simply convex, and terminates posteriorly, exactly below the inferior border of the bone, in such a manner that its extent is only half of that of the pulley.

The *ulna*, which is larger towards the humerus, has a semicircular, or *sigmoid* cavity, which receives the pulley of the humerus, by which it seems to have been moulded. Its posterior edge

is formed by the *olecranon*, and the anterior, which is the most prominent, by the *coronoid process*.

The centre of motion is not in the axis of the humerus, but in that of the ulna, on account of the obliquity of the pulley; so that, in bending the arm, the lower extremity of the ulna is brought nearer the body.

This extremity is not so large as the other; it has a little head with a flat surface, round and prominent at the external side, and presenting a styloid process at the internal.

The bone called *radius* has a round head, with a slightly concave articular surface, answering to the external process, or lesser head of the humerus, and capable of moving upon it as the ulna does upon the pulley. But this head is, besides, capable of turning upon its own centre; this is facilitated by an articular surface of the external edge of the coronoid process of the ulna, upon which the rounded edge of the head of the radius rests. The inferior head, which is much larger, particularly at the external part, has a similar surface, which rests upon the outward edge of the inferior head of the ulna; and as the opposite edge of this inferior head of the radius is farther from the axis of motion, when the superior head turns upon its centre, that edge describes a circle round the little head of the ulna. In this motion the radius carries along with it the hand, which turns, at this time,
upon

upon the femilunar bone that rests upon the little head of the ulna, like a door upon its hinge.

Hence arises the motion of *supination*, when the radius forms the outward edge of the forearm, and the palm of the hand is turned forward; and that of *pronation*, when the radius constitutes the internal edge of the forearm, and the palm of the hand is directed backward.

The ligaments which unite the bones of the forearm to the humerus, and to each other, are of various sorts. There are, in the first place, the articular capsules of the corresponding surfaces: next, there are, on each side of the elbow, two ligaments: one proceeds from the internal condyle, and is inserted into the coronoid process; and the other, proceeding from the external, is inserted into the capsular ligament of the radius. The two bones of the forearm are kept in their places by the interosseous ligament which passes from the ulnar edge of the radius to the radial edge of the ulna, and by a little oblique ligament which extends from the small tubercle of the olecranon to the tuberosity of the radius.

B. In other Mammiferous Animals.

In *monkeys* the bones are arranged in the same manner as in man, except that in the *cynocephalus*, the *mandrills*, the *maggots*, the *guenons*, and some

other species, the coronoid process of the ulna is narrower, and the articular surface of the radius deeper. In the *sapajous*, we generally remark a hole pierced in the internal salient line of the humerus. This bone is often perforated at the bottom of the cavity which receives the olecranon in the extended position. Their ulna is more compressed than the human.

The articulation of the fore-arm of the *Pedimana*, resembles that of the *sapajous*.

The *bat* and the *flying lemur* have no ulna, or, at most, only a rudiment of it, in the form of a style, situated under the radius. It remains distinct until it reaches within a quarter of the length of that bone from the lower end: consequently those animals have no motions of pronation and supination.

In the *Carnivora*, the olecranon is compressed, and extended farther back than in man. The pulley is not concave before, because the articular surface of the radius, increasing with the head of the bone, cuts off too much of the coronoid process.

In the *dog* the head of the radius has a cavity for the little head of the humerus, and a ridge for the furrow that divides it from the anterior part of the pulley. On this account the rotation of the radius becomes obscure. The posterior border of the sigmoid cavity enters into the hole which perforates the bottom of the posterior
cavity

cavity of the humerus. The external linea aspera is more considerable, and the internal has a hole as in the *sapajous*.

Notwithstanding the shortness of the bones in the *seal*, their articulation is the same.

It is the same in some of the Rodentia, as the *paca*, *agouti*, *beaver*, (which last has the linea aspera very prominent.) In others, as the *cavy*, the *hare*, and the *rat*, the coronoid process of the ulna is entirely effaced, and we see nothing but the radius at the anterior part of the articulation. Its head forms a ginglymus, having a cavity for the little head of the humerus, and a ridge for the anterior part of the pulley.

The *marmotte*, the *porcupine*, &c. hold a middle place with respect to the smallness of their coronoid process. These animals have no hole in the linea aspera of the humerus.

The *jerboa* has processes like the *monkey*.

The Pachydermata, as the *rhinoceros*, the *hog*, and the *tapir*, have the radius entirely anterior, and the ulna behind. They move together by ginglymus in a single pulley. The little head of the humerus is quite effaced inferiorly. The radius is at the internal, and the ulna at the external side of the fore-arm. Though these bones are distinct, there is not therefore any possible rotation.

In the *elephant*, the anterior part of the sigmoid cavity, or coronoid process, is divided into two ridges, with hollow surfaces turning upon the

projecting edges of a single pulley. Between them is the head of the radius; it is small, and sustained by the external ridge and middle channel of this pulley; for, as it is oblong, it cannot turn upon it. The inferior part of the radius is directed towards the internal side; the fore-arm is therefore always in a state of pronation. The inferior head of the ulna is greater than that of the radius, and this is the only instance of the kind in mammalia.

In the remaining animals the ulna is only an immoveable appendage to the radius; and its sigmoid cavity a continuation of the articular surface of the head of the radius, which performs only the motion of a ginglymus upon a single pulley.

The ulna is ankylosed with the radius almost its whole length in the Ruminantia. It is only distinguished from it by a furrow, which has, however, a chink at top and bottom in the *giraffe*, *flags*, and some *gazelles*, and at the top only in *cows* and *sheep*, but in no part in the *camel* and *dromedary*.

In the Solipeda we find a furrow with a slit at the top.

The Solipeda, the Ruminantia, and the Pachydermata, have the inferior head of the radius compressed behind and before, and the back of the carpus always turned forward.

From this variety of structure it is obvious that the rotation of the hand becomes more difficult in proportion as the animal uses it less for grasping,

grasping, and employs the anterior extremity more exclusively in standing and walking. Indeed these latter uses require a constant pronation, and a firmness which is incompatible with supination.

For a similar reason *bats* and *birds* are deprived of rotation. If their hand and radius could turn, the resistance of the air would produce that effect at every effort of their wings; the plane of which would then become vertical, and flight be thereby rendered impossible.

Let us now consider some animals whose structure could not be brought within the general view we have taken.

In the *mole*, the position of the humerus is such that its lower head is the most elevated; it happens therefore, that, when the fore-arm is in a middle state between pronation and supination, the elbow is carried upward, the radius and thumb turned downward, and the palm outward. Each condyle has a process in the form of a hook, pointing towards the shoulder. The olecranon is very long, and terminated by a transverse plate. The ulna is a compressed longitudinal lamina. A very strong ligament unites the palmar fascia and the wrist to the internal condyle. The edge of the head of the radius being prolonged under the little head of the humerus, it seems incapable of turning. The hole is found in the internal linea aspera.

In

In the *seal* the ulna is compressed, instead of the great sigmoid notch, there is one surface for the articulation of the humerus, and another oblique one for that of the radius. This has a large head, the internal edge of which runs in the pulley. The body is compressed, and very broad downward. There is a hole in the internal linea aspera, and the olecranon is compressed, high and short.

In the *lamantin* the superior and inferior heads of the two bones are anchylosed together.

In the *dolphin* these two bones are compressed and flat, and seem united by synchondrosis with the humerus and carpus.

They are similar in the *cachalot*, and without doubt in all other Cetacea.

C. In Birds.

The lower end of the humerus is nearly alike in birds and mankind. There are in the same manner between the condyles, two articular processes, of which the external is not a portion of a sphere, but rather a portion of a pulley; so that the radius may easily move upon it, but not turn upon its own centre. That which answers to the pulley is entirely convex and round. The ulna is capable of extension and flexion upon it, by means of a cavity which it possesses. It bears also another lesser cavity upon the external process. The olecranon is very short.

The

The radius, which is slenderer than the ulna, remains parallel to it. Its lower head is less than that of the ulna, and terminates in a triangular surface.

The inferior head of the ulna ends in the segment of a pulley, on which the second bone of the carpus performs the motions necessary for the adduction and abduction of the hand.

The *manchot* has this part somewhat differently constructed. The bones of the wing in this bird are extended in the same plane, like those of fins. The radius and ulna are quite flat, and articulated by arthrodia to two tubercles, placed one above, and the other at the bottom of the anterior edge of the humerus; so that the wing of the manchot is to that of other birds what the thoracic member of the Cetacea is to that of the other mammalia.

D. In Reptiles.

The humerus of the *crocodile* terminates in two round tubercles. The hollow head of the radius turns upon the external one. Between them the round head of the ulna is situated, but it has neither olecranon nor sigmoid cavity. In the upper part it is the largest of the two bones, but the smallest below.

There is nearly the same conformation in the *cameleon*, but the bones are more elongated, and the

the inferior head of the radius is less than that of the ulna.

In the *frog* the single bone of the fore-arm is articulated by a concave head, with a large round tuberosity on the base of the humerus, between its two condyles. On each side, where the lower part of this bone becomes larger, we observe a furrow, which is the only vestige of a distinction into two bones.

The two bones of the fore-arm of *salamanders* are situated one above the other. The ulna, which is the lowest, and somewhat longest of the two, has no olecranon; but there is a sort of rotula in the tendon of the extensor muscles. The ulnar extremity of the humerus is much enlarged. The articular surface which terminates it is convex, and permits the radius and ulna to turn together in every direction.

The two bones of the fore-arm in the *turtle* are always in a forced state of pronation. The radius, which is much longer than the ulna, and fixed to it by a cartilaginous substance, is the lowest, and extends even under the carpus.

These two bones much resemble each other in the humeral extremity, being formed by a single concave surface received upon a correspondent pulley of the humerus. Their articulation is such that it allows them to move together laterally, and a little upward and downward in the action of swimming.

ARTICLE VI.

Of the Muscles of the Fore-Arm.

1. OF THE FLEXORS.

A. *In Man.*

THE ulna, in the human species, has but one kind of motion upon the humerus, flexion and extension.

The flexor muscles are :

1. THE BICEPS FLEXOR CUBITI, *or* SCAPULO-RADIALIS.

This arises by two tendons, one internal, and common to it and the coraco-brachialis, and attached to the coracoid process; it is very short: The other is external, and much longer; it comes from the superior edge of the glenoid cavity of the scapula, and runs over the head of the humerus, into the channel between the two tubercles. The muscle is inserted inferiorly into a tubercle on the ulnar side of the radius, somewhat below its neck.

2. THE BRACHIALIS INTERNUS, *or* HUMERO-ULNARIS,

Is attached to about one third of the lower and anterior part of the humerus, and is inserted
by

by a tendon into a tubercle, before the coronoid process of the ulna.

B. *In other Mammiferous Animals.*

These two muscles are similar in *monkeys*, except that the *brachialis internus* ascends almost to the neck of the humerus.

In the *Carnivora* the *scapulo-radialis* cannot be called biceps, as it has only one head, which arises from the edge of the glenoid cavity of the scapula. In the *bear*, however, the *coracoid* head of this muscle is represented by a little slip sent off to it by the *coraco-brachialis*.

The *brachialis internus* arises from the posterior and exterior part of the humerus, and is situated at the external part of the *scapulo-radialis*. Its insertion is the same as in man.

The same conformation obtains in the *Rodentia*, *Ruminantia*, and *Solipeda*. In the last family, however, the *hippotomists* have given these two muscles the names of *flexor cubiti longus et brevis*.

C. *In Birds.*

In *Birds* the *flexor longus*, which does not exactly correspond to the *biceps*, arises by a long tendon from the scapula, and by a very short one from the humerus, below its inferior tubercle. It is inserted into the ulna. The *flexor brevis*

is

is extremely small; it arises from the internal linea aspera, and passes, after expanding a little, to its insertion in the internal surface of the head of the ulna.

There is, besides, the FLEXOR PROFUNDUS of *Vicq D'Azyr*. It arises from the external condyle, under the supinator brevis, and extending over the superior third of the ulna, is inserted into the part next the radius.

2. OF THE EXTENSORS.

A. *In Man.*

The human fore-arm is extended by the TRI-CEPS EXTENSOR CUBITI, OR OLECRANO-SCAPULARIS, composed of three parts uniting in a common tendon inserted into the olecranon. They are distinguished by different names. The first, which arises from the edge of the scapula, below the glenoid cavity, is called the *extensor longus*. The second, which arises from the posterior surface of the humerus, below the head, is named the *extensor brevis*. Finally, the third, which arises from the external lateral surface of that bone, is denominated the *brachialis externus*.

There is a little bundle of fleshy fibres which come from the external condyle of the humerus, and are inserted into the upper part of the ulna: it assists the preceding muscles, and is called ANCONIUS, OR EPICONDYLO-ULNARIS.

B. *In other Mammiferous Animals.*

In the *monkey* there is a fourth portion, which arises from the common tendon of the *latissimus dorsi* and *teres major*. Besides, the superior tendon of the *extensor longus* reaches almost over the whole inferior edge, or costa of the scapula.

This fourth part is also found in the *Carnivora*; but in these animals the part answering to the *extensor brevis* in man, is divided into several portions, which arise from different points of the humerus. This portion is divided into four in the *dog*, in which the *brachialis externus* is extremely large, and the *extensor longus* occupies the whole posterior edge of the scapula.—In the *cat*, which has the *extensor longus* and *brachialis externus*, like those of mankind, it is divided into two.

Among the *Rodentia*, the *rabbit* has three portions like those of man. There are, besides, that which arises from the common tendon of the *latissimus dorsi*, and *teres major*, and a fasciculus, which, having the same origin as the *extensor longus*, mixes its fibres very high up with the *brachialis internus*.

The *horse* has three portions like man; namely, the *extensor longus*, called, by Bourgelat, EXTENSOR MAGNUS, which is triangular, and very thick; the *brachialis externus*, or EXTENSOR BREVIS; and the *extensor brevis*, or EXTENSOR

MEDIUS

MEDIUS of Bourgelat. There is, besides, the fourth portion, which arises from the common tendon of the latissimus dorsi and teres major, but which appears very evidently to adhere to the edge of the scapula.

The great strength and complication of the extensors of the fore-arm in quadrupeds, have their utility in progressive motion. They perform, in these animals, the same function in the anterior extremity, that the extensors of the heel do in the posterior extremity, and are exerted to carry the body of the animal forward, when the foremost foot is planted on the ground to support it. The Cetacea, in which the two bones of the fore-arm are not moveable upon the humerus, want these muscles.

The little muscle called *anconeus* in man, is found in all the above-named animals.

The *bat* has only one flexor and one extensor muscle to the fore-arm. The superior part of the *flexor* is formed of two fleshy bellies, one of which arises from the upper part of the humeral cavity of the scapula, and the other from the coracoid process. Their common tendon begins about one third of the length of the humerus from its head, and is inserted into the anterior surface of the humeral extremity of the single bone of the fore-arm.

The *extensor* is likewise composed superiorly of two bellies, the tendon of one of which is attached behind, and to the large tubercle of the

humerus, and that of the other to the top of the humeral angle of the scapula. Their fibres join about one third from the top of the humerus; they soon after form a tendon, which passes behind the joint, and is inserted into the olecranon. It contains, in its substance, a kind of rotula.

C. *In Birds.*

Birds have the *extensor cubiti* composed of two portions; one proceeding from the scapula, and called, by Vicq D'Azyr, *EXTENSOR LONGUS*; the other from the humerus, forming the *EXTENSOR BREVIS* of that Anatomist. There is also an *ANCONIUS MINOR*.

3. OF THE SUPINATORS.

The bones of the fore-arm move one over the other, and give to the hand that motion by which the palm is turned upward or downward. These motions are termed *supination* and *pronation*.

A. *In Man.*

Supination in man is performed by two muscles, which are called the long and short supinators.

1. THE SUPINATOR RADII BREVIS, OR EPICONDYLO-RADIALIS,

Arises from the external condyle of the humerus, and the adjacent part of the capsular ligament.

ligament. It proceeds obliquely, and embraces the superior part of the radius, which it turns upon its axis, from within, outwardly.

2. THE SUPINATOR RADII LONGUS, or
HUMERO-SUPER-RADIALIS,

Arises, likewise, from the external condyle, but above the preceding muscle. It produces a thin tendon, which is inserted into the lower head of the radius, which it moves round that of the ulna, from within, outwards.

B. In other Mammiferous Animals.

The *monkey* has precisely the same muscles.

The *bat* has no muscles intended for supination, as that motion would deprive it of the faculty of flying.

The *cat* and *dog* have the *supinator brevis*, but the *longus* is wanting.

The *tapir* has neither. These muscles are likewise wanting in the *Pachydermata*, the *Ruminantia*, and *Solipeda*.

C. In Birds.

These animals have no supinator muscles.

4. OF THE PRONATORS.

A. *In Man,*

Pronation is performed by two muscles.

1. THE PRONATOR RADII TERES, *or* EPITROCHLO
RADIALIS,

Is situated opposite the supinator brevis. It arises from the internal condyle of the humerus, and is inserted into the interior and superior part of the radius.

2. THE PRONATOR RADII QUADRATUS, *or*
CUBITO-RADIALIS,

Is extended directly between the inferior or carpal quarter of the ulna and radius, upon their internal surface.

B. *In other Mammiferous Animals.*

The *monkey* and the *Carnivora* have these two muscles disposed in the same manner.

The *bat*, which has only one bone of the fore-arm, or only a rudiment of the ulna, wants the *pronator* muscles.

The *rabbit* has only the *pronator teres*, the action of which is very much confined on account of the immobility of the radius.

The *Ruminantia* and *Solipeda* have no *pronators*.

In the *Cetacea*, which have not the fore-arm
moveable

moveable upon the humerus, there are no muscles calculated for supination or pronation. Some aponeurotic rudiments of muscles are merely expanded over the whole surface of the bones, and strengthen their articulations.

C. In Birds.

Birds have two muscles which occupy the place of the *pronator teres*, and have similar insertions; they seem to act as flexors.

There is also a small one instead of the *supinator brevis*, which seems intended to bend the fore-arm, so that their uses are totally changed.

5. MUSCLES OF THE CUBITUS IN REPTILES.

The *frog* has, properly speaking, no *biceps*: Its place is supplied by another and much stronger muscle situated on the breast under the *pectoralis major*, with which it has the same insertions. At the articulation of the humerus it sends out a strong tendon, which passes along the groove of the humerus, and through a tendinous ring formed by the two parts of the *pectoralis major* under the *deltoides*. It is inserted into the humeral extremity of the radius, and may be named STERNO-RADIALIS.

There is no *brachialis internus*.

The *triceps* is composed of three parts, nearly as in man, but they are proportionably larger.

There is but one *supinator*, which arises from the external condyle, and is inserted into the carpus.

There is also but one *pronator*, which rises from the internal condyle, and is inserted into the carpus.

In the *turtle* these muscles are almost entirely aponeurotic, and produce but very little motion, the place of the member being supplied by a fin as in the Cetacea. In general the muscles of the humerus produce the motions of the fore-arm.

ARTICLE VII.

Of the Bones of the Hand.

THE hand is composed of a great number of little bones, which render the smallest parts extremely moveable. Some are situated in the superior part, or that adjacent to the fore-arm. These are called the bones of the carpus or wrist.

I. OF THE BONES OF THE CARPUS.

A. *In Man,*

They are little, and present several surfaces which correspond to each other at the points of their articulation. They are disposed in two
ranges,

ranges, each composed of four bones; the first range is articulated to the depressions at the extremities of the radius and ulna. The radius opposes to them a large surface, truncated towards the ulna, and somewhat hollow, bearing a point on the internal side. The articular surface of the ulna is considerably smaller.

Two of the little bones of the first range are joined to the radius; one of them is called the *scaphoides*, and the other the *lunare*. A third articulates with the ulna, and is called the *cuneiforme*. This last bears upon its inside, near its ulnar border, a little round bone which projects towards the palm of the hand, and is called *pisiforme*, or *inordinatum*, according as it is considered with respect to its form or its situation.

These three bones of the first range, which are articulated to the fore-arm, are retained in their situation by a very loose capsular ligament, which contains within it an interarticular cartilage of a triangular form. Ligamentous fibres also extend to the cuneiform bone. These arise from the articular depression of the ulna; and are called the *external transverse ligament*. There are two other ligaments nearly similar, on the inside, which come from the styloid process of the radius; the one is inserted into the scaphoides, and the other into the tubercle of the semilunar bone.

In the second range of the carpal bones two are articulated to the scaphoides. These are the *trapezium*, which supports the first phalanx of the

the thumb, and has a sharp eminence within the palm of the hand; and the *trapezoides*, to which the metacarpal bone of the index is articulated. The next is the *os magnum*, which is articulated both to the scaphoides and lunare, and sustains the metacarpal bone of the middle finger, and a small part of that of the ring finger; the last is the *unciforme* or *hook-bone*, which is articulated to the *os cuneiforme*; it supports both the ring finger and the little finger, and produces towards the palm of the hand a large process in form of a hook.

The carpus moves upon the fore-arm both forward, backward and sideways; but though the motions of its parts, with respect to each other, and the metacarpus, are quite complete, they are scarcely apparent. This mechanism produces great delicacy of movement in the bones of the carpus; yet such is the effect of their union, that the whole hand may be moved by a single muscle inserted into one of the bones that compose it.

A capsular ligament unites the first range of the bones of the carpus to the second, and another joins these to the articular bases of the metacarpal bones. The other ligaments of the carpus are fitted to unite together, in different modes, all these bones. Their figure and direction are therefore very various.

B. *In other Mammiferous Animals.*

The carpus of the *monkey* has one bone more than that of man. It is situated between the bases of the pyramidal and great bone. It seems to be produced by a division of the trapezoid. The os pisiforme is more prominent, because it is longer, and serves as a heel to the hand of this animal.

There are, besides, almost always certain ossified points in the tendons of the muscles, which are commonly considered as supernumerary bones. There are two, for instance, in the *gibbon* and the *maggot*; one in the tendon of the ulnaris externus, upon the joint of the pisiform and the cuneiform bones; the other without the range on the edge of the scaphoides and trapezoides. In the *sapajous* the former is wanting.

In the *rouffette*, or *ternate bat*, there are two bones in the first range, namely, a large one belonging to the radius, and a very small one answering to the ulna: the four ordinary bones are found in the second range: the third bone, which corresponds with the second finger, has a very large surface towards the inner part of the hand.

In the Carnivora in general; but especially in the *dogs*, *cats*, *hedge-hogs*, *shrews*, *bears*, and *seals*, the scaphoid and lunar bones only form a large single bone by their junction. In the *cats*
there

there is at the internal edge of the carpus a little supernumerary bone resembling the pisiforme in man, but situated at the opposite side. The pisiforme in the Carnivora is very long, and serves as a sort of heel to the anterior feet. This last peculiarity does not occur in the *seals*.

The bone analogous to the *os magnum* in man, is very small towards the back of the carpus. These that have only a rudiment of the thumb, as the *hyæna*, have the trapezium very small.

The same rule applies to the *glutton*; but that animal has also a styloid appendix to the carpus, situated below the *os scaphoides*.

In the *mole* there are the same nine bones as in the *monkey*, and, another similar to the blade of a scythe, with which the radial border of the hand is furnished throughout its whole length: This bone causes the great size and shovel-like figure of that member, which suits the habits of the animal. The *mole* has, besides, this singularity—its toes are very short, covered by the skin and the great-toe nails only visible on the outside.

With respect to the Rodentia, the *hare* has bones like the *monkey*; but the *beaver*, the *marmot*, the *squirrel*, and *rats*, have, like the Carnivora, a single bone for the *scaphoides* and *lunare*. The supernumerary bone is as large as the common pisiforme, and often larger. It sometimes supports a second supernumerary bone, as in the *jerboa* and *marmot*; so that on each side
of

of the range there is an irregular bone of equal magnitude.

The pyramidale in the Rodentia is, in general, divided in two, as in the *monkey*. The *porcupine* differs only in this, that the pyramidal bone is not divided, and that there is a supernumerary bone between the pisiforme and the metacarpal bone of the fifth toe. It is attached to the os unci-forme.

In the Cavys, the scaphoides and the lunare are united without any supernumerary bone. There is, however, a small supernumerary bone in the *guinea-pig*. The os pyramidale is not divided in the *paca* and *agouti*, though in the *cavy*, properly so called, as well as in the guinea pig, it is divided. In both these animals the only vestige of the thumb is a small bone situated upon the trapezium, with which it is articulated. This rudiment of the thumb consists of three small bones in the *marmotte* and the *agouti*.

The *two-toed ant-eater* has four bones in the first range of the carpus; two radial, one ulnar, and one long pisiforme without the range. There are only two bones in the second range; they correspond with the second and third fingers. On the radial edge of the first there is the vestige of a thumb formed of a single piece. On the ulnar extremity of the other there is a half-articulated vestige of the ring finger: there is also a much smaller bone in a single piece, which is the rudiment of the little finger.

The

The *three-toed sloth* has only five bones in the carpus; three in the first range, the pisiforme being wanting; and only two in the second.

The carpus of the *pangolins* appears to have seven bones, like that of the Carnivora. The *nine banded armadillo* has eight, and a rudiment of the little finger.

The carpus of the *elephant*, like that of man, has eight bones, but they have a different configuration. The pisiforme is elongated: the others are cuneiform.

Among the Pachydermata the *hog* has, in the first range, four bones similar to those of man; but in the second range the trapezium is very small, and no vestige of the thumb appears upon it: it is the same with respect to the *tapir*, whose fore-foot differs from that of the hog only in the lateral toes being larger. The structure of that foot is exactly similar in the *hippopotamus*.

The *Rhinoceros* has only three toes; but as the pyramidale, the os magnum, and the unciforme, belong each to one of the three, the trapezium only is wanting. There is, however, a supernumerary bone on the edge of the scaphoides, and one on that of the unciforme, as in the *porcupine*.

The Ruminantia have the four bones that usually belong to the first range; but they are more narrow in proportion to their length. Most of them have two in the second range. The *camel*,

however,

however, has three. The Solipeda have four in the first range, and three in the second.

The bones of the carpus in the *dolphins* and other Cetacea, are very much flattened, almost all of a hexagonal figure, and form by their union a compact surface resembling a pavement. There are three bones in the first range, and only two in the second.

2. OF THE BONES OF THE METACARPUS.

Each of the fingers is supported at its base by a long bone which is united with similar bones belonging to the other fingers, in such a manner as to form with them only very obscure motions. These are called the *metacarpal bones*.

A. In Man.

The thumb, which has only two phalanges, is the only finger the metacarpal bone of which is capable of a considerable separation and approximation with respect to the others. The other metacarpal bones cannot be separated beyond the extent at which they are fixed by the ligaments between them, called the *inter-metacarpal ligaments*. These bones are besides fastened to those of the second range of the carpus, by a number of articular ligaments, which are divided into the *palmar*, the *sub-palmar*, and the *lateral*.

At

At the digital extremity of each metacarpal bone there is a smooth tubercle, which receives the first phalanx of each finger. The carpal extremity exhibits several surfaces, of which the principal one corresponds with the bones of the carpus, and the other smaller and lateral ones with the nearest metacarpal bones. These bones are almost straight in man.

B. *In other Mammiferous Animals.*

The Mammalia in general have as many bones in the metacarpus as they have toes: In the Ruminants and Solipeda, however, the two metacarpal bones are, at a very early period, united into one bone, called the *cannon bone*.

The length of the metacarpal bones varies in proportion as the animal walks more or less on the extremities of the toes, or as it uses the anterior feet, like a hand, to seize objects.

The whole of the metacarpus is elevated, and forms what is vulgarly called the fore-foot, in dogs, horses, sheep, &c.

In the *three-toed sloth*, the three metacarpal bones are united into one at their base, and there is joined to them the rudiment of a fourth bone; at least this is the case with the adult individual preserved in the Museum.

The bones of the metacarpus are likewise intimately joined together, and are exceedingly flat in the Cetacea.

III. *The*

3. OF THE BONES OF THE FINGERS.

The fingers are the free and moveable parts which terminate the hand.

A. *In Man.*

They are five in number. Each of them, the thumb excepted, is composed of three phalanges, the first of which, or that which articulates with the metacarpal bones, is the longest. The smallest is that which terminates the finger, and which bears the nail (*unguinal.*) It is easy to distinguish the phalanges from one another. The base of the first has a smooth oblong articular cavity, which corresponds with the digital extremity of the metacarpal bones. In the second the articular surface of the base is composed of two small fossæ, separated from each other by a little projecting eminence. Finally, the last phalanx is terminated by a scabrous and inarticular surface.

These three bones gradually diminish in thickness, but they are nearly straight throughout their whole length. They have an articular capsule and lateral ligaments at each of their extremities. There are, besides, a number of ligamentous fibres and vaginae, by which the tendons of the muscles of the hands, inserted in those bones, are preserved in their proper position.

B. *In other Mammiferous Animals.*

If we include the rudiments, which are sometimes very imperfect, and frequently concealed under the skin, there are never less than three, nor more than five toes, on the anterior feet of the Mammalia.

The Solipeda have two imperfect and one perfect, in all three.

The *rhinoceros* has three perfect.

The Ruminantia, two imperfect and two perfect, in all four.

The *tapir* and *hippopotamus* have four perfect.

All animals with claws have five, reckoning the perfect and imperfect.

Every perfect finger has three phalanges, except the first, on the side of the radius, or the thumb, which never has more than two. These phalanges are capable of complete flexion, but none of them can be extended beyond a right line, except the first, and, in some species, the last.

The Quadrumana, like man, have the thumb separate, and capable of being opposed to the other fingers. In this consists the real characteristic of the hand; but the human thumb is always longer, in proportion to the other fingers, than that of the Quadrumana, whose hand, in this respect, does not possess the perfection of ours. It is even obliterated, and concealed under the skin, in the *coaita* (*Simia paniscus* Linnæi.)

The last phalanx, or that on which the nail is placed,

placed, is less flat and more pointed than that of man. The bones of the metacarpus and the first phalanges, are also much more curved towards the palm of the hand.

The *rouffets* and *common bats* have the phalanges exceedingly long, particularly the last, which are very much pointed, and have no nails. The thumb, however, is not subject to those deviations. It is short, and has a nail.

In the *Carnivora*, the thumb remains parallel to the other toes; by this conformation, these animals are deprived of the faculty of pinching, or seizing small objects. In the *seal* the great toe is longer than the others; it is almost of an equal length in the *bears*, *badgers*, *racoons*, and *coatis*. The *opossums* have it a very little shorter.

It is obviously shorter in *weasels*, *civets*, *cats*, and *dogs*.

It is obliterated and reduced to a single phalanx in the *hyaena*.

The form of the last and second phalanges is very remarkable in the family of *cats*, the individuals of which have the power of raising their claws, lest they should be blunted by remaining on the ground while they walk.

The second phalanx is triangular. Two of its surfaces are lateral, and one inferior. The internal lateral surface, or that which is next the thumb, exhibits a kind of twist, in consequence of which the middle part is rendered oblique, and as it were hollowed.

The third phalanx, or that to which the claw is attached, is still more singular in its form, its articulations and its motions.

The figure of this phalanx is that of a hook, consisting of two parts; one part which is directed forward, and is curvated, cutting and pointed, receives the claw, the form of which is nearly the same. The base of this first portion forms a kind of osseous hood, into which the base of the nail is received as in a sheath, but in such a manner that it cannot be pushed backward. The second part of the hook is situated posteriorly. It rises almost vertically, and is only articulated at its most inferior part. It is prolonged beneath the articulation in two appendices, to which are attached the two muscles that project the claw, and bend the phalanx—motions which take place at the same time. The articulation of this bone is indeed so disposed, that, upon its extension, which takes place greatly beyond a right line, it experiences an inversion by being turned upwardly and posteriorly on the second phalanx, towards the internal or radial side. In this situation the lateral depression of the second phalanx serves to receive the third, and the point of the claw far from touching the ground is directed upward.

This inverted position is the state of inaction. The phalanx is preserved in it by the articular capsule, and two lateral ligaments which proceed from the second phalanx.

A perfect thumb is found in the family of the Rodentia. It is however short in the *bears*, *beavers*, *jerboas*. *Squirrels*, *rats*, *porcupines*, the *paca*, the *agouti*, &c. have a diminished thumb, with two phalanges. Finally, the *cavy*, the *guinea-pig*, the *marmot*, &c. have a thumb nearly obliterated, of which only a single rudiment remains. In general the last phalanges are very narrow, long, almost straight, and pointed. The great *cavy* forms however one exception. In it the last phalanges are triangular, and enveloped in a real hoof.

The Edentata exhibit many variations with respect to the number of the toes in the anterior feet. The *tamanoir* or *great ant-eater*, and the *four-toed ant-eater*, have the thumb obliterated. The thumb and the little toe are both obliterated in the *three-toed sloth* or *ai*, in which a number of other very remarkable particularities are observable. Its three perfect toes are often intimately united together at their bases with the metacarpal bones; this very much limits their motion: besides, each of the toes consists only of two phalanges, the articulations of which, both with the bones of the metacarpus, and with each other, take place by pulleys that have very narrow and deep grooves. This construction renders lateral motion absolutely impossible. Finally, the last phalanx is much longer than the first. It is covered by the nail throughout almost the whole of its length, and has at its base

a kind of osseous sheath or hood, which is much deeper on the inferior than on the superior part.

The thumb, the index, and the little finger, are obliterated in the *two-toed ant-eater*, and in the *unai*, or *two-toed sloth*.

The *elephant* has five perfect toes; but the whole five are almost entirely concealed under the thick skin which envelopes the foot.

In the *hoofed* animals, that have four toes, as the *hog*, the *tapir*, and the *hippopotamus*, we also observe a small bone which is the rudiment of the thumb. The two lateral toes of the *hog* are short, and do not touch the ground: they are however perfect with respect to the number of the bones of which they are composed. In those animals the last phalanx is set into the interior of the horn which terminates the foot.

The Ruminantia, as we have observed, have only one metacarpal bone, which supports the two toes that form what is commonly called the cloven-foot. Several species have also, at the roots of the two perfect toes, two little bones, which are frequently covered with small nails, and which represent two other toes. The last phalanx of each toe is always of a triangular figure. Two of the surfaces are lateral; the internal being plane, and the external convex.

In the *horse*, and the other Solipeda, the only vestige of the lateral toes are two sharp-pointed bones growing on each side of the cannon-bone. The three phalanges of the only toe that exists,
are

are called the *pastern*, the *coronet*, and the *coffin bone*. This last phalanx has the form of a hoof. It is rounded, flat inferiorly, and convex superiorly.

The Cetacea have all the phalanges flattened, united in the form of a fin, and frequently cartilaginous. Such, in particular, is the case with respect to the *porpoise*, the *dolphin*, and the *cachalot*.

4. OF THE BONES OF THE HAND IN BIRDS.

There is only one row of bones in the carpus of birds; the second appears to be ankylosed with the part which represents the metacarpus.

This row of the carpus consists only of two bones. The one, which is radial, and of a rhomboid form, prevents the metacarpus from being too much extended. The other is ulnar, in the form of a wedge, and in its internal angle the ulnar side of the end of the metacarpal bone is implanted. It has frequently a tubercle, which corresponds with the pisiforme of Mammalia.

The metacarpal bone is formed of two branches, which are united, by ossification, at their extremities.

On the radial side of its base it has a particular process, or small separate bone, which bears a styloid bone representing the thumb. On the

extremity of the metacarpal bone there is a long finger, consisting of two phalanges. The first is almost rectangular, and is compressed like a knife. The second is styliform. There is also a short finger of only one phalanx, which has the form of a stillet. The thumb sustains the false or bastard quills; the primary or chief are placed upon the long finger and metacarpal bone. The little finger bears none; it is concealed under the skin.

All the bones of the hand or wing of the *manchots* are compressed, and appear like thin plates.

5. OF THE BONES OF THE HAND IN REPTILES.

The *frog*, the *toad*, and the *salamander*, have three ranges in the carpus. The first consists of two bones, one radial and one ulnar. The second consists of three bones, the largest of which bears the rudiment of a thumb with two joints. The third range has likewise three bones. The second finger proceeds from the first of these bones. The fourth finger is articulated with the second bone. The middle finger articulates with both bones. The little finger joins the third bone. The first range touches the third inferiorly, because the second is cuneiform. There is no bone without the range.

In the *mud tortoise* the first range is a single bone, which separates the radius from the ulna.

The

The second range consists of two bones, and a small one out of the row, situated on the ulnar edge. The third range consists of five bones, one for each bone of the metacarpus.

The *sea tortoise* has three bones in the first range. The ulnar bone being longest, the two anterior bones do not advance much farther. The third range consists only of three bones for those of the metacarpus, and one small bone out of the row, situated upon the radial side.

In the *crocodile* the first range consists of two long parallel bones. It has beside two little external bones without the range on the radial side.

The number of the phalanges varies in these animals.

The *crocodile* has the hand rounded: it has two phalanges to the thumb, three to the second finger, four to the middle and fourth finger, and only three to the little finger.

The *cameleon* has three fingers on one side, and two on the other, which form, with the three opposite to them, a kind of forceps. The number of the phalanges is the same as in the crocodile, with the exception of the little finger, which has four.

In the *salamander* the little finger is obliterated, and the thumb has only two phalanges.

The *frog* has only one phalanx to the thumb. The two following fingers have only two phalanges. The other two fingers have three.

The

The hand of the *sea-tortoise* is long, and compressed in the form of a fin; it terminates in a point. There are two phalanges to the thumb, three to the three succeeding toes, and two only to the last.

A similar conformation is observable in the *mud-tortoise*; with this exception, that its hand is rounder.

ARTICLE VIII.

Of the Muscles of the Hand.

I. MUSCLES OF THE CARPUS AND METACARPUS.

A. *In Man.*

THE muscles which act on the carpus and metacarpus are named *radial* and *ulnar*, according to the side of the fore-arm along which they are extended; and *internal* and *external*, according to the condyle of the humerus to which they are attached.

The os pisiforme is the only bone of the carpus into which one of those muscles are inserted; that muscle is

THE ULNARIS INTERNUS, OR EPITROCHLO-CARPALIS.

It arises from the internal condyle of the humerus,

humerus, and the posterior surface of the ulna, and extends along the ulnar side of the fore-arm.

THE ULNARIS EXTERNUS, *or* CUBITO-SUPER-METACARPALIS.

This muscle rises from the other condyle of the os humeri, descends on the outside of the preceding muscle, and is inserted in the external base of the metacarpal bone of the little finger.

THE RADIALIS INTERNUS, *or* EPITROCHLO-METACARPALIS,

Proceeds from the internal condyle of the humerus, and sends off a tendon, which passes under the hook of the os unciforme bone, and is inserted into the base of the metacarpal bone of the index.

THE RADIALES EXTERNI.

These muscles are two in number. They arise from the external condyle of the humerus, and proceed, the one upon the other, to the external side of the radius, and thence descend to their points of insertion. The first (HUMERO-SUPER-METACARPALIS,) is attached to the external base of the metacarpal bone of the index; the second (EPICONDYLO-SUPER-METACARPALIS,) into that of the middle finger.

B. *In other Mammiferous Animals.*

Monkeys have, like man, five muscles of the hand. The *cat* and the *bear* have the same number.

The *dog* has only one *radialis externus*, which divides into two tendons. It is the same with respect to the *rabbit*.

In all those, with many fingers, the external muscles, when acting in concert, approximate the back of the hand to that of the fore-arm.

The internal muscles have a different effect. When the ulnar act in concert, the hand is turned outward towards the ulnar side of the fore-arm. The radial produce a contrary motion.

In animals that have cannon-bones, in which the hand is neither capable of flexion or extension, the *radialis externus*, (*extensor rectus anticus* of the cannon-bone of Bourgelat,) is fixed to the anterior base of the metacarpus, or cannon-bone, and extends it.

The *radialis internus*, (*flexor internus* of Bourgelat,) is inserted into the posterior base. The *ulnaris internus*, (*flexor obliquus* of Bourgelat,) is inserted in the bone that corresponds to the os pisiforme. The *ulnaris externus*, (*flexor externus* of Bourgelat,) is inserted in the same bone, and extended under those of the carpus.

These muscles are all flexors.

The

The muscles which move the hands of *bats* are few in number, but they are very remarkable.

That which is analogous to the *ulnaris externus*, arises from the humerus, and from the convexity of the radius as far as its middle. Its tendon is inserted into the superior and internal part of the carpus, which it extends by abduction.

The muscle which corresponds to the *ulnaris internus*, arises from a fleshy portion common to all the muscles of the fore-arm, and is inserted into the external side of the first phalanx of the last finger. It is a flexor or adductor of the carpus.

That which takes the place of the *adductor pollicis*, arises also from the same common fleshy mass. Its tendon proceeds obliquely to the superior surface of the fore-arm, crossing the tendon of the *ulnaris externus*. It is inserted in the internal side of the carpus, at the base of the thumb.

C. In Birds.

The metacarpus of Birds is not capable of flexion, or approaching the internal surface of the fore-arm; nor of extension, or approaching the external surface of that arm. It can only perform the motion of adduction by approximating the radius and abduction, by coming nearer the ulna. As there are, however, only these two motions, we might, in imitation of

Vicq

Vicq D'Azyr, call the muscles that produce them flexors and extensors: But as it will be more easy to compare them to those of man, we shall retain the common names.

The *ulnaris internus* has the same position as in Mammalia. It originates in the same manner from the internal condyle of the humerus, and is inserted into the tubercle of the bone that resembles a wedge. There is a small muscle under the preceding to which it is parallel. It produces a long tendon, which sends off slips to the secondary quills, and is inserted in the back of the metacarpus.

The *ulnaris externus* is placed on the posterior surface of the ulna. Its tendon passes between the first secondary quill and the last primary, and is inserted in the internal edge of the base of the metacarpal bone.

There is but one *radial* muscle, but it consists of several portions, which all arise from the external condyle, except one from the radius. Their common tendon is inserted into the tubercle of the metacarpal bone of the thumb: this tubercle, as we have observed, is sometimes a small separate bone.

D. In Reptiles.

In the *sea-tortoises*, which have the carpus compressed, and fitted for swimming, the muscles are only simple bands of aponeurotic fibres,

fibres, which strengthen the several articulations.

We have still to examine those of the other reptiles.

II. MUSCLES OF THE FINGERS.

The muscles of the fingers are *extensors* and *flexors*, *adductors* and *abductors*. They are common or proper, and long or short, according as they are situated along the fore-arm, or proceed merely from the carpus and metacarpus.

A. In Man and other Mammiferous Animals,

The long muscles of the fingers are,

1. THE EXTENSORS.

These are situated on the external surface.

The EXTENSOR COMMUNIS, (EPICONDYLO-SUPER-UNGUIALIS,) arises from the external condyle of the humerus. It sends off tendons to all the fingers except the thumb, and is found in all quadrupeds. The number of its tendons is equal to that of all the fingers, the thumb not included. In general they are four; but in the Ruminantia they are two; and in the Solipeda only one, which is the *extensor anticus* of Bourgelat, and the *extensor pedis* of La Fosse.

The EXTENSOR PROPRIUS DIGITI MINIMI, (EPICONDYLI-SUPER-UNGUIALIS,) is placed on
the

the ulnar side of the preceding, and has the same origin. In man it has a tendon for the little finger only. In *monkeys* it has another for the fourth. In *dogs* and *bears* it sends off a third to the middle finger. Instead of one muscle, the *cat* has two; one for the little or last finger, and one for the fourth and third. There is but one muscle in the *rabbit*, which has two tendons, as in the *monkey*.

In the Ruminantia this muscle extends the external toe, and the *extensor indicis* the internal toe.

There are two muscles in the *horse*; one more removed from the *extensor anticus*, analogous to to the extensor communis. It is called *extensor lateralis* by Bourgelat, and *extensor of the pastern* by La Fosse. Its tendon is inserted into the side of the first phalanx of the toe. A second is placed between the two, and its tendon, after having passed before the carpus, is obliquely united with that of the preceding muscle. The hippotomists consider this tendon as a digitation of the extensor anticus.

THE EXTENSOR INDICIS PROPRIUS, (CUBITO-SUPER-UNGUIALIS,) is situated close to the inferior and external part of the ulna in man. It has only one tendon, which is inserted into the fore-finger; but it is sometimes accompanied by a proper extensor for the middle finger.

In *monkeys* it has two tendons; one for the index, and another for the middle finger.

In

In the *dog* and *cat* it is situated as in man, but it extends to the last articulation. It is entirely wanting in the *rabbit*, the Ruminantia, and the *horse*.

The thumb has two *extensores proprii*.

The LONGUS (CUBITO-SUPER-PHALANGEUS,) is placed above the extensor of the fore-finger. It passes under the external annular ligament, and extends its tendon to the first phalanx.

The BREVIS (CUBITO SUPER-UNGUIALIS,) is placed on the radial side of the preceding muscle. Its tendon accompanies that of the abductor, and extends to the second phalanx.

In *monkeys* the last muscle either intimately unites its tendon with that of the abductor, or is altogether wanting.

The *extensor brevis pollicis* is wanting in the *cat*, the *dog*, the *bear*, and the *rabbit*. The *longus* exists in these species, and in the *bear* gives a tendon to the fore-finger.

The Ruminantia and the *horse* have neither.

2. THE ABDUCTORS.

The ABDUCTOR POLLICIS LONGUS (CUBITO SUPER-METACARPALIS,) is placed above the preceding muscles, towards the radial side of the fore-arm. It crosses the radial muscles at the inferior head of the radius, and is inserted in the radial side of the metacarpal bone of the thumb.

This muscle is similar in *monkeys, dogs, cats, bears, rabbits, &c.*

In the *horse*, and in the Ruminantia, it is attached to the internal side of the base of the only metacarpal bone, and becomes what Bourgelat calls the *oblique extensor of the cannon-bone*.

3. THE FLEXORS.

These are all on the internal surface of the fore-arm.

The FLEXOR SUBLIMIS (EPITROCHLO-PHALLANGEUS,) consists of several distinct muscles, which unite in different ways, and terminate by furnishing tendinous perforated slips to the fingers which follow the thumb.

The FLEXOR LONGUS POLLICIS (RADIO-SUB-UNGUIALIS,) appears to be united to the former in a very intimate manner. It is situated on its radial side, and is extended to the second phalanx.

The FLEXOR PROFUNDUS (CUBITO-SUB-UNGUIALIS,) which is situated upon the bones of the fore-arm, transmits perforating tendons to the four fingers which follow the thumb: such is the description of these muscles in the human body.

In *monkeys* the *flexor longus pollicis* is wanting; but the *profundus* divides into five slips, one of which proceeds to the thumb, to which the sublimis does not send any tendon.

In the *dog* the *flexor pollicis* unites its tendon
with

with that of the *profundus*, from which it again separates to proceed to the second phalanx of the thumb.

The *flexor sublimis* sends a tendon to the first phalanx of the thumb, but it is not perforated.

It is the same with respect to the *cat*; but the *flexor pollicis* is not in this animal so distinct from the *profundus*, which, besides, is visibly divided into as many muscles as it produces tendons.

The *profundus* in the *rabbit* transmits a tendinous slip to the thumb, which is not the case with respect to the *sublimis*.

In the Ruminantia the *flexor sublimis* and the *profundus* transmit two tendons each, and the tendon of the *flexor pollicis* is united with that of the *flexor profundus*.

There are likewise two of these muscles in the *horse*, one perforating and the other perforated, but which have each only one tendon.

B. In Birds.

As the fingers of birds can perform no motions except those of adduction and abduction, the use of the preceding muscles is changed in the animals of this class. These two functions are distributed among the muscles without any uniform relation to the side of the fore-arm to which they adhere. If, therefore, we were to substitute for the term *adduction* that of *extension*,

and for *abduction* that of *flexion*, which might be done, still the flexors would not all be placed on the internal, nor the extensors all on the external surface of the arm. In this manner, indeed, the muscles which are flexors in man would be converted into extensors.

1. THE ADDUCTORS, or EXTENSORS of *Vicq D'Azyr*.

The *adductor phalangis primæ* corresponds to the *flexor sublimis*. It arises from the internal condyle, proceeds above the *ulnaris internus*, passes over the internal side of the wedge bone along the metacarpal bone, and is inserted into the base of the first phalanx of the great finger.

The *adductor internus phalangis secundæ*, which corresponds to the *flexor profundus*, proceeds along the internal side of the ulna. Its tendon approaches that of the preceding muscle, but proceeds farther, and is inserted into the base of the second phalanx. There is no perforation.

The *adductor pollicis*, which corresponds to the *flexor pollicis*, is situated between the preceding muscle and the ulna. Its tendon extends to the radial edge of the thumb.

The *adductor externus phalangis secundæ* is analogous to the *flexor proprius indicis*. It is attached to the external condyle, and situated along the external side of the radius. Its tendon passes to the back of the metacarpus, and even extends to the second phalanx of the great finger.

2. THE ABDUCTORS, or FLEXORS of *Vicq*
D'Azyr.

The *abductor communis*, which corresponds to the *extensor communis* in man, arises from the external condyle, and proceeds without the preceding muscle, along the external side of the radius. When its tendon arrives opposite to the carpus, it divides into two. One goes to the ulnar base of the thumb, the other to that of the first phalanx of the great finger.

IV. SHORT MUSCLES OF THE FINGERS.

The hand of man has also a great number of short muscles which arise from the bones of the carpus or metacarpus, and are inserted into the fingers.

One of them is superficial: it is placed under the skin of the palm of the hand, to which it is attached on one part, and on the other to the palmar aponeuroses. It is called CARO-QUADRATUS, and PALMARIS CUTANEUS (PALMO-CUTANEUS.)

Of the other muscles, some belong to the thumb; as—

The ABDUCTOR REVIS, (CARPO-SUPER-PHALANGEUS.) It arises from the trapezium, and is inserted in the external side of both phalanges of the thumb.

The FLEXOR BREVIS (CARPO-PHALANGEUS,) arises from almost the whole of the inferior surfaces of the bones of the carpus, and is inserted into the first phalanx.

The OPPONENS (CARPO-METACARPALIS,) arises from the ligament of the carpus, and from the os trapezium, and is inserted in the metacarpal bone of the thumb.

The ADDUCTOR (METACARPO-PHALANGEUS,) extends from the first and second bones of the metacarpus to the first phalanx of the thumb.

The little finger has also two small muscles which are peculiar to itself, viz.

The FLEXOR BREVIS, or OPPONENS, (CARPO-METACARPALIS,) arises from the os unciforme, and is inserted into the internal side of the metacarpal bone. It renders the palm of the hand concave, and bends the little finger.

The other is the ADDUCTOR, (CARPO-PHALANGEUS.) It arises also from the os unciforme, and is inserted into the external side of the first phalanx.

Lastly, there are some small muscles of the hand which are common to all the fingers: These are—

The LUMBRICALES (PALMO-PHALANGEI,) which are four in number. They arise from the tendons of the flexor profundus, and are inserted in the internal sides of the first phalanges of the fingers, except the thumb. They are auxiliaries to the flexor profundus.

The INTEROSSEI INFERIORES *seu* INTERNI, *et* SUPERIORES *seu* EXTERNI, (METACARPO-SUPER-PHALANGEI.) These muscles occupy the intervals between the metacarpal bones, and are inserted into the two sides and upper part of the first phalanx of each finger.

The *bats* have only one extensor, and some flexors of the fingers.

The *extensor digitorum* is a small muscle which comes from the external condyle of the humerus, passes to the carpus, and produces a very fine tendon, which extends to the convexity of each of the phalanges, and is terminated in the last.

The *flexor communis* arises from the fleshy mass on the inner side of the fore-arm. It produces a slender tendon, which passes under the carpus, where it divides into five small slips, which afterwards unite with the proper flexor of each of the fingers.

Lastly, the *flexores proprii*, which are four in number, arise from the carpus at the bases of the first phalanges. They there form a small fleshy body, which receives the tendon of the flexor communis, and is continued with it to the extremity of the finger, the phalanges of which it bends one over the other.

The thumb appears also to have some small peculiar muscles. Their short fibres arise from all the palmar surface of the carpus, and form a little pyramid, the apex of which is inserted into the base of the first phalanx.

In the Cetacea the above muscles are only simple aponeurotic bands fitted for connecting the rudiments of bones, which in them do not move one upon the other.

C. In Reptiles.

The muscles of the hand of the *frog* and the *salamander* are very similar to those of man.

Those of the thumb are wanting, except the *extensor*, which comes from the external condyle, and is inserted in the last phalanges.

There is an extensor of the two last fingers, which also arises from the external condyle, and is inserted into the last phalanges.

The other muscles vary very little.

In *sea tortoises* the muscles of the hand are replaced by bundles of aponeurotic and tendinous fibres, which support the articulations in the action of swimming.

We have not yet had an opportunity of studying those muscles in the other reptiles.

TABLE of the Length, in Metres, of the different Parts of the Pectoral Member in Mammalia.

NAMES	Total	Arm	Fore Arm	Carpus	Meta-carpus	Fingers
Man	0,79	0,33	0,26	0,03	0,07	0,10
Sai	0,28	0,10	0,11	0,01	0,02	0,04
Orang	0,38	0,12	0,14	0,01	0,04	0,07
Pongo	1,00	0,35	0,38	0,03	0,10	0,14
Ternate Bat	0,575	0,11	0,15	0,015	0,11	0,19
Common Bat	0,19	0,035	0,06	0,005	0,05	0,04
Mole	0,105	0,02	0,02	0,05	0,015	
Hedge-hog	0,14	0,04	0,04	0,03	0,015	0,015
Sea-Bear	0,88	0,30	0,33	0,03	0,10	0,12
Glutton	0,34	0,12	0,12	0,01	0,03	0,06
Racoon	0,33	0,10	0,13	0,01	0,03	0,06
Otter	0,24	0,09	0,08	0,01	0,03	0,03
Seal	0,30	0,08	0,11	0,02	0,02	0,07
Lion	0,85	0,31	0,30	0,03	0,10	0,11
Cat	0,27	0,09	0,11	0,01	0,03	0,03
Wolf	0,53	0,18	0,19	0,02	0,07	0,07
Opoffum	0,19	0,06	0,08	0,01	0,02	0,02
Hare	0,29	0,10	0,12	0,01	0,03	0,03
Guinea Pig	0,11	0,04	0,04	0,01	0,01	0,01
Three-toed Sloth	0,51	0,19	0,18	0,01	0,03	0,10
Long-tailed Manis	0,15	0,05	0,05	0,005	0,01	0,04
Elephant	1,53	0,77	0,48	0,11	0,10	0,07
Hog	0,67	0,20	0,24	0,04	0,09	0,10
Rhinoceros	1,42	0,46	0,53	0,08	0,20	0,15
Dromedary	1,49	0,35	0,57	0,06	0,30	0,21
Giraffe	2,44	0,51	0,91	0,08	0,72	0,22
Ox	1,00	0,26	0,34	0,04	0,18	0,18
Stag	1,10	0,25	0,38	0,04	0,27	0,16
Horse	0,92	0,22	0,34	0,04	0,18	0,14
Dolphin	0,22 in all					
Porpoise	0,18 in all					

ARTICLE IX.

*Of the Anterior Extremity in Fishes.*1. *Of the Bones.*

THE anterior extremities of fishes are their pectoral fins. These, like all the other fins, are composed of a certain number of osseous radii or fibres, each formed of a multitude of joints, and sustaining a common membrane. Sometimes one or two of these radii or rays are made of a single bony piece. These are called spinous.

In most fishes the pectoral fin moves in a horizontal plane, which is nearly perpendicular to its own plane; that is to say, in the state of repose it is placed close to the side of the body, from which it may be raised to a greater or less height, until it forms a right, or even an obtuse angle with the side.

In others, as the *rays*, the *sharks*, &c. the two pectoral fins are in the same horizontal plane; when they move, they strike from above downward, or from below upward, preserving a vertical direction.

The pectoral fin is wanting in only a very small number of fishes, such as the *eels* and *cecilias*.

In those which have the pectoral fin, it is generally articulated and firmly attached to the head, as in *osseous fishes*, or to the spine, as in *rays*, &c.

The

The pectoral fins in *rays* form those large wings which give to the body a rhomboidal shape. They are formed of a vast number of radii, placed very close together, and having a number of articulations. They are all connected with a cartilage parallel to the spine, which may be subdivided into two or three, and which is itself articulated, on the upper part, to another cartilage fixed to the spine. Beneath there is a sort of transverse bar, common to the cartilages of both fins, and which serves at once for sternum and clavicles. This inferior bar also exists in *sharks*; but we observe in them no articulations with the spine. Their pectoral fins are much smaller.

In the *osseous fishes*, and in several others which should be regarded as belonging to that class, though Ichthyologists have ranged them among the cartilaginous, (such as the *balistes*, &c.) the pectoral fins are attached to an osseous girdle which surrounds the body behind the branchiæ, and which supports the posterior edge of their aperture.

This osseous girdle is formed of one bone from each side, articulated at the posterior superior angle of the cranium, and descending under the neck, where it unites with the corresponding bone. These bones may be regarded as *scapulæ*. The portion situated above the fin is simple and thin; that which is beneath has anteriorly a projecting plate which answers instead

instead of a spine. The abductor muscles lie in the angle formed by this lamina with the body of the bone.

The portion of the body of the bone, which is situated behind the lamina, is more or less large according to the extent of the muscles. At this place there is sometimes an unossified interval. This is the case in the *flying trigla*, in the *zeus*, &c. The *sea dragon* and the *whiting* have two of these intervals.

The lamina is extremely broad in the *chaetodons*, the *zeus*, and the *sea-wolf*.

The figure of this bone, the angle under which it joins its corresponding bone, and those which intersect it, vary in the different species. In the fishes, compressed vertically, they unite by a sharp angle. In those that are depressed they are turned inwardly in such a manner that their union forms almost a right line.

In a number of fishes, particularly in those of the family Thoracici, viz. the genera *pleuronectes*, *perches*, *cottus*, *zeus*, *chaetodons*, &c. as well as in the *balistes*, and several others, the superior part produces a large spine, which descends directly behind the fin, and serves for the attachment of the *adductor* muscles. This spine is moveable, and has, by some anatomists, been improperly called the *clavicle*.

The rays which sustain the membrane do not articulate immediately with the bony girdle. Between them and it there is a range of small
flat

flat bones, separated by cartilaginous intervals, which may be compared to the bones of the carpus. There are four of these bones very large in the *sea wolf*, the *red gurnard*, the *armed* and the *flying trigla*; four small ones in the *whiting* and the *pleuronectes*; eight in two rows in the *dory*, (*zeus faber*;) three small and cylindrical in the *silurus*; and five in the *chaetodons*, *perches*, &c. When the first ray of the pectoral fin is spinous, as in the *loricaria*, some *siluri*, &c. it is immediately articulated with the girdle bone.

This disposition is remarkable in some *siluri* and some *sticklebacks*, which can, at pleasure, either lay this spine flat upon the body, or place it firmly supported in a perpendicular position. They are thus furnished with an excellent means of defence.

The osseous girdle has for this purpose a tubercle of a cylindrical form, in the front of which there is a hole. The spine of the fin articulates with this cylinder by a depression, which has a projecting process before and behind it. When the spine is extended, the anterior process, which is in the form of a hook, enters the above-mentioned hole, and the spine turning a little on its axis, the process is hooked upon the edge of the hole in such a manner that the spine cannot be inflected until it makes a turn upon its axis in a direction opposite to the former. This spine is furnished with denticulations, which form a part even of the substance of the bone.

bone. They have opposite directions upon the two sides of the *silurus aspredo*, and upon one side only in the *silurus felis*, *siluris galeatus*, and many others.

In the *trigla birundo*, *volitans* and *evolans*, *scorpena volitans*, *exocætus volitans*, and some other fishes, the pectoral fins are exceedingly long, and serve for flying.

Their situation varies considerably in different species: they are very near the branchiæ in the *exocæti*: on the contrary, they are considerably removed from them in the *blennies*, &c.

2. Of the Muscles.

The pectoral fin of the osseous fishes is firmly supported by the flat bone, which is articulated with the posterior angle of the cranium, and which corresponds with the scapula. Two strong muscles arise from the inferior or broadest part of this species of scapula, and are inserted in the enlarged or posterior extremity of the cordiform bone which supports the tongue. These are analagous to the *sterno-hyoidæi*.

Another muscle, which performs the office of the *diaphragm*, and which separates the cavity of the branchiæ from that of the abdomen, is attached, at the one part, to the point of the bone which sustains the branchiæ, and, at the other, to the internal crest of the base of the scapula.

The

The clavicle is also moved by a small muscle, which arises from its free extremity, and is inserted partly into the scapula, and partly loses itself in the muscles that cover the belly.

But the fin is particularly moved upon the scapula by two sets of muscles. One set being situated at its external and inferior surface, and the other at the internal and superior surface.

The first external muscle covers all those of the same surface. It occupies the anterior part of the infraspinous fossa, and is inserted by a great number of tendinous digitations into each of the eminences of the rays of the fin. This muscle raises the fin from the flank, and moves it forward, making it cut the water.

The first being removed, we find two other muscles; one is more internal, and its fibres, which are directed obliquely outward, terminate likewise by small tendons in each of the rays. It lowers the fin, moves it towards the corresponding fin, renders it vertical, and turns it downward.

The third muscle is more external: it arises from almost the whole breadth of the fossa; but it diminishes in breadth as it approaches the fin, and terminates at last by being inserted in the most external of the rays. By its contractions it removes the fin from the body, and directs it towards the head, making it strike the water.

The muscles of the internal surface are likewise disposed in layers. The largest and most external

external extends from the superior spine of the scapula, which is articulated with the cranium, to the base of the radii of the fin. It is considerably augmented in its progress, and it is crossed by the clavicle. It turns the plane of the fin directly outward, by removing it from the body. This muscle covers another at its inferior part.

This last muscle has a number of fibres. It occupies all the part of the sub-scapular fossa, which is situated under the clavicle. It performs precisely the same office as the preceding, but moves the plane of the fin somewhat more towards the head. There are more of its muscular fibres attached to the bases of the radii. Their different directions approximate or remove, with respect to each other, all those little bones, so as to spread out or close the kind of fan which they constitute.

The muscles of the pectoral fins of the ray form two very thick fleshy layers, which cover those fins superiorly and inferiorly, and which are divided into as many bundles as the fins are into radii.

LECTURE FIFTH.

OF THE POSTERIOR EXTREMITY, OR ABDOMINAL MEMBER.

ARTICLE I.

*Of the Bones of the Pelvis.**A. In Man.*

THE pelvis in man is a kind of osseous girdle furrounding the lower part of the trunk obliquely, and so situated that its posterior part, which is strongly attached to the sides of the os sacrum, is more elevated, and its anterior part lower than that bone.

The superior and posterior part is composed of two wings, of a form almost semicircular. The anterior and concave surface of each is turned somewhat inward, and the posterior and convex surface is extended towards the spine, where it furnishes the portion which is attached to the os sacrum.

The lower part of each of these wings is narrowed into a kind of neck, and prolonged

somewhat inferiorly, as far as the great hemispherical depression, called the *cotyloid* cavity, which serves to lodge the head of the femur. One branch, which proceeds from the anterior edge of this cavity, is directed forward and inward until it meets the corresponding branch of the other side, and completes the anterior portion of the pelvis. Another branch proceeds from the inferior edge of the same cavity. It is directed downward in such a manner as to leave between it and the sacrum a large space, called the *ischiatric notch*. Having descended a little lower than the coccyx, this branch ascends by a direction which is forward and inward, until it unites to the first branch, at the place where it joins the corresponding one from the opposite side. Thus there remains, on each side of this anterior part of the girdle formed by the pelvis, an interval surrounded by an osseous circle, and named the *oval*, or *sub-pubic foramen*.

The plane of each half of this anterior portion is turned obliquely downward and to one side. The suture which separates the two halves anteriorly, is called *symphysis pubis*. The two bones which with the os sacrum form the pelvis, are called *coxæ*, *haunch bones*, or *ossa innominata*.

In youth each of these bones is divided into three parts, all of which contribute to the formation of the *cotyloid* cavity. They have been long regarded as particular bones, and have received different names, viz. 1. The *os ilium*, or flank

bone, which is the superior portion, in the form of a wing; its superior and semicircular edge is called the *crista* of the *os ilium*; and the angle produced at its junction with the inward curvature, which assists in forming the before mentioned neck, is called the *spine*. 2. The *os pubis*, which forms the anterior transverse bar, and the portion which descends the whole length of the symphysis. 3. The *os ischium*, which surrounds the foramen ovale posteriorly and inferiorly. Its most inferior portion is called the *tuberosity* of the *ischium*, and it is on this part of the bone we rest in sitting. The margin of this last portion, which is turned towards the *os sacrum*, has, at the height of the cotyloid cavity, a small hooked process directed backward: this is called the *ischiatric spine*.

The superior margin of the *os pubis* is continued on the inferior part of the internal surface of the *os ilium* in an elevated bone, which extends to the place where the latter bone joins the *os sacrum*; and which, together with the projection the *os sacrum* itself forms at its angle with the rest of the spine, divides the pelvis into two parts: the *great pelvis*, which is superior; and the *little pelvis*, which is inferior.

This inward projection is called the *anterior strait of the pelvis*. It forms a kind of ellipsis, the plane of which makes a very marked angle with the sacrum, and another with the lumbar part of the spine. Its diameter between the

A a 2

anterior

anterior and posterior part is somewhat less than that between the sides.

The bones which form the pelvis are united by very strong ligaments, some of which contribute to the formation of its cavity. Those which unite the ileal portion of the os innominatum to the sacrum, come from the transverse process of the last lumbar vertebra, or the base and processes of the os sacrum. The bundles which they form are more or less long, and extended. They are inserted in the posterior part of the crest of the os ilium.

The ischiatic portion is also united by two strong ligaments, which complete the cavity of the little pelvis posteriorly. One extends from the tuberosity to the lateral margin of the sacrum. The other arises also from the ischium, but particularly from its spine, and extends transversely to the margins of the sacrum and coccyx, uniting its fibres with those of the preceding ligament.

The os pubis of the one side is joined with that of the other by an intermediate cartilage, which forms what we have called the symphysis. This articulation is covered with a strong ligament, which renders it immovable.

Finally, the bones of the tail or coccyx are firmly united to the os sacrum by articular capsules and ligaments, which cover them entirely. These are divided into the anterior, the lateral, and the posterior.

B. *In other Mammiferous Animals.*

We have observed, that, in *quadrupeds*, the sacrum is commonly continued in the same line with the spine. It may be farther remarked, that were we to place them so as to render their spine vertical, the planes of the two anterior halves of the pelvis would be directed forward and outward, and not downward as in man: they would even be turned upward in hoofed animals. Hence it follows, that if these planes were continued, they would meet a prolongation of the spine below the pelvis in man, above it in hoofed animals, and that they would remain parallel to the pelvis in the greater number of animals with claws. This observation is important, on account of the position of the femur.

The ossa ilii of *monkeys* are narrower, flatter, and directed more forward than those of man. Their neck is longer. It follows, that the plane of the pelvis is almost in a straight line with the spine, and that the diameter from before backward is greater than the transverse. The pelvis therefore furnishes a much smaller base to the trunk than in man; for this base must be estimated by a perpendicular section of the trunk, or cylinder to which it belongs.

The *batavian pongo* has the ossa ilii much
A a 3 broader

broader than the other *monkeys*, but their position is as described above.

The species of *monkeys* which have callosities on the buttocks have very large tuberosities to the ischium.

In the Carnivora, the abdominal surface of the bones of the ilium is not turned forward, but towards the spine. Their superior portion is not broader than their neck; it is their external surface which is concave. Their crista has so little extent, that the figure is almost that of a hatchet.

In the *bear* it is somewhat larger, and the spine is turned outward; but the position upon the whole remains the same. The branch of the ischium which runs backward is continued with the neck of the ilium in a straight line which forms an angle of about thirty degrees with the spine. As the diameter from the front to the back of the anterior *strait* of the pelvis is shorter than in *monkeys*, its particular proportions have more resemblance to those of man, but the base it affords to the trunk is notwithstanding smaller.

We observe among the Carnivora two remarkable anomalies. One in the *mole*, in which the ossa innominata are almost cylindrical, and situated so close to the spine throughout the whole of their length, that the anterior strait is exceedingly small. The ischiatic portion is also very much prolonged posteriorly: the other ap-
 pears

pears in the *ternate bat*, which has the tuberosities of the ischium joined to each other and to the extremity of the sacrum by anchylosis.

In the *Pedimana*, or the animals with a pouch, as the *opossum*, the *marnot*, the *kangaroo*, &c. the pelvis is likewise very remarkable, in having the foramen ovale very large, and the diameter of the *strait* small, but more so from the presence of an articulated and moveable bone upon the pubis. This bone gives origin to particular muscles which support the pouch that contains the mammæ. This shall be farther described in the article on Generation. Bones of this kind are called *marsupial*, they are of an oblong form somewhat compressed.

In the *Rodentia*, the general form and position of the pelvis is nearly the same as in the *Sarcophaga*. The ossa ilii are turned more or less forward, or rather downward, according to the different species: the projecting line of their abdominal surface is continued parallel to the spine, as far as their crest, which is very narrow. This elevation sometimes gives to these bones the form of a prism, in which their real margin is only an edge; their spine is reflected outward.

This is also the form of the ossa ilii in the *armadillos*, *pangolins*, and *ant-eaters*; while the *sloths* have them very broad, and directed forward with a large circular pubis: this renders their strait or opening very wide, and little oblique. As these four genera have the tuberosity

of the ischium approximated, or even ossified to the os sacrum, they have only a hole instead of the ischiatic notch.

The pelvis of the *hog* differs very little from that of the *Sarcophaga*, except that the bones of the ischium extend farther backward, and that the ischiatic notch penetrates farther into the os ilium.

In the *tapir*, and more particularly in the *Ruminantia*, the notch being still more enlarged, the neck of the ilium elongated, and its spine extended outward, this bone assumes the form of the letter T, or a hammer, articulated by one branch to the os sacrum, and the neck forming the handle. Its abdominal surface is turned obliquely towards the spine of the back: its neck forms a very obtuse angle with the ischium. We can observe the projection of its spine under the skin, and also the ischiatic tuberosity, the line which passes through these two points forms a very distinct angle with the spine. The cotyloid cavity is nearly in the middle of that line.

In the *Ruminantia* that are very strong backed, like the *ox*, the anterior part of the ilium is exceedingly large. In the *buffalo* it is even broader than the bone is long, and almost perpendicular to its neck. In the smaller species it becomes more and more narrow and oblique, outward and anteriorly. The *camel* has it rounded. The external surface of the bone is concave in these animals. The anterior strait of the pelvis forms
a large

a large angle with the spine of the back, which affords more room for the belly.

The figure of this bone is nearly the same in the *horse*; but the wings are very large, and the neck very short. The cotyloid cavity corresponds nearly with the posterior third of the above-mentioned line.

The *elephant* and the *rhinoceros* have the anterior part very broad in every direction. The crest is round, and the abdominal surface is concave. The wing next the sacrum is larger than the other in the *elephant*. In the *rhinoceros* they are nearly equal, and the neck is proportionally longer. These enormous pelves give to the bellies of those animals that vast capacity for which they are so remarkable. The plane of the anterior strait is almost perpendicular to the spine.

The pelvis of *seals* resembles that of the *Carnivora*, and particularly the *otters*; it is very long and narrow, and the pelvis, as in the *otter*, is inflected considerably backward; but the only vestige of a pelvis to be found in the *Cetacea* consists of two thin flat bones, suspended in the flesh, on both sides of the anus.

C. In Birds.

The ossa innominata form, with the lumbar vertebræ and the sacrum, only one bone in birds. They exhibit therefore only the lineaments of
the

the pelvis. In general, however, we observe the foramen ovale in the skeleton. As the ischiatic portion is almost always intimately united with the sacrum, the ischiatic notch becomes a hole. The pubis of the one side, instead of joining its corresponding bone, proceeds directly backward in the form of a style.

In young birds, the bone analogous to the os sacrum is completely perforated between the transverse processes of the vertebræ, of which this bone is originally constituted. The oval and ischiatic foramina are at that time only two notches, which very distinctly indicate the three portions of the os innominatum.

In Birds of Prey, the foramen ovale is small, and the os pubis very thin, long, and frequently articulated with the ischiatic portion.

In the Passeres, the foramen ovale is considerably lengthened, and is larger than the ischiatic hole. This elongation is still more observable in the Grallæ.

The *diver* has the os ilium extremely small; the ischium, which is very bulky, is intimately united by ossification throughout all its length with the os sacrum. The ossa pubis are very thin; they are considerably enlarged where they meet, but they are not completely ossified together. This may be remarked, in general, of all *water birds*.

In the *ostrich* and the *cassowary* the ischium is altogether separate from the coccyx, which
unites

unites with a long production of the ilium. The inferior part of the pubis is considerably enlarged, and curved, in order to unite with the correspondent bone in the *ostrich*, but not in the *casowary*: besides, the ossa ischii are in the latter entirely separate from the pubis, and placed in the same direction.

D. In Reptiles.

In the *turtle*, that part of the os innominatum which corresponds to the pubis, is the most considerable. It proceeds from the cotyloid cavity, by a thick portion, which comes forward and widens into a thin flat lamina, divided into two parts: one is turned towards the middle line, by which the two corresponding bones are united; the other is free, and is directed to the external side. The portion which corresponds with the ilium is short, narrow and thick; it rests on the shell, and is joined to the sacrum: finally, the portion which is analogous to the ischium, is turned backward and downward, and forms the real osseous circle of the pelvis.

This conformation is so singular, that the parts of the pelvis of the *turtle*, when the whole is viewed out of its natural position, may very easily be mistaken for one another; for the pubis resembles the ilium, the ischium the pubis, and the ilium the ischium.

There

There is, besides, another very remarkable peculiarity in the pelvis of *tortoises*; the ilium, and consequently the whole mass of the pelvis with which that bone is united, is moveable on the vertebral column.

In the *crocodile* and the *tupinambis*, the disposition of the pelvis has a great resemblance to that of the *tortoise*. In the *crocodile* the pubis receives the ventral ribs. In the *cameleon* and the *iguana* it is narrow, and the bones of the ischium form by this union a projecting crest.

In the *frog*, and in the *Surinam* and *common toads*, the ossa ilii are much elongated: the pubis and the ischium are short, and united in a single solid piece, the symphysis of which forms a crest more or less round.

In the *salamander* the conformation is precisely the same. The ossa ilii are narrow, and almost cylindrical; and the ossa pubis completely united with the ischium, forms only a large bony plate without any hole.

ARTICLE II.

Of the Muscles of the Pelvis.

A. *In Man.*

THE muscles of the pelvis in man are few in number.

I. THE

1. THE QUADRATUS LUMBORUM *or* ILEO-COSTALIS.

This muscle occupies the space between the os ilium, from which it arises, and the last false rib which receives one of its insertions: the others go to the transverse processes of the four first lumbar vertebræ. It acts more manifestly on the spine than on the pelvis.

2. THE PSOAS PARVUS, *or* PRÆLUMBO-PUBALIS,

Arises from the body of the last dorsal vertebra, and forms a thin flat tendon, which is inserted into the ileo-pectineal eminence. It raises the pelvis towards the spine.

B. *In other Mammiferous Animals.*

These muscles have the same origin in almost all *quadrupeds*; they differ only in their proportions, which depend upon the number of the lumbar vertebræ. The *psaos parvus* is wanting in the *rat*.

Bats have no *quadratus lumborum*; but their *psaos parvus* is very strong, and its aponeurosis is very broad.

C. *In Birds.*

Birds have neither the *psaos parvus*, nor the *quadratus lumborum*.

D. *In*

D. *In Reptiles.*

In the *tortoise* the muscle analogous to the *quadratus lumborum* expands under the back shell between the last anterior ribs; it arises from the ilium towards the articulation of that bone with the os sacrum, which in this animal is moveable.

This mobility of the pelvis is assisted by a muscle analogous to the *rectus abdominis*, which, as we have observed, instead of extending under the belly, is attached under the posterior extremity of the breast plate, by two fleshy portions, one anterior, the other posterior, which are both inserted in the anterior margin of the external branch of the pubis.

There is no *psoas parvus* in *frogs*. The *quadratus lumborum* extends from the long transverse process of the third vertebra, to the origin of the long bone of the pelvis, which is analogous to the ilium. It is inserted in this bone, which it raises towards the head; their ilium being moveable, like that of the *tortoise*.

N. B. We shall postpone our observations on the posterior extremity, or ventral fin of fishes, until the end of this Lecture.

ARTICLE III.

Of the Thigh Bone.

The cotyloid cavity is semi-spherical. In its brim, opposite to the oval or sub-pubic foramen, there is a notch which corresponds to the axis of the thigh bone when man is erect. The direction of the cavity is from the side downward and a little forward. The brim of this articular cavity is furnished with a very strong ligament, which greatly augments its extent in the recent state.

In other mammiferous animals the notch of the cotyloid cavity corresponds also to the foramen ovale; but the difference of position of the plane of that hole renders it necessary that the bone of the thigh should be perpendicular to the spine, or form an acute angle with it anteriorly, in order that its axis may correspond with the notch. This indeed is the position of the femur when quadrupeds rest tranquilly on their four feet. The angle which the femur forms with the vertebral column is almost a right angle in the Carnivora: in the hoofed animals it is acute. The direction of the cavity in mammiferous animals is also conformable to the position of the femur. It is such that when the spine is horizontal, it is directed outward and downward; but in the animals which swim much, as the *otter* and the *beaver*, it proceeds directly

directly from the side, and even inclines a little upward.

A. *In Man.*

The femur itself is a simple bone, almost cylindrical, and slightly arched upon the inner and back part. Its superior extremity is enlarged, and has two processes: one almost in the direction of the axis, called the *great trochanter*; and another, which is directed inwardly, and forms an obtuse angle with the axis inferiorly: the latter is called the neck. It is terminated by a spherical tuberosity, which moves in every direction in the cotyloid cavity, and is called the head of the os femoris. This articulation is supported by a capsular ligament which arises from the whole circumference of the cavity, and is inserted around the neck and the head of the femur. There is besides a round ligament within the articulation, which arises from the small fossa of the cotyloid cavity, and is inserted in a depression in the middle part of the head of the bone. Under the neck, and somewhat anteriorly, there is situated a small tubercle called the *little trochanter* or *trocantin*, and along the posterior surface there is extended an elevated line called *linea aspera* of the femur.

B. *In other Mammiferous Animals.*

In all classes of animals the thigh has only one bone: Its form varies little, but its proportion
with

with respect to the other parts of the abdominal member, depends, in general, on that of the metatarsus.

In the Ruminantia and the Solipeda, for example, it is so short that it seems to be concealed within the flesh of the abdomen: on this account, the part which really corresponds to the leg is, in those animals, vulgarly called the thigh.

The os femoris is not incurvated in the mammiferous quadrupeds; its neck is also shorter than in man, and more perpendicular to the axis. Thus the head is directed entirely inward, and the great trochanter rises above it.

In *monkeys* the os femoris is perfectly cylindrical, and has hardly any *linea aspera*.

In the *tapir* the middle part of the thigh-bone is very flat; it has, on its external edge, a projecting ridge, which terminates in a process resembling an hook.

This conformation is still more striking in the *rhinoceros*. The great trochanter and this unciform process are much prolonged, and close again in such a manner as to leave a hole between them and the body of the bone.

The unciform process is also found in the *horse*, the *armadillo*, and the *beaver*.

In the *seal* the thigh is so short that the two articular extremities make up more than half its length.

C. *In Birds.*

The thigh-bone in birds has only one trochanter. It is always very short in proportion to the leg. Its form is cylindrical. It is almost always straight, and rarely incurvated, as in the *cormorant*, the *diver*, and the *little grebe* (*colymbus minor*.)

In the *ostrich* the thigh-bone is very thick in proportion to the humerus, its diameter being almost four times as great. Its two extremities are larger than its middle part, which is nearly triangular.

D. *In Reptiles.*

The thigh-bone of oviparous quadrupeds resembles that of other animals; it has, however, a double curvature, more or less evident. In front it presents a convexity towards the tibial extremity, and a concavity near the pelvis. In the *tortoise* the trochanters are well defined, but they are not to be found in the *lizards* and *frogs*.

The figure of the femur is in general round, except in the *Surinam toad*, in which it is very flat.

ARTICLE IV.

Of the Muscles of the Thigh.

I. MUSCLES OF THE GREAT TROCHANTER.

THE muscles which extend to the great trochanter of the os femoris, roll it upon its axis in the cotyloid cavity, either by bringing the toe from within outward, or by producing the opposite motion. They may also extend the thigh a little in the direction of the spine, or, what amounts to the same thing, make it diverge from the other thigh :

A. *In Man.*

The layer next to the bone is composed of the following muscles :

1. THE GLUTÆUS MINIMUS, or ILIO-TROCHANTERUS,

Which arises from the anterior and inferior part of the os ilium, and is inserted, by a thin tendon, into the anterior and superior side of the great trochanter. It raises the thigh directly up towards the side.

2. THE PYRIFORMIS, *or* SACRO-TROCHANTERUS.

This muscle proceeds from the interior of the pelvis, where it arises from the superior part of the lateral edge of the os sacrum, and is inserted, by a slender tendon, into the top of the great trochanter, behind the preceding. It turns the thigh on its axis from within outward.

3. THE GEMINI, *or* ISCHII-TROCHANTERI.

These arise from the posterior edge of the ischium, and are inserted into the top of the great trochanter, behind the preceding muscle, to the tendon of which they in some degree adhere. They likewise produce the same effect.

4. THE OBTURATOR INTERNUS, *or* SUB-PUBO-TROCHANTERUS.

This muscle arises from the internal part of the border and membrane of the foramen ovale, and is inserted into the great trochanter by a slender tendon that turns round the posterior edge of the ischium, between the gemini, which form a sort of sheath for it. Its action is similar to theirs, but much more powerful, as it is aided by the pulley over which it slides.

5. THE QUADRATUS FEMORIS, *or* ISCHIO-TROCHANTERUS,

Arises from the tuberosity of the os ischium, and is inserted into the posterior edge of the
great

great trochanter, under the preceding. It is a rotator of the thigh, which it moves from within outwardly.

Over the glutæus minimus and pyriformis we find

6. THE GLUTÆUS MEDIUS, *or* ILIO-TROCHAN- TERUS.

It arises from all the large circumference of the os ilium, and, collecting its fibres, is inserted into the great trochanter. It raises the thigh, carrying it, at the same time, outwards, in the same manner as the glutæus minimus.

Lastly,

7. THE GLUTÆUS MAXIMUS, *or* SACRO FEMO- RALIS.

This covers part of the preceding, and all the smaller muscles. It arises from the posterior edge of the os ilium and the sacrum, and is inserted into the posterior part of the os femoris, below the great trochanter. It is a very strong muscle, which erects the trunk upon the extremities, carries the thigh backwards upon the trunk, and is one of those that act most powerfully in the motions of the abdominal member.

B. *In other Mammiferous Animals.*

In the *monkey* the elongation of the os ilium renders the *glutæus medius* and *minimus* larger;

B b 3

but

but the muscle analogous to the *glutæus maximus* is the least of the three.

The *quadratus femoris* is proportional to the greatness of the tuberosity of the ischium.

Bats have a *glutæus minimus*, which descends almost perpendicularly from the ilium to the thigh. They have neither *pyriformis*, *gemini*, *obturator internus*, nor *quadratus femoris*.

In the *Carnivora* and *Rodentia* the same proportional minuteness of the *glutæus maximus* is found as in the *monkeys*.

The *glutæus medius* and *maximus* exhibit nothing peculiar.

In the *horse*, the muscle analogous to the *glutæus maximus*, (but called by Bourgelat *glutæus minimus*,) is, in a great measure, aponeurotic. It has a long slender belly in addition to the ordinary one, which arises from the summit of the os ilium.

The *glutæus medius*, which is very considerable, arises likewise from the sacrum, and from all the membrane between that bone, and the ilium and ischium. This muscle is the principal agent in kicking; it is inserted into that particular process which may be considered as a third trochanter.

The other little muscles of the great trochanter are the same in quadrupeds as in man.

C. *In Birds.*

The three *glutæi* have the same proportions as in quadrupeds.

That which is analogous to the *maximus* is the muscle called *pyramidalis* by *Vicq D'Azyr*. The *minimus*, which arises from the inferior edge of the os ilium, is his *iliacus*.

The *pyriformis* and the *gemini* are wanting. That analogous to the *quadratus femoris* is very large.

The *obturator internus*, instead of passing through the hole corresponding to the ischiatic notch, passes over that which is analogous to the foramen ovale.

In some birds there is even a transverse piece of bone which forms a particular foramen.

II. MUSCLES OF THE LITTLE TROCHANTER AND THE INSIDE OF THE THIGH.

The muscles which go to the little trochanter and the internal surface of the thigh, bend it, or bring it nearer to the other. They are,

A. *In Man,*

I. THE PSOAS, or PRÆLUMBO-TROCHANTINUS.

This muscle arises from the sides of the lumbar and last dorsal vertebræ, and is inserted, by a

B b 4

small

small tendon, into the lesser trochanter. It raises the thigh, and brings it directly forward.

2. THE ILIACUS, *or* ILIO-TROCHANTINUS.

This arises from the internal surface of the os ilium, and has its insertion in the lesser trochanter, in common with the psoas. It produces the same effect as that muscle.

3. THE PECTINEUS, *or* PUBO-FEMORALIS,

Arises from the superior margin of the os pubis, and is inserted by a slender tendon below the little trochanter. It assists a little the action of the preceding muscles.

4. THE THREE ADDUCTORS, SUB-PUBO, SUB-PUBI, ISCHII-FEMORALES, *or* TRICEPS ADDUCTOR,

Arise thus: namely, the first from the symphysis pubis, the second from its descending branch, and the third from the tuberosity of the ischium. They all extend to the linea aspera of the thigh, where the second is inserted between the two others, but somewhat above them. They bring the thighs inward, or towards each other.

5. THE OBTURATOR EXTERNUS, *or* SUB-PUBO TROCHANTERUS EXTERNUS.

This covers the foramen ovale, and is inserted behind and into the cavity of the great trochanter; it rolls the thigh outwards.

B. In

B. *In other Mammiferous Animals.*

In *quadrupeds* in general the *psoas* and *iliacus* are much longer than in man.

The *pectineus* of the *dog* is fleshy, and its lower tendon extends to the bottom of the os femoris; but this is not the case in other *quadrupeds*.

Bats have neither *psoas* nor *iliacus*. Their *pectineus* is long and slender, as well as the *obturator externus*. They have but one *adductor femoris*, which arises from the symphysis pubis, and is inserted into the upper part of the thigh, about one-third from the head.

The *Cetacea* have not even a rudiment of the muscles of the thigh.

C. *In Birds.*

Birds have neither *psoas iliacus*, nor *obturator externus*. The muscle which *Vicq D'Azyr* has named *iliacus*, is no other than the *glutæus minimus*. They have two *adductors* in the common situation.

In the part occupied by the *pectineus* of *quadrupeds*, there is a little slender muscle which is prolonged to the knee. Its tendon passes obliquely over, and then under the leg, to join the *flexor perforatus* of the second and fifth toes. We shall speak of it presently.

D. *In Reptiles.*

In the *frog* there is only one *glutæus*, which is in the place of the *medius*. It arises from the elongation which supplies the place of the os ilium, and is inserted below the head of the femur.

The *pyriformis* comes straight from the point of the coccyx, and is inserted about one-third from the top of the os femoris.

The *gemini* and the *obturator internus* are wanting.

The *quadratus femoris* is long. It arises from the posterior symphysis of the ischium, and is inserted into the inner side of the thigh-bone, about one-third from the head.

They have neither the *psoas magnus* nor *parvus*.

The *iliacus* is proportionally elongated.

The *pectineus* descends to the middle of the thigh-bone.

The *three adductors* have the same origins and insertions as in man.

The *obturator externus* is to be found, though there is no foramen ovale. It arises from the symphysis pubis, and its fibres are attached to the capsular ligament.

In the *tortoise* the muscles of the thigh produce motions proper to swimming; that is to say, the abduction, adduction, depression, and elevation of the thigh.

The

The muscle analogous to the *adductor longus* arises from the symphysis pubis, and is inserted into the internal part of the thigh-bone, about one-third from its tibial extremity.

Another muscle, which cannot easily be compared to any in man, arises from the interior of the sacrum, and is inserted into the little trochanter. It is another *adductor femoris*.

A muscle composed of different radiated fasciculi, arises from the broad inferior surface of the os pubis, and forms a thick tendon, inserted into the little trochanter. It occupies the place, and answers the purposes of the *psoas* and *iliacus*.

That which is analogous to the *adductor brevis* arises from the symphysis of the bones of the ischium and the interosseous ligament of the pubis. It is inserted into the os femoris below the little trochanter.

The muscle answering to the *glutæus maximus* arises from the spine opposite to the last rib, and is inserted into the thigh-bone, below the great trochanter.

The muscles analogous to the *glutæus medius* and *minimus* can hardly be distinguished from each other. They rise from the internal surface of the os pubis, and are inserted into the great trochanter.

That which resembles the *obturator internus* arises from the internal surface of the ilium and the superior edge of the cotyloid cavity, and is inserted into the great trochanter.

ARTICLE V.

Of the Bones of the Leg.

THE human thigh-bone becomes thicker towards the extremity next the tibia. It there forms two eminences, which rise from the axis of the bone, and which are named the *internal* and *external condyles of the os femoris*. Each is furnished with an articular surface like the segment of a wheel, which corresponds to another in the tibia, one of the bones of the leg. They are likewise as it were separated before by a large notch or articular depression, in which the *rotula*, a little bone situated upon the knee, moves. Behind the condyles there is a hollow which is called the *fossa poplitea*.

The two condyles of the os femoris are unequal. When that bone is placed in an erect position by resting the condyles upon a horizontal plane, its axis leans towards the external side.

This observation is worthy of notice; for, in quadrupeds, the position of the condyles is horizontal, and the axis of both thigh-bones parallel in a state of rest, while the situation of the condyles in birds is so oblique, that the coxal extremities and the whole axis of the bones bend towards the central line, or take a direction opposite to the human.

A. *In Man.*

The leg is composed of two bones; a larger, called *tibia*; and a smaller, attached to the exterior side of it, called *fibula*, or *perone*.

The tibia is articulated with the thigh-bone by a broad surface, in which we find two slight depressions that correspond with the condyles of the thigh. The femoral extremity of this bone is much larger than the middle part, and has three longitudinal ridges, which continue almost three-fourths of the length of the bone. The anterior one is called the *spine of the tibia*, and is flattened towards the top into a large rough triangular surface. That of the outside is next the fibula, and serves for the insertion of a membrane, occupying the space between these two bones, and which is called the *interosseous ligament*. The third ridge is internal, and somewhat posterior.

The superior extremity of the fibula is connected to the tibia beneath a projection at its external and posterior angle. And as the bodies of both become smaller, there is a space between them, larger towards the top, but contracted below. The fibula has also three longitudinal edges.

These two bones are incapable of that rotatory motion on each other which those of the forearm possess.

The

The fibula is joined to the tibia by three sorts of ligaments. The one a capsule, which binds the articular surface of the superior extremity to the head of the tibia. The second is a ligamentous membrane, which fills the whole space comprized between the two bones, and unites them by those ridges which are next each other. The third kind is produced by fibres which arise obliquely from the tibia, and extend to the malleolus externus both before and behind.

Over the articulation of the os femoris with the tibia, and between the condyles of the former, there is placed a little bone, almost circular, but rather pointed towards the lower part. It is convex, and rough before, and has, on its posterior part, two articular surfaces, which correspond with those of the thigh-bone. It is suspended, in this place, by ligaments and muscles, and prevents the extension of the tibia beyond a right line. It is called *rotula*, or *patella*, and is the bone that forms the angle of the knee.

The articulation of the four bones which form the knee is strengthened by a great number of ligaments. There is, in the first place, a capsule, which rises from the circumference of the condyles of the femur, and is inserted into the edges of the rotula and tibia. We next observe some fasciculi of ligamentous fibres which pass in different directions. Some rise from the external condyle of the thigh, and are inserted into the
inside

inside of the head of the tibia. One ligament proceeds from the internal condyle, and is inserted into the external side of the tibia, and even into the fibula. In the joint itself are situated two ligaments, placed crossways one over the other, and called the *crucial ligaments*; they proceed from the posterior part of the condyles of the thigh, and are inserted into the middle of the elevated line that divides the two articular depressions of the head of the tibia.

Two *interarticular ligaments* of a semilunar form, are also interposed between the tibia and os femoris: they are retained in their situation by little bundles of ligamentous fibres, which rise from different points of the capsule. Finally, the rotula has a peculiar and very strong ligament which proceeds from its pointed end to the spine of the tibia. It seems to be of a tendinous nature, and produced by the termination of the tendon of the exterior muscles, in the substance of which this super-articular bone is enclosed.

B. *In other Mammiferous Animals.*

The bones of the leg are generally the same in the inferior mammalia as in man.

In *monkeys*, the anterior spine of the tibia is not very distinct.

In the *bat*, the fibula is extremely slender; and
as

as the thighs are turned backward, the legs must have the fibulæ facing each other.

In the *mole*, the fibula is ossified to the tibia, about one-third of the lower part of its length.

The tibia of the *bear* is somewhat curved forward: the tuberosity of its anterior edge is very prominent, and its articular surfaces very far back.

The *dog* has the fibula attached to the whole length of the tibia posteriorly.

The fibula of the *opossum* is large and much bent, which separates it considerably from the tibia.

The *longtailed manis*, the *armadillo*, and the *sloth*, likewise have the fibula pretty large, curved, and separate from the tibia.

The Rodentia have the fibula entirely behind. *Rats* have it ossified to the tibia about one-third from its lower end. In the upper part it forms a large vacant triangular space.

In the *elephant*, the *rhinoceros*, and the *hog*, the fibula is flat and anchylosed in its whole length to the tibia.

In the Ruminantia it does not exist. This bone seems supplied by a small osseous substance placed on the external edge of the astragalus below the tibia, and forming the malleolus externus.

Finally, in the *horse*, the fibula is only a rudiment anchylosed by age to the upper part of the tibia.

C. *In Birds.*

Birds have the lower part of the thigh-bone nearly disposed like that of mankind.

The leg is likewise formed by the tibia, the fibula, and the rotula.

The tibia differs but little from that of the mammalia, except in its lower extremity, as we shall see in treating of the tarsus. The anterior and superior tuberosity has generally two ridges.

The fibula is always ossified to the tibia, and never reaches its lower extremity.

The *diver* and the *little grebe* have the tibia prolonged in the front of its articulation with the thigh-bone: this prominence has three surfaces; it serves for a rotula, and furnishes insertions for the muscles.

In the *manchot*, this prolongation of the tibia has already been remarked, but the projection which it makes before the knee is scarcely the length of a centimetre.

D. *In Reptiles.*

Oviparous quadrupeds have the tibia and fibula distinct and separated from each other throughout their whole length. These two bones are nearly of the same magnitude in the *tortoises* and *lizards*.

The *frog* has but one bone, but a furrow seems to indicate the union of the tibia and fibula.

In these animals the tibia and fibula are, for the most part, directly articulated to the thigh-bone.

ARTICLE VI.

*Of the Muscles of the Leg.*A. *In Man.*

THE extensors of the leg all terminate in one common tendon, which is inserted into the rotula, and thence continu'd to the anterior tuberosity of the tibia. These muscles are four in number: the three first of which, the *vastus internus*, the *vastus externus*, and the *cruralis*, are by many regarded as one single muscle, which they nam

TRICEPS-FEMORIS, or TRIFEMORO-ROTULARIS.

The *cruralis* arises from the whole anterior surface of the thigh-bone, the *vastus externus* from the region of the great, and the *internus* from that of the little trochanter.

The fourth extensor is the

RECTUS ANTERIOR, or ILIO-ROTULARIS,

Which arises from the spine of the os ilium, and extends along the whole anterior part of the thigh.

The flexors of the leg are all inserted into the internal side of the tibia, except one, which is inserted into the fibula. This is the

BICEPS, or ISCHIO-PERONEUS,

Which receives one part of its fibres from the
tuberosity

tuberosity of the os ischium, and the other from the middle of the linea aspera of the os femoris. These two unite in one small tendon, which is inserted into the head of the fibula.

From the same tuberosity of the ischium, arise two other muscles situated behind the biceps, viz.

THE SEMIMEMBRANOSUS, *or* ISCHIO-SUBTIBIALIS, *and* THE SEMITENDINOSUS, *or* ISCHIO-PRETIBIALIS.

The first is inserted into the tibia by a flat thin tendon, and the other a little lower down, by a round and slender tendon. Under the semitendinosus is inserted

THE SARTORIUS, *or* ILIO-PRETIBIALIS,

Which arises from the spine of the os ilium, and passes spirally over the fore part to the inside of the thigh, somewhat lower than the others.

THE GRACILIS, RECTUS INTERNUS, *or* PUBIO-PRETIBIALIS.

This muscle arises from the lower edge of the symphysis pubis, and descends straight along the inner side of the thigh.

Lastly:—

THE POPLITEUS, *or* POPLITO-TIBIALIS.

This is a little muscle situated behind the knee: it extends obliquely from the external
Cc 2 condyle

condyle of the thigh to the internal part of the head of the tibia.

These muscles, with the adductors of the femur, &c. form altogether the long and round mass which surrounds that bone, and is called the thigh. They are all inclosed in an aponeurotic sheath, called the *fascia lata*, which is provided with a particular muscle, ILIO-FASCIALIS, the fibres of which are entirely covered by the aponeurosis.

B. In other Mammiferous Animals.

The thigh of the *monkey* is less round than that of man; their muscles, however, differ but little from his, except the *biceps*.

In *quadrupeds*, in general, the thigh being pressed against the flank, the fleshy mass becomes more compressed. The *sartorius* and *gracilis* form the anterior edge of the thigh in the Carnivora and Rodentia.

In the *horse* the *sartorius* becomes more conspicuous, and takes the name of ADDUCTOR LONGUS, in opposition to the *gracilis internus*, which is called ADDUCTOR BREVIS.

In *all quadrupeds*, and even in the *monkey*, the muscle analogous to the *biceps* in man has only a single head rising from the os ischium: it covers a large portion of the external surface of the thigh, and not only transmits fibres to the fibula,

fibula, but likewise to the whole length of the *fascia lata*, so that it thus performs the office of an extensor of the thigh. This is the muscle which Bourgelat has named *VASTUS LONGUS* in the *dog* and the *horse*.

The *gracilis internus* is large in all quadrupeds, and particularly in those that have the thigh short. In the *hoofed animals*, therefore, it forms a very considerable muscle. Bourgelat calls it *ADDUCTOR BREVIS*, and gives the name of *GRACILIS INTERNUS* to the muscle which is analogous to the *semitendinosus*.

The *semimembranosus* and *semitendinosus* are found in all quadrupeds as well as in man; but they are both inserted into the tibia by a broad aponeurosis. It must also be remarked that their point of insertion is lower than that of man. This conformation keeps the leg perpetually in a state of semiflexion, and is one of the causes which prevent quadrupeds from walking upright. In *monkeys* these muscles are also inserted very low in the tibia.

The extensors, that is to say the *rectus anterior* and the *triceps*, are found in quadrupeds as well as in man, with some small difference in their proportions.

The *bats*, in which the posterior extremities seem turned in such a manner that they bend backward, have only two muscles proper to the leg; one, which supplies the place of the *sartorius*, the *gracilis*, the *semitendinosus*, and the *semimembranosus*,

membranofus, rises by two fleshy bellies separate from each other, between which the *adductor femoris* passes. The first of these portions comes from the anterior part of the ilium, and the other from the pubis and the ischium. They form one common tendon, which goes to what is commonly the posterior, but which is here the anterior part of the leg, and is inserted into the tibia below its articulation with the os femoris. This is the flexor of the leg.

The extensor of the leg rises by a single fleshy belly, from the superior extremity of the os femoris. Its tendon is slender, and is inserted into the posterior extremity of the leg, which, we repeat, is here turned round.

C. In Birds.

The extensors of the leg in birds are nearly the same as those of quadrupeds; they have three flexors.

The most external seems analogous to the *biceps* in man. It rises from the whole spine of the ischium, and sends off a round tendon, which passes through a ligamentous pulley under the joint of the knee, and is inserted into the fibula.

The internal is analogous to the *semimembranofus*. It arises from the extremity of the ischium, and is inserted in the inner side of the head of the tibia.

The third, which is intermediate, is wanting
in

in several birds, particularly in *those of prey*. It likewise arises from the spine of the ischium, and its tendon receives a second bundle of fleshy fibres from the bottom of the thigh. It passes between the gastrocnemii, and is inserted into the posterior surface of the tibia.

The *sartorius* forms the anterior edge of the thigh, but it inclines towards the inner side.

D. In Reptiles.

The *frog* has the thighs round, like those of a man, and the muscles of the leg very conspicuous.

The *triceps femoris* is formed only of two very distinct portions. The *vastus externus* and the *cruralis* are manifestly but one.

There is no *rectus anterior*.

The *biceps flexor cruris* has only one belly. It arises from the posterior and interior part of the ilium, and is inserted into the exterior and anterior surface of the tibia, for there is no fibula.

The *semimembranosus* is like the human; but the *semitendinosus* is composed of two bellies, one of which rises from the symphysis pubis, and the other from that of the ischium.

The *sartorius* is situated exactly in the front of the thigh, without any obliquity.

There is nothing remarkable in the *gracilis*.

There is no distinct *popliteus*.

Some differences occur in the muscles of the leg of the *tortoise*. These have a relation to the faculty of swimming, for which its extremities are fitted.

The muscle which takes the place of the *semi-membranosus* arises from the interosseous ligament of the pelvis, and proceeds to form a strong aponeurosis at the inferior part of the leg.

That which is corresponding to the *semi-tendinosus* arises also from the interosseous ligament: it passes under the ham, and is inserted into the tibia, which it bends.

That which is analogous to the *sartorius* arises from the os pubis near the interosseous ligament, and passes over the knee, to be inserted into the tibia, which it extends.

A muscle, composed of two fleshy portions, both of which arise from the lateral parts of the sacrum, is inserted below the head of the tibia, and bends the leg. In its action it much resembles the *biceps*, from which, however, it differs with respect to its attachments.

Another muscle resembling the fascia lata, and very thin in its fleshy part, arises from the sides of the coccyx. It passes under the skin of the fin to its insertion almost opposite to the heel. It bends the leg upon the thigh, and extends the foot upon the leg.

The muscle analogous to the *biceps* arises from the sacrum and ilium. It goes to the external surface of the leg, where it is inserted into the fibula.

The *extensor* of the leg presents nothing particular.

The muscle analogous to the *rectus anterior* arises from the internal surface of the pubis, and joins the common tendons of the *extensors*.

ARTICLE VII.

Of the Bones of the Ankle or Tarsus, and those of the Metatarsus.

A. In Man.

THE tibia, which is nearly triangular at the top and the middle, becomes round towards the bottom, where it is sensibly enlarged. It is truncated by a flat articular surface. There is a slight elevation in the middle, passing from the front backwards; on the inner side there is a descending production called the *malleolus internus*.

Upon the external side of the inferior extremity of the tibia, there is a depressed articular surface that receives the fibula, which is here prolonged downward to form the *malleolus externus*, that is longer than the *internus*.

Under the articular surface of the tibia, and between the malleoli, there is a pulley-shaped or semi-cylindric portion of the *astragalus*, the first bone of the ankle or *tarsus*.

This

This bone moves freely by ginglymus, giving to the foot a motion like a balance ; but as the articulation is lax, it has also a confined motion sideways.

The astragalus, besides its articular part, has two short and thick processes, one descending anteriorly, and turning somewhat inward ; the other posteriorly, and outward. The first receives the *os scaphoides* upon its digital extremity, and is joined by an articular portion of its inferior surface to a particular process of the *calcaneum*. The other process of the astragalus extends to the body of the *calcaneum*.

This second bone of the tarsus has, besides the process on its internal surface which supports the astragalus, an anterior production directed somewhat outward, and parallel to the side of that of the astragalus : it is at the same time lower than the latter. The other is turned backward, and terminates in a large tuberosity, which projects downward, and forms the heel.

The anterior process of the *calcaneum*, or *os calcis*, supports the *os cuboides*, to which the two metatarsal bones of the two last toes are applied. Those of the three first are supported by the three *ossa cuneiformia*, which are placed in front of the *os scaphoides*.

Several ligaments strengthen the articulation of the bones of the leg with those of the ankle. Some extend from the malleolus externus, or the
tarsal

tarfal extremity of the fibula, to the astragalus and os calcis: one rises from the malleolus internus or tibialis, and is inserted into the astragalus, and the circumference of the os scaphoides; its figure is triangular. Lastly, a capsular ligament unites the articular cavity of the tibia to the circumference of the articular surface or pulley of the astragalus.

The metatarsal bones are parallel, nearly of an equal length, and retained by ligaments analogous to those of the metacarpus,

B. *In other Mammiferous Animals.*

Quadrupeds with toes have almost all the bones of the tarsus nearly resembling those of man. The following are the principal differences:

In the *monkeys* the articular surface of the astragalus, opposite to the fibula, is almost vertical; that next to the malleolus tibialis is, on the contrary, very oblique, and the anterior production of that bone is turned more inward. It hence follows that the foot rests more on its external edge than on the sole.

The os calcis has not the large tuberosity which forms the heel at its posterior extremity: on the contrary, it is turned upward, except in the *Batavian pongo*, in which this bone is similar to that of man.

The

The first os cuneiforme is shorter than the human, and has an evident groove for the muscles of the great toe.

The metatarsal bone of the great toe is shorter by one-half than the others, and can be easily held asunder from them.

Amongst the *lemurs*, the *tarsier* and *galago* have the calcaneum and os scaphoides excessively long, which produces a disproportion in the whole posterior extremity, and gives to the foot of these animals the appearance of a hand and fore-arm.

The *Pedimana*, in which the fibula is equal to the tibia at the bottom, have the astragalus very small, and articulated almost exactly between them. The os calcis is short, and the first cuneiforme is very large, and of a semilunar shape.

The *opossum* has a little supernumerary bone on the edge of the first os cuneiforme.

In the *Carnivora* the middle projection of the lower surface of the tibia is stronger, and the ginglymus more complete than in man; but the lateral movements are more obscure.

The first cuneiform bone is less in proportion to the others.

The heel is longer: it terminates quite straight in those that tread only upon the toes: but it has a small tubercle in those that walk entirely on the sole.

Those that have only four toes have the first os cuneiforme smaller.

In

In the common *bat* the os calcis is of a considerable length. It is a styloid bone, concealed in the thickest part of the membranes of the wing which it supports; but in the *ternate bat* the tuberosity of the os calcis turns under the foot, being curved like that of the cuneiform bone of the carpus in man.

With respect to the *Plantigrada*, the *mole* is particularly remarkable in having its tarsus articulated only to the tibia, to which the fibula is completely ossified at its lower parts.

The *Rodentia* have the os calcis much prolonged posteriorly.

The following facts in those that have five perfect toes are remarkable:

In the *beaver* the os scaphoides is divided into two parts; one situated in front of the astragalus, and supporting the second and third ossa cuneiformia; the other at the inner side of the astragalus, sustaining the cuneiform bone of the great toe, and a flat supernumerary bone placed along the inner edge of the tarsus.

The same structure is observable in the *marmotte*.

The *porcupine* and the *paca* have the scaphoides divided, but the supernumerary bone is not found in these animals.

The *squirrel* has this inner portion of the scaphoides very small; it does not support the cuneiform bone belonging to the great toe.

In all, the scaphoides forms a tubercle under the sole; that of the *paca* is elongated.

Among

Among those that have four toes only, the *jerboa of the Cape*, which is remarkable for a long foot, has the inferior tubercle of the scaphoides elongated and very prominent; upon the internal edge of the tarsus are some long flat bones, which are probably the rudiments of the great toe.

There is nothing similar in the *rabbit* and *bare*, though these animals resemble the *jerboa* in the tubercle of the scaphoides.

In the *cavy* and *agouti*, which have only three toes, we find this internal part of the scaphoides supporting a single bone that answers to the first os cuneiforme, and the rudiment of the great toe externally. Upon the cuboides there is a small bone which may be regarded as a rudiment of the little toe.

In the Edentata the tarsus of the *three-toed sloth* is very remarkable, both with respect to its articulation and form. It is composed of only four bones, viz. the astragalus, the os calcis, and two cuneiformia. The astragalus is articulated with the fibula, the os calcis and the great cuneiforme. The articulation with the fibula takes place through the means of a conical depression in the superior surface of the astragalus, and in which is received the head of the bone, the figure of which corresponds in relief with that of the depression of the astragalus. Upon the internal lateral part there is an articular convex surface which rolls upon the external portion of the tar-
fal

sal extremity of the tibia. From this mode of articulation it follows, that the foot of the *sloth* cannot be moved up and down, and that it is only capable of the lateral motions of adduction and abduction: It possesses therefore the faculty of embracing the trunks of trees, and climbing them; but the action of walking is rendered extremely difficult.

The articular surface of the os calcis is a simple tubercle received in a depression of the astragalus: this also assists the motions we have just described. Its tuberosity, or the heel, is considerably elongated, and forms more than two-thirds of the bone.

The two ossa cuneiformia present nothing particular in their structure. The internal is articulated with the astragalus, the external with the os calcis.

The *elephant* has the tarsus and metatarsus very short; these parts have nothing singular, only that the cuboides turns inwardly quite before the scaphoides.

In the *hog* there are, upon the scaphoides, the three common cuneiform bones, and one below the first, which seems the rudiment of a great toe.

The *tapir* and the *rhinoceros* have only two cuneiformia; and here we must remark, that all the animals hitherto mentioned have as many metatarsal bones as toes.

In

In the Ruminantia, the cuboides and the scaphoides are united together, except in the *camel*, which has them distinct: at the outward side of the pulley of the astragalus, there is a bone which seems to represent the inferior head of the fibula. It is articulated to the top of the os calcis.

There are only two cuneiform bones: in the *giraffe* they are united by ossification. The two metatarsal bones are always anchylosed, and form a cannon bone, as in the metacarpus.

In the Solipeda there are two cuneiform bones; and the os scaphoides is distinct from the cuboides. The little peroneal bone is wanting, as well as the articular surface of the os calcis that receives it.

The bone of the metatarsus is also single, and called the cannon bone of the hind leg. It has a little osseous stile on each side.

C. In Birds.

In birds in general, the fibula terminates by uniting into one with the tibia about its middle. The latter ends in two condyles, like wheels, between which there is a sort of pulley. The single bone which represents the tarsus and metatarsus, has as its head a projection in the middle, and two lateral depressions. It consequently moves in a ginglymus, and bends forward, but it cannot go beyond a right line in the opposite direction.

Its

Its proportional length varies : it is extremely long in the birds that seek their food on the sides of rivers, lakes, &c. and which are for that reason called *stilts* or *waders*.

At the lower end it terminates in three processes, shaped like pulleys, for the three anterior toes. At the internal side it produces a little bone that supports the posterior toe or pollex.

In the *horned owl* the process of the external toe has its flexure directed outward, and simply convex, which permits the toe to turn horizontally upon it.

It is turned directly backward in birds that climb.

In those that have no back toe, the little bone is wanting.

The *ostrich* has only two articular processes, which correspond to its two toes.

The *manchot* has the three bones which represent the tarsus and metatarsus separate from each other at their middle part ; but they are united at their extremities, one of which receives the tibia, and the other the three toes.

D. *In Reptiles.*

The astragalus is articulated to the tibia, and the os calcis to the fibula in all reptiles.

The tarsus of the *crocodile* has five bones, viz. an astragalus, an os calcis, two cuneiformia,

answering to the two middle metatarsal bones, and one out of the range which answers to the external metatarsal bone.

There are four metatarsal bones.

The bone situated without the range serves to support the little toe in the *mud tortoise*. In the *sea tortoise* it is very flat. The os calcis and astragalus are very small.

In *frogs* the astragalus and the os calcis are very long, and might at first sight be taken for the tibia and fibula, if they did not form the third joint of the posterior extremity. There are on the fore part, four little cuneiform, five metatarsal bones, and one in the form of a hook, which is very minute. These are similar in the *Surinam* and *common toad*.

ARTICLE VIII.

Of the Muscles of the Ankle or Tarsus, and of the Metatarsus.

THE muscles which affect the foot are,

1st. Those which act upon the heel by means of the *tendo Achillis*. They extend the foot, and are the principal agents in walking and leaping.

2d. Those which bend it.

3d. Those that lift up either of its sides.

The

The *tendo Achillis*, which is inserted into the head of the os calcis, has three muscular bellies.

1. THE GASTROCNEMIUS, OR BI-FEMORO-CALCANEUS.

These muscles arise from the two condyles of the thigh, and compose the calf of the leg.

2. THE SOLEUS, OR TIBIO-CALCANEUS

Is situated before the others. In man, where it is of considerable magnitude, it rises from the posterior surface of the upper part of the tibia and fibula.

These muscles are very large in man, as he has the calf of the leg much greater than any quadruped.

The three muscles are always to be found, but the *soleus* is not so large in quadrupeds as in man. It arises from the external surface of the superior head of the fibula. It is remarkably slender in the Ruminantia and Solipeda.

3. THE PLANTARIS, PLANTARIS-GRACILIS, OR FEMORI-CALCANEUS,

Spreads its tendon, in man, over the outward edge of the *tendo Achillis*, and has scarce any function except raising the capsule. It is therefore very small.

In *monkeys*, this muscle is evidently continued along with the plantar fascia. We shall see

hereafter, that in the other quadrupeds it supplies the place of the *flexor perforatus*.

In *birds*, the tendons of the *gastrocnemii* remain separate till very near the heel. The *soleus* runs inwardly, and is inserted into a *linea aspera* which belongs to the tibia. It is proportionally larger than in quadrupeds.

The flexion of the foot with respect to the leg, or of the leg with respect to the foot, is performed by

THE TIBIALIS ANTICUS, CRURALIS ANTERIOR,
OR TIBIO-SUPER-TARSEUS,

Which arises from the anterior surface of the tibia. Its tendon having passed through the annular ligament of the leg, runs to the inside of the foot, where it is inserted into the first cuneiform and the metatarsal bone of the great toe.

In animals which have no great toe, such as the *dog* and the *rabbit*, it is inserted into the metatarsal bone of the second toe, which with them is the first.

It always raises in some degree the inside of the foot.

In the Bifulci and Solipeda, it is inserted into the anterior surface of the base of the cannon bone.—It is similar in *birds*.

Besides the action of the tibialis anticus, the inner side of the foot is likewise raised by

THE

THE TIBIALIS POSTICUS, CRURALIS POSTERIOR, *or* TIBIO-SUB-TARSEUS.

This muscle rises from the posterior surface of the tibia. Its tendon runs behind the malleolus internus, and is inserted into the under part of most of the bones of the tarsus.

In the *monkey*, its tendon contains a sesamoid bone of considerable size, situated under the os scaphoides.

In animals that have no great toe, such as the *dog*, the tendon of the tibialis posticus is inserted into the edge of the base of the metatarsal bone of the first toe; and in the *rabbit* it even extends to the second phalanx. It acts, therefore, as an abductor of that toe.

It is entirely wanting in the quadrupeds that have *cannon bones*, and in *birds*.

The external side of the foot is raised by the *peroneal muscles*. Man has three which arise from the fibula, and transmit their tendons behind the malleolus externus.

THE PERONEUS LONGUS, *or* PERONEO-TARSEUS.

This muscle adheres to the under part of the os cuboides, crosses the sole of the foot, and is inserted in the metatarsal bone of the great toe, and the first os cuneiforme.

THE BREVIS, *or* PERONEI-SUPER-METATAR-
SEUS,

Extends directly to its insertion in the metatarsal bone of the little toe.

THE MEDIUS, *or* PERONEO-SUPER-METATAR-
SEUS,

Extends to the first phalanx of the same toe, and serves to separate it from the others.

The *peroneus longus*, in the *monkey*, has the peculiar office of bringing the great toe towards the other toes. In animals which have no great toe, it is inserted into the metatarsal bone of the first toe.

In *ruminating* animals it crosses below the joint of the cannon bone in the same manner, and proceeds to its insertion in the first os cuneiforme.

The two other *peronei* in the *monkey*, and all unguiculated animals, resemble the human, except that, in the *rabbit*, the *medius* sends off a tendon to the last but one of the toes, thereby performing the function of abductor to the two outermost toes.

In the Ruminantia this tendon extends to the two toes, but the *brevis* is wanting.

The *horse* has but one *peroneus*, which unites its tendon to that of the *extensor digiti*, about the middle of the anterior surface of the cannon bone.

In

In *birds* there is a *peroneus brevis*, which is inserted into the external base of the metatarsal bone; and also a muscle seemingly analogous to the *peroneus medius*, (FLEXOR DIGITORUM ACCESSORIUS of *Vicq D'Azyr*.) Its tendon is bifid; one passes backward, and is inserted into the posterior surface of the head of the metatarsus; the other descends along the external surface of that bone, and is united with that of the *flexor perforatus* of the middle toe.

B. In Reptiles.

In the *frog* the *gastrocnemius* has only one belly; it has however a small tendon by which it is inserted into the outward side of the head of the tibia. Its tendon runs under the heel, and there sliding over a sesamoid bone, expands itself under the foot to form the plantar fascia.

There is neither *soleus* nor *plantaris*.

The *tibialis anticus* rises by a strong tendon from the lower part of the os femoris. About the middle of the tibia it divides into two bellies, one internal, the other external. The tendon of the first is inserted into the tibial base of the long bone of the tarsus, and that of the second into the same bone, a little more outwardly.

An assistant to this muscle arises from the

middle and anterior part of the tibia, and proceeds to the internal side of the base of the long bone of the tarsus.

The *tibialis posticus* resembles the human, but it is only inserted into one bone of the tarsus, viz. that which is long, and situated at the inner side.

There is but one muscle to which the term *peroneus* can apply. It arises by a slender tendon from the external condyle of the thigh, and is inserted into the base of the tibia on the outside, by two tendinous portions, one of which extends to the bone of the tarsus. It extends the leg with respect to the thigh, or more properly the thigh with respect to the leg.

Besides these muscles, which extend from the leg to the foot, there is another, which arises from the metatarsal extremity of the tibia, at its internal edge, passes between the two bellies of the *tibialis anticus*, and proceeds very obliquely to its insertion at the digital extremity of the long bone of the tarsus, on its inner side.

In the *sea tortoise* the muscles of the feet are supplied by aponeurotic fibres, somewhat fleshy, which serve only to strengthen the articulations, and keep the fins properly extended.

ARTICLE IX.

*Of the Bones of the Toes, and their Motions.*A. *In Man.*

ALL the toes have three phalanges, except the great toe, which has only two. This, in man, is the longest and thickest; the rest gradually diminish to the fifth: they are short, and remain parallel to each other; their ligaments are the same as those of the fingers.

B. *In other Mammiferous Animals.*

The Quadrumana and Pedimana have the toes longer than the human; but the great toe is shorter than the rest, and its metatarsal bone is capable of being brought close to the others, or separated from them like the thumb.

The *aye-aye*, or *Madagascar squirrel*, one of the Rodentia, seems to possess the same faculty.

In the Carnivora the great toe is always united and parallel to the other toes. The *bears*, *coatis*, *civets*, *badgers*, *racoons*, and *moles*, have it nearly equal to the other toes. The *weasels* and *shrews* have it very little shorter.

In the *cats* and *dogs* it is perfectly obliterated.

Among the Rodentia, the *beaver* has the great toe nearly equal to the other toes; the *marmotte*,
the

the *porcupine*, and the *rats*, have it shorter. The *paca* has it almost obliterated. In the *jerboa* of the *Cape*, it is completely obliterated, and reduced to a single bone.

The *hares* have not even a rudiment of it.

In the *cavys*, the *agouti*, and the *Guinea pig*, the great and little toe are each reduced to a single bone.

The *jerboa* (*mus jaculus*), and the *alastra* (*mus sagitta*), have their three middle metatarsal bones consolidated into one cannon bone. The two lateral toes are distinct, but shorter in the *jerboa*. They are obliterated in the *alastra*.

Among the *Edentata*, the *ant-eaters*, the *orycterope* (*myrmecophaga capensis*), the *pangolins* and the *armadillos* have five toes. The great toe is shorter than the others in all; and in the *armadillos* the little toe is likewise shorter.

In the *sloths* the great and little toe are reduced to a very small single bone. The other bones of the metatarsus are ossified together at the base. There are only two phalanges to the toes; that which supports the nail being the largest of the two.

In the families of animals which follow, the metatarsal bones deserve to be considered by themselves. In the *elephant* and other *Pachydermata*, the tarsal extremity presents a flat surface; and that which is opposed to the phalanges is a convex tubercle, which has on the under side a projecting longitudinal line in the middle of
the

the bone. In the Solipeda this line is found both above and below. In the Ruminantia, in which the cannon is formed by the two metatarsal bones, a deep line, like the cut of a saw, at the union of the two bones, may always be remarked. The conformation is the same in the pectoral member.

The *elephant* has five perfect toes.

The *hog* four.

The *tapir* and the *rhinoceros* three.

The Ruminantia have two perfect toes upon a single metatarsal bone, and two little ones attached to the lower part of the same bone, which sometimes has on each side a styloid process.

The Solipeda have one perfect toe, and two imperfect, reduced to a single bone in the form of a style.

In Birds.

In Birds the number of phalanges generally increases from the pollex to the fourth toe, which has always the greatest number.

Those that have four toes have the number and order of the phalanges as follows :

2, 3, 4, 5.

Among those that have only three toes, the *cassowary* has them thus disposed :

4, 4, 4.

The rest have them thus :

3, 4, 5.

The

The *ostrich*, which has only two toes, has four phalanges in each.

Those which have four toes have them either all four in front, as the *martins*, or (more generally) three before and one behind; or, like the *Scanfores*, two before and two behind; as the *parrots*, *toucans*, *barbets*, *cuckows*, *curucuis*, and *woodpeckers*.

Those that have only three toes have them all before. These are the *bustard*, the *cassowary*, the *plover*, the *oyster-catcher*, and the *long-legged plover*, (*charadrius hemantopus*).

Among the *Palmipedes*, -the *albatrosses*, the *petrell*, and the *penguin*, have the pollex obliterated.

D. In Reptiles.

The number of the toes varies much in reptiles; as may be seen from the following table.

Number of the phalanges of the toes of reptiles, exclusive of the metatarsal bones, beginning at the pollex or internal toe.

Crocodile,	2, 3, 4, 4.
Lizard,	2, 3, 4, 5, 4.
Cameleon,	3, 3, 4, 4, 3.
Salamander,	2, 3, 3, 3.
Sea Tortoise,	2, 3, 3, 4, 2.
Mud Tortoise,	2, 3, 3, 3, 2.
Frog,	1, 2, 2, 3, 4, 3.

ARTICLE

ARTICLE X.

Of the Muscles of the Toes.

THE toes, like the fingers, have *extensors*, *flexors*, *abductors*, and *adductors*, either common or proper, long or short.

I. The extensor muscles are :

A. *In Man.*

THE EXTENSOR LONGUS DIGITORUM PEDIS,
or PERONEO-SUPER-UNGUIALIS.

THE EXTENSOR LONGUS POLLICIS PEDIS, or
PERONEI-SUPER-UNGUIALIS.

These muscles are situated on the fore part of the leg behind the tibialis anticus. Their tendons pass below the annular ligament of the leg. The second sends its tendon to the great toe; the first to the other four toes. They extend to the extremities of the toes.

THE EXTENSOR BREVIS DIGITORUM PEDIS, or
CALCaneo-SUPER-UNGUIALIS,

Extends over the upper surface of the foot, and detaches its tendons to all the five toes.

B. *In other Mammiferous Animals.*

The *monkeys* have three muscles, like man ; but there is besides, at the inner side of the *extensor longus*

ongus pollicis, an *abductor longus pollicis*, which is wanting in man.

Other *digitated* quadrupeds have only three muscles like man. The *extensor pollicis* is wanting in those animals that have no pollex, as in the *dog* and the *rabbit*.

The quadrupeds with *cannon bones* have fleshy fibres arising from the cannon, and inserted into the tendon of the *extensor longus*, which supplies the place of the *extensor brevis digitorum pedis*.

In the *bisulcated* quadrupeds the internal toe has an *extensor proprius* representing the *extensor pollicis*, but in the Solipeda it is wanting.

C. In Birds.

Birds have the long extensor of the three anterior toes, answering to our *extensor longus digitorum pedis*; but there is no *longus pollicis*.

Instead of the *extensor digitorum brevis*, the anterior surface of the metatarsus is furnished with four distinct muscles:

1. EXTENSOR POLLICIS PROPRIUS.
2. EXTENSOR DIGITI MEDII PROPRIUS.
3. ABDUCTOR DIGITI PRIMI.
4. ABDUCTOR DIGITI TERTII.

VI. The

II. The flexors of the toes are:—

A. *In Man.*

THE FLEXOR LONGUS POLLICIS PEDIS, or TARSO-PHALANGEUS, and

THE FLEXOR LONGUS DIGITORUM PEDIS, or TIBIO-SUB-UNGUIALIS.

These are situated on the posterior part of the legs, before the muscles of the tendo Achillis. They transmit little tendons to the last phalanx of the toes. The tendons of the second pass through those of the *flexor brevis*.

THE FLEXOR BREVIS DIGITORUM PEDIS, or CALCANEO-SUB-UNGUIALIS.

This third flexor is situated under the sole of the foot. It arises from the os calcis, and sends perforated tendons to the four toes.

The FLEXOR LONGUS POLLICIS sends off a tendinous slip, which unites with the tendon of the *flexor longus digitorum*. This tendon has besides a particular fleshy mass, situated above the *flexor brevis digitorum*, and rising like it from the os calcis, but inserted into the tendon of the *flexor longus digitorum*. This is what is called the *massa carnea*.

The great toe and little toe have, besides, each its FLEXOR BREVIS PROPRIUS, (TARSO-PHALANGEUS of the great and little toes,) but they are not perforated. They are inserted into the base of their first phalanges.

The plantar fascia has no connexion with the *plantaris* muscle. It is inserted on one part into the os calcis, and on the other into the inferior heads of the metatarsal bones, and the bases of the first phalanges. It is not the organ of any voluntary motion.

B. *In other Mammiferous Animals.*

In the *monkey* the flexors are differently disposed.

1st. The *plantaris* is evidently continued along with the plantar fascia, and communicates its action to it. 2d. The two *flexores longi* and the *brevis* are mingled together in a very complicated manner, as follows :

a. The part of the *flexor brevis* which extends to the first toe, is alone attached to the os calcis. It transmits to that toe a perforated tendon.

b. The *flexor longus pollicis* (at least the muscle analogous to that which receives this name in man,) sends a tendon as usual to the pollex, and two perforating tendons to the third and fourth toes.

c. The *flexor longus digitorum* sends two perforating tendons to the second and fifth toes.

d. The *three perforating tendons* of the third, fourth, and fifth toes, do not arise from the os calcis, as in man, but their fleshy fibres are attached to the tendon of the *flexor longus digitorum* just mentioned.

e. The

e. The tendons of these long muscles are strongly united.

f. The *masa carnea* is attached by a thin aponeurosis to the tendon of the *flexor longus pollicis*, and sends a strong tendinous band to that of the *flexor longus digitorum*.

The short flexors of the great and little toes are like the human. Such is the structure of a vast number of *monkeys*, and in particular of the *mandrill*.

In some, indeed, it is not quite the same, but there is no very material difference.

In other quadrupeds the *flexor brevis digitorum* is wanting; but the *plantaris*, which is larger than that of man, or of the *monkey*, supplies in them the place of the *flexor perforatus*.

The *flexor digitorum longus* is in them as usual a perforant.

Each furnishes as many tendons as the number of toes requires; four in the *dog* and the *rabbit*, two in the Ruminantia, and one in the Solipeda.

Although the *dog*, the Ruminantia and Solipeda, have no great toe, the *flexor longus pollicis* nevertheless exists. Its tendon is intimately united with that of the *flexor digitorum perforans*. We have not observed it in the *rabbit*.

C. In Birds.

The long flexors in birds are divided into three masses; two placed before the muscles of

the tendo Achillis, one before those, and all close to the bone.

The first is composed of five portions, three of which may be regarded as forming a single *flexor communis perforatus*.

It arises by two bellies, one coming from the external condyle of the thigh, the other from its posterior surface. The latter forms directly the *perforated tendon of the middle toe*, which receives one from the peroneus. The second belly sends off those of the index and little toe. In this muscle is lost the *accessorius femoralis flexorum*, a muscle situated on the internal surface of the thigh, the tendon of which passes over the knee. They are united by fibres which extend from one to the other, and the tendons are inserted into the third phalanges.

The other two muscles of this first mass are the flexors, which are at once both *perforating* and *perforated*.

They arise below the preceding; and one is extended to the first toe, the other to the *middle toe*, perforating two tendons of the preceding. They are inserted in the last phalanx but one.

The other two masses are the *flexores perforantes*; they furnish the tendons which go to the last phalanges. One belongs to the three anterior toes, the other to the posterior. The latter sends off a tendon, which unites with the *perforating* tendon of the *index*.

There

There is a *flexor brevis pollicis* situated on the posterior side of the tarsus.

III. *Muscles of the Toes in Reptiles.*

There is no *extensor longus digitorum* in the frog. Neither is there any *flexor proprius pollicis*.

The *extensor brevis digitorum* is very distinct. It arises from the whole length of the long external bone of the tarsus, and extends obliquely to all the four toes, the last excepted. It is inserted into the last phalanges.

There are *superior* and *inferior interosseous* muscles, which are very apparent, to the number of ten. Their direction is very oblique.

The *flexor communis digitorum* is situated under the long bone of the tarsus, on the inner side, and is covered by the aponeurosis of the gastrocnemius. When it reaches the little bones of the tarsus, it divides into five tendons, which receive, at their inner side, assistant fleshy fibres, apparently proceeding from a muscle situated below the long bone of the tarsus, on the inner side. It may perhaps represent the *flexor longus*.

In the *sea tortoise* all these muscles have their places supplied by bundles of aponeurotic fibres.

*TABLE of the Length in metres of the different
Parts of the Abdominal Member of
Mammiferous Animals.*

SPECIES	Total	Thigh	Leg	Tarsus	Meta- tarsus	Toes
Man	1,11	0,46	0,39	0,11	0,08	0,06
Sai	0,36	0,13	0,12	0,03	0,04	0,04
Orang	0,81	0,09	0,09	0,03	0,04	0,06
Pongo	0,81	0,28	0,24	0,07	0,10	0,12
Ternate Bat	0,175	0,05	0,07	0,005	0,01	0,04
Common Bat	0,06	0,02	0,02	0,01	0,005	0,005
Mole	0,065	0,02	0,02	0,005	0,01	0,01
Hedge-hog	0,12	0,08	0,04	0,015	0,02	0,015
Sea-Bear	0,93	0,35	0,27	0,11	0,09	0,11
Glutton	0,41	0,14	0,13	0,03	0,05	0,06
Racoon	0,36	0,12	0,13	0,04	0,04	0,03
Otter	0,28	0,09	0,09	0,03	0,04	0,03
Seal	0,37	0,06	0,13	0,06	0,04	0,08
Lion	1,07	0,35	0,39	0,11	0,12	0,09
Cat	0,34	0,11	0,11	0,04	0,05	0,03
Wolf	0,61	0,20	0,20	0,07	0,07	0,07
Opoffum	0,20	0,07	0,07	0,02	0,02	0,02
Hare	0,40	0,12	0,14	0,04	0,05	0,05
Guinea Pig	0,15	0,05	0,05	0,015	0,02	0,015
Three-toed Sloth	0,37	0,11	0,11	0,04	0,03	0,08
Phatagin, or Long-tailed Manis	0,155	0,05	0,05	0,02	0,01	0,025
Elephant	1,71	0,85	0,54	0,15	0,08	0,09
Hog	0,81	0,27	0,23	0,11	0,09	0,11
Rhinoceros	1,47	0,59	0,37	0,18	0,17	0,16
Dromedary	1,57	0,50	0,40	0,15	0,33	0,19
Giraffe	2,10	0,50	0,60	0,24	0,74	0,22
Ox	1,15	0,31	0,31	0,14	0,21	0,13
Stag	1,29	0,32	0,38	0,13	0,31	0,15
Horse	1,07	0,33	0,27	0,12	0,21	0,14
Dolphin	0	....	....	....	....	....
Porpoise	0	....	....	....	....	....

ARTICLE XI.

*Of the Posterior Extremity in Fishes.**1st. Of the Bones.*

THE ventral fins of fishes take the place of the abdominal member. The situation and form of these fins vary much; they are even wanting in the family of Apodal fishes, as *eels*, the *gymnotus*, the *anarhicas*, &c. and in some genera of the Chondropterigii and Branchioptegi, as *lampreys*, the *pipe fish*, and some species of *balistes*, *ostracion*, *tetrodon*, &c.

Sometimes they are situated below the throat, beneath the aperture of the gills, and before the pectoral fins. Fishes thus constructed have obtained the name of *jugulares*.

Sometimes they are placed a little behind and below the pectoral fins. These fishes have been called *thoracici*.

Lastly, they are placed in a situation more analogous to that of the abdominal member in other animals, and which also seems most common, that is to say, under the belly and nearer to the anus than to the pectoral fins. Such are the fishes named *abdominales*.

The ventral fins are composed of two principal parts; one consisting of radii, covered with a double membrane, always appears externally, and forms what is properly called the fin. The

other is internal, and represents the ossa innominata, or the pelvis. It is frequently articulated with other bones of the trunk, and always receives the radii of the fin, which move upon it.

The pelvis is never articulated with the spine; nor does it ever form an osseous girdle round the abdomen. The bones which compose it are generally flat and of different shapes; they touch each other only at their internal edges.

The *sharks* and *rays* only have a single transverse and nearly cylindrical bone, at the extremity of which the fins are articulated. The situation of the plane of the bones of the pelvis, with respect to the parietes of the abdomen, varies according to the shape of the body. In flat fishes these bones are turned obliquely, and make the keel of the belly with their internal edge. In fishes, with a broad or cylindrical abdomen, they form a plate more or less horizontal.

In the Jugular and Thoracic fishes, the bones of the pelvis are always articulated to the base of the girdle that supports the pectoral fins. Their figure and respective situation varies very much, as we shall presently see.

In the *sea dragon* and *star-gazer* these two bones are soldered together at their internal edge; their inferior surfaces are opposed to each other, and leave between them an oval space. The angle of their junction projects within the cavity of the abdomen.

In

In the *cottus*, *sciæna*, *chaetodon*, and the *perches*, the bones of the pelvis are likewise united by their internal edge. They are flat and long, and their external edges are directed downward, so as to form a fossa.

In the *trigla cuculus*, or *red gurnard*, these bones are only united at the posterior extremity of their inner edge. They are very broad, flat, and form an oval shield, the middle part of which is furrowed, and the posterior extremity long and pointed.

The bones of the pelvis of the *pleuronectes* bear the fins at their anterior extremity; they are united into a quadrangular pyramid, the point of which tends upward and backward, and its base forward.

In some of the *gasterosteus* the bones of the pelvis are separate, extremely long, and receive near their middle a moveable spine that occupies the place of the fin.

The *dory* (*zeus faber*, Linn.) has the bones of the pelvis triangular and flat; they touch each other in the whole of that part which should be the lowest surface. Their anterior angle is rounded, and receives the fin; the two others are very long and acute. One is situated within the abdomen, the other over the side of the sternum outwardly. In the *zeus vomer* these bones are very small and cylindrical.

In Abdominal fishes the bones of the pelvis are never articulated to the shoulder, or the girdle

of the pectoral fins. They are situated on the middle and inferior part of the belly, at different distances from the anus.

These bones are in general unconnected with each other, and are preserved in their situation by ligaments. In *carps* they are long, and only touch about one-third from the lower end. In *herrings* they are very small, close, and form an addition to the little bones that supply the place of the sternum.

Those of the *common pike* are broad, triangular, and close together at the anterior end, but diverge at the posterior extremity, which is broader, and receives the fin.

In the *anableps* they are very far asunder, and bear upon their external border a very long spine, which ascends towards the vertebral column, and is inflected in the direction of the ribs.

In the *siluri* the bones of the pelvis are united together: they take the shape of an escutcheon, round in the middle, and often spinous in front. The fins are attached to their external and posterior edge.

Lastly, in the *loricaria* the bones of the pelvis are ossified into one piece, the posterior groove of which forms an aperture for the anus. The fins are articulated to the outward edge.

The fin properly so called, in ordinary fishes, consists of a certain number of bony radii, either simple or forked, supported by one or two rows
of

of little ossicula placed between them and the bones of the pelvis. The rays which form the fin move upon the ossicula, so as to open and close like the sticks of a fan. This movement produces the expansion and folding of the fin; but there is still another motion, both of the whole fin, and of its ossicula, upon the bones of the pelvis, by which the fin is alternately raised and brought close to the body.

The radii of the ventral fins are for the most part shorter than those of the pectoral fins.

The ventral fin of the Chondropterygii has a peculiar conformation. Two principal cartilages are articulated upon the extremity of the bone of the pelvis: the one, which is external, forms a kind of finger of seven or eight joints; the other, which is internal, receives all the remaining radii of the fin, frequently to the number of thirty or more.

2d. Of the Muscles.

The ventral fins move up and down, as well as inwardly and outwardly. The muscles which move them from above downward, or depress them, are situated on the external or inferior surface of the pelvis. Those which elevate them are situated on the upper or abdominal surface of those bones.

There is commonly but one muscle for depressing the ventral fin; it occupies all the inferior surface

surface of the bone of the pelvis. In Jugular and Thoracic fishes, it even extends as far as the clavicle: it terminates by several little tendinous slips which are inserted into the ossicula and bases of the radii. At the same time that this muscle, by the general contraction of its fibres, depresses the fin, it pulls its two edges asunder in such a manner as to unfold or spread it.

The muscles which raise the ventral fins are only two, situated on the abdominal surface of the bone of the pelvis. That nearest the middle is of a pyramidal figure, the ossicula which support the radii are attached to it throughout the whole length of its base. It pulls the fin backward, at the same time that it removes the external edge from the middle line.

The muscle the most remote from that line lies directly over the abdominal surface of the bone of the pelvis, and is partly concealed by the preceding. It is the larger of the two. Its fibres run obliquely from without inwardly towards the internal border of the ventral fin, which it moves outwardly, at the same time that it carries the whole fin backward.

There are besides, at the base, or articulation of the radii of the fin with the inter-articular ossicula, little muscles perfectly analogous to those we demonstrated in treating of the motion of the fin of the tail.

In the genus *cyclopterus*, the ventral fins are
united

united to each other by a membrane, and form a kind of funnel below the pectoral fins.

In the genus *gobius*, the two fins only form a single one, placed before the anus.

The muscles of the ventral fins of the *ray* genus, are disposed nearly in the same manner as those of the pectoral fins.

LECTURE SIXTH.

OF THE ORGANS OF MOTION IN ANIMALS
WITHOUT VERTEBRÆ.

ARTICLE I.

Organs of Motion in Mollusca Cephalopoda.

THE mollusca that have the head furnished with long appendages for progressive motion, are called *cephalopoda*, and have two orders of muscles, one belonging to the body, the other to the feet or *tentacula*.

1. *Muscles of the Body.*

The sack which composes the body of these animals, stripped of the external skin, presents a muscular tissue of very compact fibres. Those of the outward layer appear to have a longitudinal direction; the middle layer is transverse; and the layers of fibres that succeed these have different obliquities. They all act in such a manner as to flatten, to elongate, to twist, and to bend

bend the sack; but the action of each of the layers cannot be assigned in a positive manner, on account of their very complicated structure.

In the back of these animals, under the skin, there is found a body more or less solid. In the *cuttle fish* it is a species of bone composed of different thin parallel plates one above another, and separated by little columns disposed in the form of a quincunx. This bone is oval, thick towards the middle, and thin at the circumference. In other species its form varies much, but its substance is generally elastic, and transparent like glass. Its surface is sometimes marked with longitudinal furrows.

The *sepia octopus* wants it entirely.

Two strong muscles arise from the inner surface of the sack, on each side of this bone. They run towards the head, and, on their arrival there, divide each into two branches. One branch is inserted into the head; the other mixes its fibres with those of the sack, at the edge of which it ends.

2. *Muscles of the Foot.*

The Cephalopoda have eight conical feet, of different lengths, arranged in a circle at the top of the head, round the mouth. The animal can turn and bend them in every direction, and fasten itself to bodies by help of the cups or suckers with which they are furnished. The muscles
which

which perform these motions are very numerous; they may, however, be distinguished into those that are common to the whole foot, and those that are proper to the suckers.

Below the skin we find a very thin muscle, the fibres of which are united by a loose cellular substance. It accompanies the skin in all its different shapes, and may perhaps be regarded as a *musculus cutaneus* employed to corrugate the skin, and give greater force to the muscle situated within it, and upon which it acts like a girdle.

Between the feet, and under the skin which unites them at the base, we find two thin muscles situated one below the other, the fibres of which are transverse. One arises in the middle longitudinal line of the foot on the side opposite to the suckers, and proceeds directly to its insertion in the same line of the adjacent foot on either side.

The other arises below the suckers themselves, goes over the lateral parts of the foot, and, at last, forms a muscular membrane with transverse fibres, which passes under the preceding muscle, and proceeds to its insertion in the other foot, exactly in the same manner as it took its origin. This double muscular membrane bears some analogy to that which unites the toes of web-footed birds, such as *ducks*, *geese*, &c. It produces a circular plate, which occupies the intervals between each base of the feet. These two muscles probably serve to bring the feet nearer
to

to each other; the second may besides separate the two rows of suckers. It reaches the whole length of the foot, but it becomes thinner towards the extremity.

Below these three layers of muscles (the two *transversales* and the *cutaneus*,) we find another pretty large one, the conical figure of which determines the shape of the foot. At the surface it seems entirely formed of transverse fibres; but on cutting it in different directions, we find that it has longitudinal fibres. These fibres are interwoven precisely like those of the human lingual muscle towards its centre. In the centre of this muscle there is a vacant space, in which we find very large vessels and nerves.

The suckers are fastened to the inferior surface of this muscle, and to a layer of fibres still more evidently longitudinal, by little fleshy bands, differing in direction according to the species. It is thought that the cylindrical muscle serves to embrace bodies. Its structure is conformable to the action it produces.

3. *Muscles of the Suckers.*

The suckers are formed by a muscular cup of radiated fibres, which, by their contraction, diminish its capacity. But at its edge, and close to the plate under the cylindrical muscle, there is another layer of circular fibres, like a

sphincter, which renders the cup more convex. Finally, each sucker is retained, and moved upon the foot by little muscular fasciculi interlaced together, and uniting at last in the inferior transverse muscle of the foot. At least this is the case in the *sepia octopus*.

In the *calmar* (*sepia loligo*), and the *cuttle fish*, the suckers are attached by very small muscular peduncles.

When an animal of this kind approaches any body with its suckers, in order to apply them more intimately, it presents them in a flat or plain state; and when the suckers are thus fixed by the harmony of surfaces, the animal contracts the sphincter, and forms a cavity in the centre, which becomes a vacuum. By this contrivance the sucker adheres to the surface with a force proportioned to its area and the weight of the column of air and water of which it constitutes the base. This force, multiplied by the number of suckers, gives that by which all or a part of the feet adhere to any body. This power of adhesion is such, that it is easier to tear off the feet than to separate them from the substance to which the animal chooses to attach itself.

In the *cuttle fish* and the *calmars*, the mouth of the sucker is surrounded by a cartilaginous indented zone; in the *octopus* it is only a fleshy disk, flat, and perforated in the middle.

Besides the eight feet which we have just described, and which are all that are possessed by

by the *octopus*, the *cuttle-fish*, and the Calmar, have two others that are much longer, much smaller, and have no suckers, except at the extremity, which is enlarged. Their structure is in other respects the same as that of the other feet.

ARTICLE II.

Organs of Motion in Mollusca Gasteropoda.

WE shall not here describe the muscles that serve for mastication or deglutition; nor those that are appropriated to the organs of generation, smelling, sight, and feeling: these we shall particularly explain in treating of the functions to which they belong.

As to the organs of locomotion in the Gasteropoda, they principally reside in that inferior part of the body on which they drag themselves forward, and which is called their foot. It is a fleshy mass, formed of fibres which cross each other in several directions, and give to it every possible shape. Most commonly it has that of an oval, pointed behind; but by the various contractions of which these fibres are susceptible, they extend or contract it in whole or in part, so as to produce that slow progressive motion which every body has remarked in the common *snail* or *slug*.

The transverse muscular fibres are easily seen

in the foot of the *slug*, if it be opened by the back. They proceed from the edges of the foot to two longitudinal, middle, tendinous lines. Below these we meet with others in a contrary direction, but so interwoven that it is difficult to trace the layers.

In the *scyllæa*, the foot is only a longitudinal furrow, impressed in the whole length of the belly of the animal. By the help of this furrow the animal embraces the stalks of the fucus upon which it crawls. In other respects, the organization of its foot is nearly the same as that of the *slug*.

In the *limpet*, the most inferior layer is composed of transverse fibres, which, at the edge, are interlaced with a great number of others that are circular. The superior layer is a muscle composed of two rows of fibres, which meet and form an acute angle upon a middle line, which corresponds to the long diameter of the foot. There are also at its edge some circular fibres.

The inferior layer, by its contractions, lengthens the ellipsis of the foot, while it lessens its breadth; and the superior diminishes the length, but increases the breadth. This is the mechanism which produces the progression of these animals. Lastly, the circular fibres diminish the surface on all sides, and render it convex above, thereby producing a vacuum, which makes the animal adhere firmly to the surface that supports it.

The gasteropodal mollusca, which are covered
with

with one or more shells, and are called *testacea*, have, besides the muscles of the naked gasteropoda, others that enable them to retreat into the shell, and protrude their body from it again.

These shells, or moveable habitations, vary much in their form. They are most generally made of one piece of different shapes, simple, without twisting, as in the *limpet*; in a flattened spire, as in the *planorbis*; in a globular and pyramidal spire, as in the shell of the *snail*, *bulimus*, *dipper-snail*, &c.

There is but one single genus of the gasteropoda, the *chiton*, which has a shell formed of several pieces.

In the *limpet*, the foot is fastened to the circumference of the shell by a ring of fibres which are attached all round the shell, and which, after piercing the outward covering or cloak, are inserted in the edges of the foot, and interlaced with its circular fibres. Anteriorly they leave a free space for the passage of the head. This muscle, by its contractions, brings the foot and the shell closer together, and compresses the body; on relaxing, it allows the shell to be raised up by the elasticity of the body.

In the *garden snail*, there are two strong muscles which draw the foot and the whole body within the shell. They arise from the columella, or axis of the shell, and having penetrated the body below its spiral part, they run forward under the stomach, and spread their fibres in se-

veral slips which interlace with those of the muscles proper to the foot, the substance of which they enter. From these attachments their mode of action may very easily be comprehended.

When the animal wishes to protrude itself from the shell, its head and foot are forced out by circular fibres which furround the body immediately above the foot.

ARTICLE III.

Organs of Motion in Mollusca Acéphala.

THE acephalous mollusca have the body enveloped by a membrane principally muscular, which is called the *cloak*. This fleshy integument is more or less complete according to the genus, as will be seen hereafter.

The cloak is generally covered by valves, or shells of various forms and proportions. Few of the genera want this solid covering; among these, however, are the *ascidia* and *salpa*.

The valves of the shells are so disposed that they can move one upon another, by means of ossious projections, which reciprocally receive each other, thus forming a real hinge. They are besides connected by an elastic ligament of a horny substance which tends continually to open them.

The

The hinge of the shells presents so many varieties, that naturalists have drawn from it the characteristics of the genera.

In fact, the *oyster*, the *placuna*, the *scallop*, the *avicula*, &c. have no tooth in their joint. The *piddocks*, and the *mya*, or *gapers*, have it only upon one of the valves; but it is not received into a fossa. The razor-shells have the hinge strengthened by a tooth in each shell which projects inward. These two projections meet and move upon each other.

The *anomia*, the *unio*, the *spondilus*, or *thorny-oyster*, the *chama*, and several others, have one or two teeth upon one valve only, which are received into corresponding cavities in the opposite valve. The *venus*, the *cockle*, and the *mastra*, have teeth on each shell, which are mutually received. Finally, the *area* has a multitude of little teeth which are closely indented with each other.

These different conformations serve either to facilitate the motions of the hinges, or to strengthen the joint; or they permit a greater or less opening of the valves.

The elastic ligament, which tends continually to open the valves, is not always situated at the same point of the shell. The *muscles*, for example, have the ligament at one side of the valves. The *placuna* have a little osseous appendage, which forms a projection in the inside of each valve; and from this arises the ligament that

holds them together. The *perna* has in each valve several little cavities opposite to each other in pairs, in which an equal number of small ligaments are lodged.

The shells of the acephala present several other peculiarities. We find the valves immoveable, and foldered together at the angle in *pinna*. The *teredo*, or *pipe-worm*, has the body enclosed in a calcareous tube, and is armed with two little moveable valves, which are used in penetrating wood. The *terebratula* has, on the inner part of one of the valves, two osseous appendages which support the body.

The contractile membrane which covers all the body of the acephalous mollusca, and is called the *cloak*, is a real muscle, which presents a great many varieties. Sometimes, and indeed most commonly, it is open before, in the direction of the valves, as in the *oyster*, the *muscle*, &c.; sometimes in the shells that have two ends always open, as the *razor-shells*, the *gapers*, the *piddock*, &c. it is perforated at both extremities. Lastly, the cloak envelopes the whole body of the animal, and, like a sack, is open at one end only; this may be observed in the *ascidia*.

The cloak of the *oyster* is composed of two pieces of the same form as the shell; they are fixed to the body posteriorly, or on the side of the hinge, and extend to the edges of the valves. Their substance is soft, semi-transparent, and furnished with a number of muscular bands. They
are

are perforated by the muscle which closes the shells. One of the edges is in folds, like a flounce, and festooned. The other is furnished with small conical and contractile tentacula.

The cloak of the other acephala differs from what we have described above, in its general form : in the tentacula on its edge ; in the tubes which are prolongations of it ; and, lastly, in the muscles which perforate it.

The aperture which serves for the ejection of the excrements, and that which receives water, and the different aliments, are sometimes prolonged into a kind of tube, which is a continuation of the cloak : this is called a *proboscis*. The *oyster*, the *muscle*, the *unio*, and the *anodontites* have only one of these apertures, which is the anus. The water merely enters by the large slit in the cloak. In the *cockle*, each aperture is a few lines elongated. That which serves for respiration is longer and larger than the other. They are still more elongated and unequal in the *venus*, the *tellina*, the *maetra*, and some other genera. The *razor-shell* has likewise two ; but in the *piddock* both tubes are enclosed in a very thick fleshy proboscis, through the whole length of which they pass without uniting.

In the acephala that have the cloak open before, the tentacula are placed at the edge of the cloak, and in particular towards the anus ; but in those that have tubes they are situated at the orifice

of the proboscis. In the edible muscle, (*mytilus edulis* Linnæi,) they are branched.

The valves of shells having a continual tendency to open, in consequence of the action of the elastic ligament situated at the side of the hinge which operates as a muscle, it was necessary that the contained animal should have the power of closing them at pleasure. There are, therefore, according to the different genera, always one or two muscles fitted for this purpose.

In the *oyster* there is only one muscle of this kind, situated near the centre of the shell, behind the liver, and in the middle of the cloak. It is inserted into both valves, and, by its contraction, brings them together with an astonishing force. The same mechanism prevails in the *perna*, *avicula*, and *spondylus*.

There are two muscles for closing the shell in the *muscle*, *razor-shells*, *venus*, *mactra*, *cockle*, &c. They are always separate from each other towards the extremities of long shells, and generally approximate at the edge on which the hinge is situated, in order that a very small relaxation on their part may produce a large opening on the opposite side.

A great number of the acephalous mollusca have the power of removing their testaceous covering from one place to another, by the help of a muscular appendix which they can protrude and retract at pleasure, with which they fasten them-

themselves to the sand and rocks, and drag themselves along. This appendix is called the *foot* of the animal.

The *common oyster*, the *spondylus* or *thorny oyster*, some species of the *scallop*, the *anomia*, and in general all the mollusca that have shells with unequal valves, have no foot, and are therefore deprived of the means of voluntary locomotion.

One of the most simple of these feet is that of the *anodontites* of ponds, (*mytilus anatinus* Linnæi.) It is situated before the body towards the margin of the shells. Its form is a compressed oblong. We observe on each side, externally, a layer of fibres proceeding from the bottom of the shell. There are also some internal fibres which cross each other at right angles, and others unite the two external layers, to which they are attached in a circular manner. From this disposition it will easily be conceived that the animal may, when it pleases, change the three dimensions of the foot, or of one of its parts: by this means it is enabled to place its shell flat on the ground, and to crawl along like the snail by the help of its foot.

We find this simple foot in the *piddock*. Its form is almost spherical, and truncated by a flat surface. The part which Linnæus has observed in the *razor-shell*, and which he compares to a glans in its prepuce, is the foot by which the animal buries itself in the sand, or rises to the surface. In these two genera the foot is protruded

ed at the aperture of the shell, which is opposite to that through which the tubes pass.

The foot of the *cardium* or *cockle* is somewhat complex. It has a triangular appendix, which is capable of inflexion, of seizing with its point the glutinous matter, and drawing it out into threads. But the foot of the sea-muscle (*mytilus edulis*) is most remarkable in its organization. It resembles a small tongue, marked with a longitudinal furrow, susceptible of considerable elongation, and of being shortened into the form of a heart. This organ is moved by five muscles on each side. Two arise from the extremities of the shell, near those which close it: the other three come from the bottom of the shell and the depression for the *nates*. They are all inserted into the foot, with the fibres of which they are interwoven, in the same manner as the external muscles of the human tongue join the lingual. The organ is completely enveloped in a sheath formed of transverse and circular fibres of an obscure purple colour. This foot is employed both in spinning and crawling; the last office is performed as in all the other bivalves: it accomplishes the first by seizing, with its point, the gluten supplied by a gland situated under its base, and drawing it out into threads in the above-mentioned furrow.

The gland that secretes this humour, of which the thread is formed, shall be described hereafter.

ARTICLE IV.

Organs of Motion in Crustacea.

THE muscular system of the Crustacea is confined to the motions of the legs, the tail, and the false feet: in this class there are no muscles for moving the head on the corcelet, as these two parts are united together. The antennæ, the mandibles, and the palpi, have their true particular muscles; but we shall not describe them until we have occasion to treat of the organs to which they belong.

I. OF THE TAIL.

The tail is a principal part of the body in the greater number of the Crustacea. It is a very strong and moveable member, which those animals employ with great advantage both in leaping and swimming.

1. *Solid Parts of the Tail.*

In several *monoculi*, the tail is composed of long fillets, which in the *polyphemus* are solid, and moveable on the base only.

The *crabs* have the tail short, flat, and bent under the body, in a depression situated between the feet.

The *pagurus*, or *hermit crab*, which is in the habit of introducing itself into empty shells, or
any

any accidental cavity in a stone, has a soft tail without scales.

The tail of the *cray-fish*, properly so called, merits a particular description. It is formed of six principal segments, and terminates in five laminæ. The segments vary a little with respect to their form. On the upper part they are convex and imbricated: beneath they are narrower, and united by a loose membrane which admits of much motion. At the angle where the inferior portion joins the dorsal, these segments are furnished with a kind of crustaceous fins, bordered with cilia, and consisting of several articulations. These are called *pedes notii*, or *pedes natatorii*. They are moved forward and backward, and a little outward and inward, by small muscles contained within each articulation, but which do not differ so much from those of the real feet as to require a particular description.

Of the five laminæ which terminate the tail, two are pairs, and one single. The middle one is immediately articulated with the last segment. The aperture of the anus is situated under this lamina. In some species it seems broken in the middle, and capable of a small degree of motion. The two lateral laminæ are supported by a common piece, which is articulated with the last segment of the tail. The most internal lamina is simple and ciliated at its extremity only, like that of the middle; but the

external seems articulated about one-third of its length from the lower end; or it may rather be said to be formed of two portions; the first, covering with its extremity, which is denticulated, the smaller, which follows it, and which has its margin furnished with very close cilia.

The muscles which move this tail have so singular a conformation, that it appears necessary to give a sort of monographical description of them.

2. *Muscles of the Tail.*

The muscles of the tail in *cray-fish* form two masses, distinguished from each other by the intestinal canal. The dorsal mass is the thinnest, and least complex. We observe in it three kinds of fibres.

The first form a muscle which arises from the dorsal portion of the corcelet, about one-fourth of its length forward from the posterior end. It is afterwards directed obliquely from before backward, and from within outward, to the lateral parts of the first segment of the tail, into which it is inserted. When the muscle of one side acts separately, it moves the tail to the right or left; when they act both together, they raise the tail, if it has been inflected, and preserve it straight.

The second and the third series of muscular fibres extend throughout the whole length of the

the back in two parallel and very contiguous lines. They arise from the lateral and superior parts of the septum of the corcelet to which the branchiæ are applied; they are attached to these parts by several digitations. Upon tracing them to the first ring of the tail, we find on the surface a small intersection, and observe that a little bundle of fibres turns off to be inserted in this first annular segment. A similar insertion takes place in each succeeding ring. This disposition gives to the internal band the appearance of a twisted cord.

The external dorsal mass is formed of distinct longitudinal fibres.

These three orders of muscles very much resemble the straight muscles of the back of caterpillars, as will be seen hereafter.

The ventral mass of the muscles of the tail is thicker and more complicated than the dorsal. To give a correct idea of its composition, we shall describe its appearance on the view of three different surfaces. We shall first describe its back, or superior surface, the muscles of which we have already spoken, as well as the intestinal canal being removed; next, its inferior surface, the scales below the tail and the nerves being removed; finally, an internal lateral surface, produced by the longitudinal bisection of the muscle, to shew its interior structure.

The ventral muscle of the tail, viewed on the dorsal surface, arises from the inside of the thorax,

thorax, above the osseous cancellated part which incloses the muscles of the coxa. This muscle then divides into two, a right and a left, each composed of three large digitations. At the first segment of the abdomen the longitudinal fibres sink under others which are twisted round them. The remainder of the muscle, throughout the whole length of the tail, is also formed of two series of convex and incurvated fibres, parallel to each other, and separated by a gutter, in which the intestinal canal is lodged.

Viewed inferiorly, the same muscle exhibits three very distinct orders of fibres. The first series is produced by the inferior surface of the digitations, which are inserted into the osseous cancelli of the thorax. The second series is formed of oblique fibres, which are continuations of those of the first, and which extend from the middle line, where the medullary cord of the nerves is situated, to the lateral parts of the rings, at the angle formed by the dorsal and ventral portion. There are two strong bundles of fibres to each angle of the rings, from the first to the sixth. The third series is produced by single bundles of transverse fibres, which describe arches, with their convexity downward. These flat muscular hoops correspond to the intersection of each of the rings, and appear to form an equal number of derivative pulleys for the oblique fibres we have just described.

Finally, the ventral muscle of the tail, when
bifected

bisected longitudinally, exhibits the appearance of a rope, the spiral twists of which have little obliquity. The fibres which correspond to the transverse bundles are distinct, but narrower.

It results from this singular complication, that the muscle, when detached from the parts to which it adheres, resembles a very close twist, the threads of which, instead of acting longitudinally, move obliquely in the canal formed by the neighbouring fibres.

II. OF THE FEET.

The feet of the Crustacea vary with respect to their number and their form. In the *monoculi* they assume very different figures: sometimes they serve instead of feelers, jaws, fins, gills, &c. Their form is also very various in the genus *Cancer*. As an example of the organs of motion in the feet, we shall describe those of the cray-fish species.

1. *Solid Parts of the Feet.*

The *cray-fish* have commonly five feet on each side. They are all formed with six joints.

The first pair is the longest, and forms what is called the *pincers* or *claws*.

The *coxa* is connected with the thorax. The only direction in which it can move is backward and forward. It supports one of the divisions
of

of the branchiæ, and the second portion of the foot, which represents the *femur*. This is flat, short, nearly square, smooth, and a little bent. The plane of its articulation is parallel to the length of the part. As the two muscles which move it are inserted in the two most distant points, the femur is situated horizontally. It moves by a hinge upon the coxa. The motion is compound, the member being directed both backward and forward, and outward and inward. Its motion, with respect to the *tibia*, is very limited, being merely upward and downward: by this motion it is applied to the thorax. The third joint, which answers to the *tibia*, is also somewhat flat, particularly at its femoral extremity: it is incurvated a little in the direction of the femur, and thus corresponds with the convexity formed by the corcelet. At its tarsal extremity, the tibia becomes thick, broad, and spinous. Its motion on the femur is very limited. The fourth articulation is intermediate between the pincers and the tibia, on which it moves at a very conspicuous angle. The *pincer* makes the fifth articulation, which is the largest of all. It terminates on the external side by a sharp spinous process, and receives, on the internal side, a moveable pollex, capable of being opposed to it. The movement of the pincer on the fourth articulation is outward and inward.

The two succeeding pairs of feet, though much smaller, also resemble pincers, with this differ-

ence, that the pollex, or the articulation which represents it, is not thicker than the immovable part.

The two last pairs are not, like the three former, terminated by pincers, but by a single moveable *claw* or *nail*. In other respects they are similar to the second and third pairs.

2. *Muscles of the Feet.*

Each articulation of the feet has two muscles, an extensor and a flexor.

The extensor of the coxa is situated within the corcelet, on the cornuous portion which supports the branchiæ, a little before the coxa, which it moves forward.

The flexor of the coxa is also attached to the horny part that sustains the branchiæ; but it is situated posteriorly, and the motion it produces is the opposite of the preceding.

The extensor of the femur is stronger than the flexor. It arises within the coxa, from its anterior portion, and is inserted into the superior eminence of the articulation of the femur. It ought rather to be called a depressor.

The flexor of the femur, or more properly the levator, is shorter than the preceding. It occupies the posterior internal part of the femur, and is inserted into the inferior eminence of its articulation.

The extensor of the tibia occupies the whole
length

length of the femur internally. It is inserted into the external margin of the articulation of the tibia.

The flexor of the tibia is not so strong as its extensor. It lies under it, and is inserted into the internal edge of the articulation.

The extensor of the first part of the tarsus arises internally from the whole of the superior edge of the tibia, and is inserted into the most elevated eminence in the fourth articulation.

The flexor of the same piece arises likewise within the tibia, but from its inferior border: it is inserted into the lowest eminence of the articulation.

The extensor and the flexor of the pincer occupy and divide the interior of the fourth articulation. Their situation determines their functions.

The extensor of the pollex is a very small muscle, which fills the superior part of the pincer.

The flexor pollicis arises from the whole of the other part of the claw. It has an intermediate osseous tendon, which is strong, flat, and oblong. It is very large.

ARTICLE V.

Organs of Motion in the Larvæ of Insects.

THE transformations which insects experience at different periods of their existence, occasion great variety in their organs of motion. It is therefore necessary to examine them in all the different states through which they pass, if we would acquire an accurate knowledge of this class of animals, with respect to these parts.

All the winged insects which undergo a complete metamorphosis, differ considerably, in their first state, from those which they afterwards assume. The principal of these differences consists in their organs of motion. In this first state they are called *larvæ* or *caterpillars*. The animal exists in the larva form for a certain time, after it has left the egg.

Insects, while in this state, are covered by a soft tender skin, divided into segments or rings, capable of being moved towards each other by muscular bands situated within the body.

The motion of insects is frequently performed on these rings only, either in the manner of reptiles, or by resting alternately each segment of the body on the plane which supports it. Such is that of the larvæ of the Diptera, or two-winged insects, and a great number of the Hymenoptera.

Sometimes

Sometimes the surfaces of these rings are covered by spines, stiff bristles, or hooks, which strengthen their hold on other bodies. This may be observed in some species of *flies*, *gadflies*, *tipula*, *stratyomis*, *syrphius*, &c.

The body of the larva, in some orders of insects, has inferiorly, and towards the head, six feet, each formed of three small joints, the last of which is scaly, and terminates in a hook. By opposing these members to one another, the insect is enabled to embrace a portion of adjacent bodies, to hook itself to them, and afterwards draw the remainder of its body towards that fixed point. This is the usual conformation of the larvæ of the Coleoptera, and a number of those of the Neuroptera.

The other larvæ of the Coleoptera, which live in wood, as the *cerambix*, the *wood beetle*, the *rhagium*, &c. have the six feet exceedingly short, and almost obliterated, or of no use.

These move in sinuities, formed with their mandibles, which also serve to hook them to other bodies, and by the help of plates or tubercles that rise out of their skin on the back and belly. This gives to their body a tetrahedrous form. The manner of their motion may be compared to that of chimney sweepers ascending a funnel.

The Lepidoptera and the larvæ of some genera of the Hymenoptera have, besides the six scaly articulated feet, a variable number of other

false feet, which are not jointed, but terminate in hooks disposed in circles and semicircles. These hooks, which are attached to the skin by appendices or retractile tubercles, serve as cramps to assist their motion on other bodies.

The larvæ of the insects which undergo only a semi-metamorphosis, as the Hemiptera; and of those which experience no transformation whatever, as the Aptera, the *flea* excepted, differ nothing from the perfect insect with respect to the feet.

After this account of the external organs of motion in larvæ, it may still be useful to give a particular explanation of the muscles of some of them. We shall therefore describe in succession, 1. The Muscles of *Caterpillars*; 2. of the Larva of a *Scarabæus*, which lives underground; 3. of a *Hydrophilus*, which swims; and, 4. of a *Cerambyx*, which inhabits the crevices of wood.

1. *Muscles of Caterpillars.*

The deepest layer of muscles in the caterpillar is formed of four principal divisions; two corresponding to the back, and two to the belly. Their direction is longitudinal.

Those of the back are separated from each other by the longitudinal vessel, and from those of the belly by the tracheæ.

They

They begin at the union of the first ring with the second, by two fasciculi of fibres somewhat separate from each other, which are inserted into a kind of tendinous line, produced by the union of the second ring with the third. The same arrangement prevails between all the annular segments of the body. Upon the third ring, the fibres of the two fasciculi, although still distinct, are much more gross. On the fourth ring, the internal fasciculus only has the fibres separate. The fibre is continued, without any apparent intersection, over all the other rings. It diminishes in thickness towards the last, and again forms several fasciculi, first three, then four, and lastly five or six.

These muscles, by their contraction, shorten the body when they act with those of the belly; when they act separately, they bend it upward.

The longitudinal muscles of the belly are separated from each other by the medullary cord, and from those of the back by the tracheæ. They have precisely the same direction. They likewise commence at the union of the first ring with the second, by numerous fasciculi, which unite at the third ring, where they seem to form only a single mass. The fibres afterwards separate higher or lower according to the species, and form four or five fleshy cords, which terminate at the last pair of false feet.

These assist the dorsal muscles in shortening the body: when they act separately, however,

they are the opponents of the former, for they then bend the body downward.

Between the long muscles of the back and the skin there are others which are short; but their direction is oblique.

Some of these are extended from the outside inwardly, towards the dorsal line, between the annular intersections.

The others are situated in the same interval, but their direction is opposite. They proceed from the inside outwardly, and form, with the preceding muscles, an angle like the letter V.

These two kinds of oblique muscles have not an equal quantity of fibres in every part. Those which are situated in the first rings are the longest and narrowest. Those of the fourth, fifth, and sixth, are much shorter. In some species they afterwards become longer and more numerous. In others, on the contrary, they continue broad and short.

These fibres act separately on each ring, which they shorten by their simultaneous contractions: but as they do not extend the whole length of the ring, the parts which correspond to the folds, and over which the oblique muscles do not pass, are elongated, while the action of the same muscles diminishes the diameter of the ring. This facilitates progression.

There is a second layer with oblique fibres, under the long muscles of the belly. They very much resemble those of the back. In consequence

sequence of their different directions, they may also be distinguished into two kinds or orders.

Some are near the middle ventral line, along which the knotted cord of the nerves extends. In ascending, they pass from the inside outwardly, in the intervals of each of the rings.

The others are not so oblique, except the three first superior pairs: these muscles therefore form with the preceding an angle similar to this kind of *A*.

The oblique muscles which run from within outwardly, or the most internal, have many fibres. They usually consist of three or four distinct fasciculi. Those which extend from without inwardly, or the most external, have fewer fibres, and never more than two fasciculi.

The action of these muscles appears to be similar to that of the oblique muscles of the back; but it is probable that they also extend immediately the skin of the feet on which they are situated.

Besides the longitudinal and oblique muscles of the back and the belly, caterpillars have some which are lateral; that is to say, muscles situated below and above the *stigmata* or apertures, which ought to be described separately. These muscles are of three kinds, the *straight*, the *transverse*, and the *oblique*.

The straight lateral muscles are situated between the annular segments, above the *stigmata*. They are all placed longitudinally one over the other.

other. Their points of attachment are covered by the transverse muscles. They seem intended to bend the body towards the sides when they act separately; but when they contract in concert with the long muscles of the back and the abdomen, they shorten the body, and thereby assist its progression.

The transverse lateral muscles are of two kinds: some, which are longer than the others, arise from the intervals unoccupied by the attachments of the straight lateral muscles, and are inserted at the termination of the oblique external muscles of the abdomen. Their fibres are disposed somewhat in the form of a fan. The others have the fasciculi formed of parallel fibres; they are shorter, and are extended in each of the rings between the straight, lateral, and oblique muscles of the abdomen. These muscles diminish the diameter of each ring, and consequently lengthen it in each of its folds. This mode of action is necessary for progression.

The oblique lateral muscles are situated on each side of the straight. They proceed in an oblique direction from below upward, under the insertion of the straight lateral muscles, which they assist when they act together.

Such are the muscles of the body in general; but the true and false feet, and the head, have particular muscles, which must be described separately.

The muscles of the true or scaly feet are situated

situated within the three articulations of which these feet are formed. They may be distinguished into those which move the articulations, and those which act on the *unguis* or claw that terminates them.

The muscles of the first joint consist of five or six fasciculi, which arise from the superior margin of this articulation, and are inserted into the superior margin of the next. The muscles of the second joint are nearly equal in number, and are inserted into the superior margin of the third.

The muscles of the *unguis* terminate by two tendons; but they are formed of several fasciculi, some of which arise from the second and third joints in two very distinct layers; others from a line which corresponds with the convexity of the *unguis*; and lastly, others from the line which answers to its concavity. These tendons are inserted into two tubercles at the superior extremity of the *unguis*, on the concave side, towards its point. They serve to bend the *unguis*, which probably recovers its position by the elasticity of its articulation.

There are two muscles to each of the membranous or false feet. Their direction with respect to the body is almost transverse. They extend from the centre of the feet, into which they are inserted towards the back, and beyond the stigmata, whence they arise by lateral bands more or less oblique.

Their

Their use is to draw the centre of the foot inwardly, and to retract the hooks with which the limb is armed.

It is probable that the contractions of the oblique muscles of the abdomen produce the opposite effect.

With respect to the muscles of the head, we shall at present describe only those which produce its entire motion. We shall notice the others in treating of the different functions to which they are subservient.

The muscles which act on the head, bend it upward, downward, and towards the sides.

Those which bend it upward are very numerous. They arise from the second and first ring, and are inserted into different points of the occiput; some near the middle line, others more laterally. They form in general two fasciculi. The most internal is the least bulky.

The lateral flexors are very oblique. They arise from the inferior or abdominal part of the body, and extend to the lateral parts of the occiput.

The inferior flexors, which bend it downward, appear to be the continuation of the straight muscles of the belly. They consist of eight or nine fasciculi.

2. *Muscles of the Larva of a Scarabæus.*

The larvæ of the scarabæus have the body arched, and convex superiorly, and concave on

the side next the feet. The back and the belly are separated by a membranous border, which has folds, and is situated under the stigmata. These larvæ have only six articulated feet, none of which are membranous.

On opening these larvæ longitudinally, either on the back or the belly, we observe three very deep layers of muscles—the lateral, the dorsal, and the ventral.

The dorsal layer is formed of two series of very distant fibres. One series is external, and occupies the intervals of the ten first rings; that is to say, those which are furnished with the stigmata. The muscles which compose this series are narrow, and preserve a longitudinal direction. The second series is produced by fibres which are somewhat oblique, and extended in the same space, but more towards the middle line. These muscles are broader and stronger towards the head, and more narrow and less fibrous towards the tail. They terminate between the tenth and eleventh ring by a very narrow fleshy band.

These muscles seem intended to shorten the dorsal portion of each of the rings: this action diminishes the convexity of that part, and thereby serves to assist progression.

Near the middle line, between the ninth and tenth ring, there are two small muscles a little oblique; but between the twelfth and the last ring we observe only one series of small short muscles, which occupy all the convexity described

scribed by the curvature. The action of these muscles is obviously the same as that of the preceding, to which they are accessories.

When the first layer of dorsal muscles is removed, we find fibres precisely similar underneath, but running in the opposite direction.

Finally we observe, in the dorsal layer, lines of very short muscular fibres above the inferior plane of the ninth and tenth ring. The use of these little muscles is probably the same as that of all the preceding, though their action is less apparent.

The ventral layer very much resembles that of the back. These muscles, like the dorsal, form planes of opposite directions; the most deep-seated proceeding from the internal side, while those which are nearest the skin ascend from the external side. This produces a small but very regular rhomboidal figure in the middle of each ring on the line bisecting the belly.

The action of these muscles is the opposite of that of the dorsal layer.

On the last segment, and towards the part that answers to the anus, we observe a bundle of transverse fibres, which, by their contraction, doubtless serve the purpose of a sphincter.

The lateral layer of muscles is composed of three kinds of fibres, which are very distinct with respect to their course. They represent a lace passed through the meshes of a net. All these muscles are situated behind the stigmata, and
 inserted

inserted into the folds which separate the belly from the back on both sides.

Those of the first order are completely transverse. They extend over the union of each ring with the succeeding in the space included between the ventral and dorsal muscles. It is obvious that they must diminish, by their contractions, the diameter of the body, and consequently extend it longitudinally. These muscles are in general very narrow.

The second set is formed by oblique fibres which ascend from without inwardly towards the middle ventral line, from the union of one inferior ring to the union of the preceding. These muscles are broad and very strong, they serve to form the folds of separation between the back and the belly.

The muscles of the third order are less oblique than the preceding, to which they appear to be accessories. Each of the muscles which compose this division arises from the middle of a ring, and is inserted under the head, where the preceding muscles are inserted, that is to say, on the ventral side.

It should be remarked, that the two last rings have no lateral muscles.

The muscles of the head are very strong, the flexors are attached to the ventral muscles above the union of the second ring with the third. They are formed of three principal fasciculi, which approach each other and are inserted in-

to

to the posterior and inferior part of the head, at the base of that scaly piece called, by Latrielle, *ganache**.

The extensors or levators of the head consist also of three fasciculi, but they are longer and stronger than the former. They have their origin in the side, and penetrate under the transverse and oblique muscles: one is attached to the sixth ring; another to the fifth, and another to the fourth. They are inserted into the posterior lateral parts of the head.

3. *Muscles of the Larva of a Hydrophilus.*

The larvæ of the hydrophili are elongated. Their body is somewhat flat, and all its rings are distinct. They not only walk very quick, but they even swim with great velocity, in consequence of different inclinations suddenly and successively given to the body.

These larvæ, when opened longitudinally, likewise exhibit four different kinds or divisions of muscles. Those of the belly, those of the back, and those of both sides.

The ventral muscles very much resemble those of caterpillars: They are formed of two distinct layers. The deepest, or that which first appears on the belly when examined through an opening on the back, is composed of longitudinal fibres with intersections which correspond to each
skin

* See—*Tableau Elementaire de l'Histoire Naturelle des Animaux*, par CUVIER. Livre 7, Chap. 5.

ring: the second layer, or that which is next the skin, is entirely covered by the preceding; it is composed of oblique fibres, which cross each other in the form of an X, and which are extended longitudinally in each ring.

The dorsal muscles are long, extending from the head to the tail, and forming on each side two rows of fibres, which appear twisted over each other like ropes. They are broadest towards the head. Their fibres are inserted partly into the inferior border of an anterior ring, and partly into the superior border of the next ring.

These long muscles cover some which are oblique, and cross each other in the form of an X. They extend from the middle part of one ring to the anterior edge of that which succeeds it.

The deep seated lateral muscles, which are numerous, have a transverse direction. Each ring has three or four, and their course is such, that they resemble the letters N or M lying on one side, thus Σ Z

Beneath the transverse lateral there are some longitudinal muscles that have a small degree of obliquity: they form a pretty large surface, which is uninterrupted throughout its whole length, and confounded with the oblique muscles of the belly. Their fibres determine the chief motions of the body, in the same manner as the long muscles of the back and belly.

The muscles of the feet are the same as in the perfect insect.

The head has no particular muscles. The long muscles of the back, being inserted into the occiput, become extensors. The first transverse lateral pair are inserted beneath the head, and produce the lateral flexion. The long oblique muscles, which terminate at the inferior part of the head, become real flexors.

4. *Muscles of the Larva of a Cerambix.*

In the larvæ of the *cerambices* we find the same muscles as in those of the *scarabæi*; but as the shape of the body differs considerably in these two kinds of larvæ, there results some variation in the form and extent of the muscular organs.

A great part of the head of the larva of the *cerambices* can be drawn within the skin whenever the animal pleases. Very strong muscles, similar to those we have described in the *scarabæus*, are appropriated to this function. As the head, which is very large, enters into the body, the extremity which receives it is somewhat thicker than the same part of the *scarabæi*, and the muscles which move the rings are more extensive than theirs.

The flat, fleshy tubercles which we find continued along the back and the belly, are a kind of feet, which this larva uses in progression. They move by the alternate contractions of the correspondent muscles: this larva, therefore, moves with equal facility on the back and on the belly.

ARTI-

ARTICLE VI.

Of the Organs of Motion in Perfect Insects.

THE great variety of motions which insects are capable of performing, entitles them to hold the first rank among the animals that have no vertebræ. We discover, in these minute beings, all the requisites necessary to produce those voluntary actions, the execution of which astonishes us in vertebral animals of far greater magnitude. They even unite several functions which are very seldom found combined in the other classes; for insects walk, run, leap, swim, and fly with as much facility as the mammalia, birds and fishes, exercise one or more of these faculties.

Insects are probably indebted for this advantage to the numerous articulations of which their bodies are formed. We must therefore pay attention to their different articulations, before we proceed to examine the actions they permit or produce.

The bodies of insects may, in general, be divided into the *head*, the *corselet*, the *pectus*, the *abdomen*, and the *members*. There are some genera, however, as the *scorpions*, the *phalangium*, and *spiders*, in which the head is not separate from the corselet. Other Apteræ, as the *julus*, *scolopendra*, *ticks*, *mites*, *fleas*, &c. have the corselet and the abdomen confounded together. Lastly, there are some insects which have the ab-

domen prolonged into a moveable tail, allotted to particular functions: such are the *scorpions* and the *panorpæ*.

We shall now consider the different articulations of all these parts, independent of their external forms, the description of which comes more properly within the province of what is strictly called Natural History.

I. *Of the Head.*

The articulation of the head of insects with the thorax presents two general dispositions. In the one, the points of contact are solid, and the motion depends upon the shape of the parts: in the other, the articulation is ligamentous; and the head and the thorax are united and held together by membranes.

The articulation of the head, by the contact of solid parts, takes place in four different ways.

In the most common conformation, the head has, at the part answering to the neck, one or two smooth tubercles, which are received into correspondent cavities on the anterior part of the corselet. This is observable in the *scarabæus*, the *lucanus*, the *cerambix*, and a great number of Coleoptera: In this first case the head is moveable forward or backward, and the mouth is directed forward and downward.

The

The second mode of solid articulation takes place when the posterior part of the head is rounded, and turns on its axis in a correspondent socket on the anterior part of the thorax. Examples of this conformation are to be found in the *weevils*, the *attelabus*, the *brentus*, the *reduvius*, &c. The axis of motion is then in the centre of the joint, and the mouth of the insect can be directed either forward and backward, upward and downward, or to right and left.

The third sort of articulation, by solid surfaces, occurs when the head is truncated posteriorly, and articulates by a flat surface, either to a tubercle of the thorax, or to another flat and corresponding surface; as is the case in almost all the Hymenoptera, and in the greater number of the Diptera, such as *flies*, *syrphus*, *stratyomis*, *afilus*, &c.

The fourth species of articulation allows to the head only the single motion of an angular hinge. We know as yet of no examples of this kind, except in some species of the genus *attelabus* of *Fabricius*. The head of these insects terminates posteriorly by a round tubercle, which is received into a correspondent cavity of the thorax: the inferior edge of this cavity is notched, and confines the motion of the head to one direction.

The ligamentous articulation is found only in the Orthoptera order of insects, and in some of the Neuroptera: In this mode of articulation

the head is not confined in its motion, except towards the back. In that direction it is opposed by a projection of the thorax, but inferiorly it is perfectly free. The membranes or ligaments extend from the circumference of the occipital foramen to that of the anterior part of the corselet: This admits a very extensive motion.

The muscles which move the head are situated within the thorax. We shall describe here only those most generally met with. The *levators* or *extensors* of the head are commonly situated in the superior part of the corselet, and the *depressors* inferiorly.

Immediately beneath the middle dorsal part of the corselet, we find a pair of muscles which arise from the anterior portion of the scutellum, when that part exists; or from the superior part of the pectus. These muscles are inserted into the posterior and superior part of the head, on the edge of the occipital hole: they draw the head back, and lift it up when it is depressed.

On the lateral parts of this first pair we find another which is more slender: The insertion of this pair likewise takes place at the occipital hole, but more outwardly. They arise obliquely from the lateral parts of the corselet. These muscles turn the head to one side when they act separately; they raise it, and bring the mouth into the middle line when they contract together. It will be easily conceived that in insects which have the head articulated like a knee, these rotatory

tatory muscles are much stronger, and more conspicuous.

The flexors of the head are also four in number, two on each side.

The first pair arises in the internal inferior part of the pectus, from a small horny process, which, in the Coleoptera is of a square form, and has the four angles terminated by solid branches. These muscles extend directly to the inferior part of the occipital hole. From their position they doubtless move the head directly backward.

The second pair, which are much shorter, arise from the inferior lateral part of the corselet, and proceed to the side of the preceding, with which they concur in their effect when they act together; but when one of the two contracts separately, it bends the head to side.

II. *Of the Corselet or Thorax.*

The thorax or corselet of insects is situated between the pectus and the head. The first pair of feet are joined to this part, and it contains the muscles for moving their first articulations, and the head. The corselet is remarkable for its small extent in the Hymenoptera. There is often no part of it to be seen on the back. In the *chrysis*, however, it forms an articulation before the pectus, which may be very easily distinguished.

There is another peculiarity in the conformation of the corselet, which gives to the *elater* the faculty of leaping: two posterior and lateral points prevent it from being thrown too far back, while inferiorly there is a single bent spine which the animal inserts with a spring into a fossa of the pectus.

III. *Of the Pectus or Breast.*

The pectus is the third articulation of the body of insects. The wings in those that have them, are attached to it superiorly, and the four posterior feet inferiorly: the dorsal surface of this part is frequently furnished with a horny process or appendix, the figure of which is various, and which is called the *scutellum* or *escutcheon*; the situation of this appendix between the wings appears to indicate that it serves as a point of support to these members in flight. It is wanting however in the *Lepidoptera*.

There is also inferiorly, in the middle line between the coxæ, a longitudinal ridge, which is called the *sternum*, and which is more or less elevated in different genera. It is very remarkable in the *buprestis*, the *dytiscus*, and the *hydrophilus*.

The breast contains the muscles that move the wings and the four posterior feet, as will be seen when we treat of the members. It also appears that this part is capable of being compressed and
dilated,

dilated, at least we find within it some very strong muscles which seem to approximate the dorsal and ventral surfaces: they may indeed assist in the general movement of the wings, but this we have not yet been able to determine with precision. They are, however, four in number on each side, and differ very much in their colour and texture from the other muscles; for they are of a reddish yellow hue, and their texture is extremely loose.

IV. *Of the Abdomen or Belly.*

The abdomen of insects is the fourth and last division of the trunk. It commonly consists of several rings, the number of which is very variable: sometimes it is *sessile*, that is to say, situated so close to the pectus that it seems to be a continuation of it; as in most of the Coleoptera, *teuthredo*, *lirex*, *scorpions*, &c. Sometimes it is *petiolated*, that is to say, there is a very conspicuous contraction between the pectus and the abdomen, as in *wasps*, in the greater number of Hymenoptera; some Diptera, *spiders*, &c. Sometimes the abdomen is terminated by a *sting*, *bristles*, *plates*, *points*, *hairs*, *long threads*, &c. but it belongs to the Naturalist to describe these peculiarities. We must confine ourselves to the consideration of the motions of the abdomen: these are of two kinds, one total, and another partial.

The

The total movement of the abdomen is not very obvious, except in the insects which have that portion of the body pediculated: It has then a real joint, a kind of hinge, in which the first ring is indented superiorly, and receives a projecting process of the pectus, on which it moves. This articulation is rendered secure by elastic ligaments, which have a considerable degree of force. Some muscles which arise within the pectus, are inserted into the first ring, and determine the extent of its motions.

With respect to the insects in which the abdomen is sessile, the muscles that move the first piece are the same as those that act from one ring to another.

The partial motion of the rings is produced by very simple muscles: they consist of fibres which extend from the anterior edge of one ring to the posterioedge of that which immediately precedes it. When the dorsal fibres contract, the superior part of the abdomen being shortened, it turns up towards the back; but when the contraction takes place in the ventral or lateral fibres, the abdomen is inflected towards the belly, or directed towards one of the sides. The extent of the motion, however, depends upon the number of the rings, and the mode of their junction. In the Coleoptera, for example, the rings only touch each other by their edges, and the motion is very limited; but in the Hymenoptera they are so many small hoops which are incased
into

into one another like the tubes of a telescope, and often only one-third of their extent appears externally.

Such are all the motions that belong to the abdomen of perfect insects.

V. *Of the Members.*

The organization of the members remains still to be considered. We shall begin with the feet, and describe in succession their *number*, their *general form*, their *structure*, their *respective proportion*, and their *motions*.

The *number* of the feet varies. There is never more nor less than six in the winged insects; but the number is very unequal in those that have no wings: *lice*, *fleas*, *podura*, *lepidisma* and *mites*, have six attached in the same manner as those of winged insects: *scorpions*, *spiders*, and the *phalangium* have eight, the *oniscus*, *julus* and *scolopendra*, have them attached to all the rings of the body, the head and tail excepted. In some we find two pair to each ring, and in others only one pair.

The *general form* of the feet of insects depend upon their mode of life. Those that inhabit water, and swim, have their feet flat, long and ciliated: In those that employ them in digging the earth, they are broad, ferrated and sharp-edged; if used in walking only, they are long
and

and cylindrical; when they are calculated for leaping, the femur is thick, the tibia long, and frequently arched. From these different conformations it is very easy to recognize the habits and mode of living even of the dead insect.

The feet of insects are *composed* of four principal parts, which are denominated the *haunch* or *coxa*, the *thigh* or *femur*, the *leg* or *tibia*, the *toe* or *tarsus*.

Each of these parts is enveloped in a case of a horny substance. They move on one another by ginglymus, because the hard substance being external, the articulation cannot take place by less than two tubercles. The motion of each joint is therefore performed in a single plane, that of the coxa excepted, as we shall presently see.

The *coxa* joins the member to the body, and moves in a corresponding cavity of the corselet, or the pectus, without being articulated in a positive manner, but as it were incased. The form of the coxa varies. The insects in which the feet serve for walking only, as the *cerambix*, the *chrysomela*, the greater number of the Hymenoptera, Diptera, &c. have the coxa globular, and forming a real mechanical knee: but those in which it is necessary the feet should possess that lateral motion which is requisite in swimming, removing the earth, &c. have the coxa broad and flat, and, in general, its longest diameter in the transverse direction of the body. There are even
some,

some, as the *dytiscus*, or *water beetles*, in which the posterior coxa is consolidated with the trunk, and immoveable. It is compressed into the form of a plate in the *blatta*, the *lepisma*, and some other genera which walk very rapidly.

The *femur* immediately follows the coxa, to the internal part of which it is articulated, in such a manner that, when the animal is in a state of repose, it is parallel to the inferior surface of the body. It is limited to a forward and backward motion, with respect to the first piece. The nature and extent of the motions of the femur appear to determine its form. In the insects that walk much, and fly little, as the *carabus*, the *cicindila*, &c. the femur has one or two eminences, called trochanters, at its base. These appear to be intended for removing the muscles from the axis of the articulation. Those that require strong muscles, suited to leaping, have the thigh thick, and frequently elongated, as in the *grass-hopper*, *altica*, some *weevils*, *fleas*, &c. In those that dig the earth, the femur, which is moved with much force, has an articular surface corresponding to the flat part of the coxa, on which it rests. This is observable in the anterior feet of some *scarabæi*, *scarites*, *mole-crickets*, &c. In fine, the form of the femur is always subordinate to the kind of motion it has to perform.

The *tibia* is the third joint of the limb. It moves in an angle, with respect to the femur,
and

and is not susceptible of any other direction. The figure of the tibia depends essentially on the uses to which it is applied: this may be remarked in the swimming insects, which have it flat and ciliated; and in those that dig the earth, which have it ferrated and sharp-edged. In the *nepa*, *mantis*, and several others, the anterior foot is terminated by an unguis, and forms with the femur a kind of forceps, which these insects employ to retain their prey while they devour it living.

The *tarsus* or *toe* of insects forms the last portion of the foot. It consists, in general, of several joints, the last of which is terminated by one or two hooked unguis, or claws. These joints move upon each other, and sometimes they are capable of being opposed to the tibia, and thus form a kind of pincers: The figure of the tarsus is always conformable to the insect's mode of life. The articulations are slender, scarcely distinct, and destitute of tufts, or balls, in the great number that burrow in the earth, and seldom walk on its surface, as the *scarabæus*, *bister*, *sphæridium*, *scaritis*, the *savages*, &c. They are flat like fins, ciliated on the edges, and often destitute of claws in the insects that swim, as the *hydrophilus*, *water-fleas*, the *naucoris*, *figara*, &c. They are furnished with viscous balls, bristly tufts, or vascular fleshy tubercles, in those that move upon smooth and slippery bodies, as *flies*, *chrysomelæ*, *cerambices*, *thripes*, &c. They
are

are formed into two moveable and opposable claws, in insects that crawl along hairs, and hook themselves to them, as common *lice*, *vicini*, and *mites*. In the males of some species of the genus *crabro*, and some *dylisci*, one of the articulations is very much enlarged, and covered with hairs disposed in parallel lines.

The tarsus is terminated by a single claw in some *may beetles*, the *water-scorpion*, &c; by two in the greater number of insects; and by two and an appendix, forked in the middle, in the *stag beetles*.

There is a particular variation with respect to the number of joints which compose the tarsus. In most of the Coleoptera, and in all the Hymenoptera and Diptera, it consists of five articulated portions; in the genera *curculio*, *chrysomela*, *cerambix*, and *gryllus*, of four; in the *dragon-flies* and *ear-wigs*, of three; in the anterior feet of the *mantis*, *nepa*, and *naucoris*, of one only; the anterior feet of the *papiliones nymphales* have none.

The *relative proportion* of the feet determines in a certain degree the manner of each insect's motion in walking: for example, when the legs are all equal, the movement is uniform, but its rapidity varies according to their length. The species therefore which have long legs run very quickly: this is observable in the *phalangium*, *spider*, *scolopendra*, *asilus*, *rhagio*, *cerambix*, *molorchus*, *cicindela*, *carabus*, &c. On the contrary, those that have short

legs are remarkable for a very slow pace: of this kind are the *julus*, *ticks*, *gall insects*, &c.

When the anterior feet are longest, they retard motion: this takes place in the *ephemera*, the *mantis*, the *nepa*, *ranatra*, and in some of the *scarabæi*, the *cerambix*, *clytra*, &c. Feet of this kind, therefore, are of little use to the insect that is provided with them, except in enabling it to lay hold of bodies to hook itself to them.

When the posterior feet are longest, they give to the insect the faculty of leaping. This effect may be remarked in the *grass-hoppers*, *crickets*, *fleas*, &c. There are, however, some insects distinguished for leaping, in which the posterior legs are not longer than the others, but they possess this faculty in consequence of their thighs being very thick, and furnished with particular muscles. Such are the *altica*, *cicada*, some *weevils*, and some *ichneumons*.

Lastly, there are some insects which do not leap, though the posterior legs are longest, and the thighs very thick. Among these are some of the *bruchii* of Fabricius, the *boria*, *ædemera*, *leucospis*, *chalcis*, &c. but all these insects have a great curvature in the legs.

We may now examine the *organs of motion in the feet*. The motion of each joint is performed in a single plane. It is provided by only two muscles, which are enveloped in the preceding joint. These are an extensor and a flexor.

In the Coleoptera the coxæ move by a kind of rotation

rotation on their longitudinal axis, which, as we have already observed, is situated transversely, and forms, with the middle line of the body, an angle more or less approaching 90° . As the femur is attached to the internal extremity of the coxa, the distance between the thighs is greatest in those insects in which the femur is most bent with respect to the coxa, to which it is articulated. It is obvious, therefore, that the position of the plane in which this flexion is made, depends upon the situation of the coxa: when it is turned forward, the plane is vertical; when turned backward, the plane is always more oblique; and in the insects that swim, it is even horizontal. It appears then that the almost imperceptible motion of the coxa determines the most remarkable movements of the feet.

The muscles of each pair of coxæ and femora are situated in the superior part of the corselet or of the pectus. To obtain a proper view of them, it is necessary to cut the body of the insect in a vertical direction.

Over the last pair in the pectus there is a scaly substance, in the form of a Y. The stalk of this part affords an origin to a muscle which turns the coxa backward, and is inserted into its posterior edge. The muscle which turns it forward arises from the back, and is inserted by a thin tendon into its anterior edge.

The muscle which extends one femur, while it is approximated towards the other, is very con-

siderable. It arises from the whole branch of the piece, in the form of a Y, and is inserted into the internal edge of the head of the femur. Its antagonist is situated within the body of the coxa.

The muscles which extend the two pairs of anterior femora, arise from the corresponding dorsal parts, and not from particular internal substances: the flexors, however, are always situated within the body of the coxæ.

The muscles which turn the femora arise also from the parietes of the corselet, viz. the muscle which moves it backward to the dorsal part, and that which moves it forward to the lateral part. In the *water beetles*, which, as we have observed, have the posterior coxa consolidated and immoveable, these muscles seem to extend to the femur, which is therefore furnished with four, two extensors and two flexors.

The other orders of insects have nearly the same conformation as the Coleoptera.

The muscles of the tibia are situated within the femur. The extensor, which is short and slender, is attached to its external edge, (the femur being supposed extended in the longitudinal direction of the body :) the flexor is much stronger and longer. It is situated on the inner side, and in the whole of the superior part.

There are likewise two muscles to each joint of the tarsus: one, which is small, and placed on the superior or dorsal surface, acts as an extensor.

tensor. The other, which is more conspicuous, and situated on the inferior side, acts as a flexor.

The wings, as we have already remarked, are members attached to the lateral parts of the pectus. They are particularly appropriated to flight. One entire order of insects, the Aptera, is deprived of them; another order, the Diptera, has only two; but the greater number have four. In the latter, however, there is much variety in the texture of the wings. In the Hymenoptera and the Neuroptera the four wings are entirely membranous. Those of the Lepidoptera are covered with farinaceous scales of different colours. In the Coleoptera the two superior wings are horny cases, more or less solid, called *elytra*. They completely cover the two inferior wings, which are membranous, and fold upon each other, forming a doubling at their external edge. In the Orthoptera the superior wings consist of *elytra* or semimembranous cases. They cover the inferior wings, which fold longitudinally, without any transverse doubling, the genus *forficula* excepted. Lastly, in the Hemiptera the inferior wings fold crossways under *elytra*, which are partly coriaceous, and partly membranous.

In the Diptera order, there is under each wing the rudiment of another, which terminates in a little button or small solid head. These parts are called *halteres* or *balancers*, because it is supposed they serve to maintain the

equilibrium of the insect's body during the rapid motion of its wings: this much at least is known with certainty, that every time the insect strikes the air with its wings, a very quick motion is perceived in the balancers. There is also found in the *Diptera*, between the balancer and the wing, a hollow membranous scale, resembling a spoon without a handle. When the balancer moves, it strikes against this part, and appears in that manner to produce the well-known buzzing sound made by flies when they are on the wing.

The muscles that move the wings are not yet well ascertained. They appear to be two kinds. Some, which are small and short, are fitted to extend or fold the wings, at the same time that they move them to or from the body: the others, which are somewhat longer, are calculated to produce the motions of elevation and depression which the wings perform.

The elytra of the *Coleoptera*, *Orthoptera*, and *Hemiptera*, do not appear to assist in the action of flying, at least they are not moved in the same manner by the muscles of the pectus.

The manner in which the wings are folded or plaited merits some consideration. Citizen Jurine, of Geneva, has made some very curious observations on the appearance of the nervous lines and divisions of the superior wings in the *Hymenoptera*: he has shewn that these appearances are highly characteristic, and has founded
some

some very natural genera upon them. This method, applied to the other orders, would perhaps afford results equally satisfactory. The genus *cicindela*, for example, has a kind of transparent disk at the corner of the wing. The wings of the *forficula* are folded three times transversely, and afterwards plaited throughout their whole length, &c.

We shall here close our examination of the organs of motion in perfect insects.

ARTICLE VII.

Of the Organs of Motion in Worms.

THE organs of motion in worms are not so perfect as in caterpillars. Having neither scaly nor membranous feet, several of them crawl or drag themselves along by the help of stiff hairs or bristles, with which they are wholly or partly covered: of this description are the genera *apbródita*, *terebella*, *nercis*, *lumbricus*, &c. Two kinds of muscles contribute to their motion.

The one extends the whole length of the body, and forms four principal fasciculi, two of which belong to the belly, and two to the back. These four muscles may be said to constitute the mass of the body. We find them immediately below the skin. Their fibres are parallel; but their

length does not exceed that of the rings, being interrupted in the folds of each ring by a very compact cellular tissue. The structure of these muscles is, however, most distinctly observed on the inside. We there find that they are separated from each other by a longitudinal line, and enveloped in a kind of sack, of a close cellular substance, which corresponds to each ring of the body. These four muscles produce the principal motions. When those of the back contract wholly or partially, they raise the portion of the body to which they belong: the same effect, but in the opposite direction, is produced by the contraction of the ventral muscles.

The second order of muscles in worms is particularly appropriated to the motion of the spines or bristles. Their number is equal to that of the tufts of hairs. The description of one of them will be sufficient to give us a knowledge of the whole.

The hairs, bristles, spines, tubercles, &c. which project more or less from the surface of the bodies of these animals, are manifestly moveable. They are retracted and pushed out at pleasure. The muscles which produce these motions are visible only when the animal is laid open, the intestinal canal taken out, and the skin stripped off. We then observe that each tuft of hairs is received in the concavity of a fleshy cone, the base of which is attached to the longitudinal muscles, and the apex to the internal extremity

extremity of the hairs. All the fibres which form this cone are longitudinal, but enveloped by a compact cellular substance. They move the hairs outwardly, and in the direction which their contraction may determine. This first class of the muscles, which belong to each bunch of hairs, may be called the *protractors of the spines*.

The motion by which the spines are drawn within the body, is produced by another set of muscles, which may be called *retractors*. They have fewer fibres than the former; their action is therefore very feeble. They are situated under the internal surface of the long muscles, at a short distance from the holes with which the latter are perforated for the passage of the hairs. They are inserted into the tufts of spines, nearly on a level with the point which these reach when completely retracted. It may be conceived that the protractors, when they act, push the retractor outward; but the latter, when contracting in its turn, tends to recover the parallel situation of its fibres, and thus draws the spines inward.

It is by the help of those muscles, and the spines on which they act, that the imperfect locomotion of these worms is effected.

There is another family of worms which want both spines and bristles, and have therefore a different muscular organization. Their manner of crawling varies considerably from that of the former.

Their progression is accomplished by the help of the two extremities of their bodies, which they apply alternately to the surface on which they crawl. They are fitted for this kind of motion by a peculiar structure. We may divide them into two orders.

The first, as the *leeches*, and several *intestinal worms*, have the head and the tail terminated by a kind of contractile fleshy discus, somewhat resembling those of the *cuttle fish*. The structure of these two disks, which perform the office of suckers, cannot be easily ascertained, for when the skin which covers them is removed, we observe only some very small fibres interwoven in different directions.

Though the worms with suckers possess a great power of contraction, it is extremely difficult to trace the muscles that move their bodies. Their whole skin may indeed be regarded as one muscle, or a kind of fleshy sack, furnished with circular and longitudinal fibres, and containing the vessels, viscera, and glands. This muscular skin is thick, and lined with a very solid and compact cellular substance.

When the worm wishes to change its place, the body is fixed at one of the extremities by the means of the sucker that terminates it; the circular muscles of the skin then separately act, which elongates the animal's body by diminishing its diameter: when the free extremity has in this manner reached the place to which the
worm

worm chooses it should be extended, it is applied and made fast to that spot by the sucker, and becomes the fixed point of a new motion: the animal having removed the sucker first made use of, draws it by the operation of the longitudinal fibres of the skin, towards the second sucker, and proceeds in this manner to fix each extremity alternately. This is the mechanism by which progression is effected in the worms that have terminating disks.

The second order of worms which move by fixing their extremities, comprizes the greater part of the *vermes intestina*. These possess a less degree of contractile power than the *leeches*, and their motions are therefore less extensive. Their head, instead of being terminated by a disk, is sometimes provided with hooks, by the means of which they fasten themselves to the parts they suck. Such are the *common tænia*, the *tenia folium*, the *hydatigena*, the *hæruca*, the *echinorhynchus*, the *uncinaria*, &c. &c. The disposition and curvature of the hooks, which vary considerably, have been described by Naturalists.

ARTICLE VIII.

Organs of Motion in Zoophytes.

THE organs of motion in the zoophyta vary considerably in their nature, their form, and their action.

action. It is therefore necessary to the obtaining a just idea of these organs, that we should take a particular and successive view of them in certain orders of those animals. There is indeed often more difference as to form between one of the Infusoria and one of the Echinodermata than between a reptile and a fish, or even between a fish and some mammalia.

In treating of the parts which contribute to the motions of zoophytes, we shall follow the course traced out to us by Naturalists; we must therefore first examine them in the order Echinodermata, the greater part of which is distinguished by numerous retractile feet, and an envelope more or less solid.

These retractile feet are a kind of suckers, and have nearly the same organization in the three genera which compose this order. Each of these suckers can be contracted separately. In their form they resemble a globular phial, or ampulla, with a long tube. They are filled with a fluid, and their parietes are formed of circular fibres. The elongated or tubular portion of the ampulla is the only part that appears without the animal when the feet are extended. It is terminated by a kind of disk, which is concave in the middle. The spherical portion is situated within the body. From this construction of the foot, the mechanism of its action will be easily understood.—The liquor contained in the ampulla, becomes, by a change of place, the cause of motion:

tion: when the foot is drawn into the body, the spherical portion of the ampulla is greatly enlarged: when the foot protrudes, the parietes of the ampulla contract and impel the contained fluid into the tubular part, which consequently increases both in length and circumference. In the retractile motion of the foot, the tunic of the tube is contracted, and the liquor thereby forced back into the body of the ampulla.

The number and portion of these feet vary considerably, even in the species. This will be apparent from the view we are about to take of the different genera.

The *bolothuria* are covered with a thick coriaceous skin, which the animal can lengthen or shorten at pleasure. These two motions are produced by longitudinal muscular bands, which vary as to their length and breadth in different species, and smaller transverse bands extended over the whole internal surface of the body. The animals included in this genus have their feet disposed in different manners, and in some species they are even wanting. In the others we find them either spread irregularly over the whole body, situated upon one side only, or placed in longitudinal rows.

The *asterias* or *sea-stars* have the covering of the body of a very close fibrous texture, the interstices of which are filled with grains of calcarious matter of various forms and dimensions. This kind of crustaceous skin is,
however,

however, susceptible of a certain motion, which, though slow, is very remarkable. The body of the animal is commonly divided into five branches to which the feet are attached. These last are ranged in several files throughout the whole length of the branches from the mouth. The branches are sometimes furnished with spines, their middle portion is frequently entirely calcarious, but articulated at its origin, and moveable upon the central part of the body.

The *echinus* or *sea-eggs* are encrusted by a complete calcarious skin, the surface of which is covered with tubercles disposed in a very regular manner. Moveable spines of various shapes and sizes are articulated to these tubercles. It is very difficult to discover the fibres by which the spines are moved at the will of the animal; for in their joints we observe only a solid ligamentous substance, which cannot be easily cut. The feet are protruded from the body of the animal through holes which perforate the shell with a great deal of regularity, and which form uniform and parallel lines, called by naturalists *ambulacra*, because they have compared them to the alleys of a garden.

The organs which produce motion in the other orders of zoophyta are not more apparent. They escape our observation in consequence of their transparency. A great number of them have their mouths furnished with tentacula, which are moveable at the will of the animal,

and

and with which it seizes its prey. The *medusa* swim by displacing the water with alternate motions, which render their bodies at the one time flat, and at the other convex. The coriaceous skin which covers the *actinia*, possesses so extraordinary a power of contraction, that these animals can assume the most dissimilar forms at pleasure. Sometimes they are flattened into a disk, sometimes elevated into a cone, sometimes lengthened into a cylinder, &c. &c. In the *hydra* we find only some moveable tentacula. In the *vorticella* and the *rotifer*, we can observe, by the help of instruments, some cilia of different figures turning round their axis with astonishing rapidity.

We now close our anatomical view of the organs of motion: we have not thought it necessary to describe their external forms, because that has already been done by Naturalists, and because our object is merely the examination of their internal structure.

LECTURE SEVENTH.

OF THE ORGANS OF MOTION CONSIDERED
IN ACTION.

IN the first part of this work we have described the forms, the connexions, and the relations of all the organs of motion.

Our attention has been principally directed to the articulations of each bone, and the particular action of each muscle, and to the variations which these organs undergo in different animals.

We shall now consider the effect which results from the united or successive action of all these organs, in producing the general and partial motions performed by animals; and examine how far these effects are modified by the different organs in each family.

 ARTICLE I.
Of Standing.

STANDING is that position in which an animal supports itself firm and erect on its legs.

If a man, or any other animal, suddenly dies while standing, or ceases, in consequence of some other

other cause, to make the necessary efforts for preserving that position, all the articulations of the legs yield to the weight of the body, and bend under it. Standing is then solely the effect of the continued action of the extensor muscles of all the joints; the flexors contribute nothing to it. This is one of the causes which renders it more fatiguing to stand long, than to walk during an equal time; as in walking the extensors and the flexors act alternately.

There are, however, some animals in which certain articulations are maintained in a state of extension, in consequence of their particular form, and the ligaments attached to them. The *stork* affords an example of this. The surface of the femur that articulates with the tibia, has in its middle a depression which receives a projection of the latter bone. In bending the leg, this process is lifted out of the depression, and removed to its posterior edge. By this motion the ligaments are necessarily more stretched than during the extension of the leg, in which the process remains in its socket. These ligaments therefore preserve the leg extended in the manner of some springs, without receiving any assistance from the muscles.

This structure enables birds of this kind to pass whole days and nights on one foot without being fatigued.

It is not so with man and quadrupeds; they are preserved in a standing position by the action
of

of the muscles only: but the extension which that action produces is not to be regarded as a state perfectly motionless. It rather consists of very small alternate flexions and extensions.

Animals may stand on two, on four, or on a greater number of feet.

Those which stand upon two feet, may have the body either vertical, or inclined towards the horizon.

A. Standing on two feet with the body vertical.

To retain a body in a vertical position, it is necessary that all its parts be so disposed as to be easily preserved in a state of equilibrium;—that the muscles have the power of continually correcting all motions which might produce a deviation from this balanced state;—that the centre of gravity of the whole body fall within the limits of the plane occupied by the supports of the body, or its feet;—and finally, that these feet be placed firmly on the ground, and so formed as to accommodate themselves to its inequalities.

Man is the only animal that possesses all these requisites in the necessary degree.

It is obvious that the more extensive the surface which the feet include, the less is the danger of the centre of gravity being removed beyond its boundaries. This observation applies peculiarly to man, whose feet are very broad, and
who

who can separate them to a much greater distance than the other animals.

The power of separating the feet in man depends, 1st, on the width of the pelvis, which is proportionally greater than that of all the other animals, who, in other respects, possess some of the conditions requisite for a perpendicular posture; as may be observed in the *Quadrumana* and *Sarcophaga*: 2d, on the length and obliquity of the neck of the femur, which carries that bone more outward, and removes it farther from its articulation than in any other animal.

The great superficies of the human foot is a consequence of the tarsus, metatarsus, and all the toes resting on the ground. This does not take place so perfectly in any other animal as man. The end of the *os calcis* is elevated even in *monkeys* and *bears*, while in man, on the contrary, it forms a downward projection to sustain the foot posteriorly. The genus *didelphis* also very much resembles man in the hind feet, but these animals want all the other requisites for standing. The quadrupeds which have the tarsus longer than that of man, have it at the same time narrower, and touch the ground with the points of their toes only.

Man, likewise, surpasses all quadrupeds in the advantageous form of his foot, and its aptitude to place itself firmly on the ground.

It is flat inferiorly, and both its edges rest upon the earth. In other animals the foot is

commonly convex, or rather as in the *monkies*; it is articulated in such a manner with the tibia, that it rests only on its external side. This disposition is, however, necessary to them, as it gives them the free use of their pollex or great toe, and of their long toes. Even the length of the toes, which is so useful to *monkies* in seizing the branches of trees, is extremely inconvenient when they are placed on level ground; for their power is diminished, in proportion to their length, when they merely press upon a plane surface, and have no round part to encircle. The toes of man, on the contrary, are short and thick: his pollex is very strong, and longer than the other toes. This conformation, which adds to the extent of the foot, does not occur in the other mammalia. It should also be observed, that the human toes have neither nails nor horn inferiorly, which would obstruct their application to the ground, and prevent them from discerning its inequalities.

Lastly, the *flexor brevis digitorum pedis* in man is situated entirely under the foot, and arises before the heel: it has nothing in common with the muscle improperly called *plantaris gracilis*, which is inserted into the os calcis, along with the other extensors of the foot: the flexor longus passes by the side of the os calcis; so that neither of these muscles are confined by the heel when it rests upon the ground.

On the contrary, the *plantaris gracilis* serves
even

even partly in the monkey, and more completely in the other mammiferous animals, to bend the toes: It passes over the head of the os calcis, and its action would be obstructed were it compressed between that bone and the earth.

The weight of the body tends to bend the leg forward on the foot: it is therefore maintained in its proper position by the extensors of the heel. These muscles are the gemelli and the soleus. They are proportionally thicker in man than in the other mammalia, except perhaps in those that are remarkable for great leaps. This is the reason why man is the only animal that has real calfs to the legs, and why the men that exercise those muscles most, as the persons who practise leaping, have them always thicker than others.

The thigh of man, when standing, forms one line with the trunk and the leg: In quadrupeds, on the contrary, it is situated close upon the flank, and frequently forms an acute angle with the spine. In consequence of this difference, the thigh is flat in those animals, and round in man.

The extensors of the thigh are proportionally stronger in man than in other animals: It is the contrary, however, with the flexors, which, besides, descend much lower on the leg in quadrupeds, and thereby prevent the complete extension of the leg upon the thigh.

In the extension of the leg, the rotula ascends in a groove, situated below, and before the femur;

this reaches higher up in man than in the other mammalia.

The thigh moves upon the pelvis in every direction, but the weight of the body tends chiefly to bend it forward. On this account its extensors, and particularly the gluteus maximus, are so considerable in man, that he is the only animal possessed of what are properly called hips, as he is the only one that has true calfs.

In consequence of this structure, our inferior extremities are furnished with a sufficient base, and solid columns for supporting the trunk. It was also necessary that the trunk itself should be maintained in equilibrium in all its parts.

The first advantage which man possesses in this respect, consists in the breadth of his pelvis. Its form is such, that his trunk rests on an extensive base; and the muscles of the abdomen, as well as all those that proceed from the pelvis, have a sufficient hold, at their inferior attachments, to enable them to counteract, instantly, the most minute deviations of the trunk from its erect position. In all the multidigital animals, the pelvis is so narrow that the trunk resembles an inverted pyramid. It will be easily conceived, that, with such a form, it would be much more difficult to preserve the equilibrium of the body, were these animals to attempt to stand upon their posterior feet. In the animals that somewhat resemble man with respect to the breadth of the pelvis, viz. those with hoofs, there

there are a number of other circumstances which prevent that part of their structure from becoming useful to them. *Bears* and *flots* are the only animals in which the width of the pelvis, which, however, is much less considerable than in man, is not completely counteracted by the form of the feet. These species, therefore, stand more frequently on their hind feet than any others.

The second advantage possessed by man is the facility with which he holds his head erect. In treating of its articulation, we have shewn that this is owing to the position of the foramen magnum, under the middle of the head, and the horizontal direction of the eyes and mouth. These two peculiarities are as unfavourable to his progressive motion on the four members, as they are useful to him while he preserves himself on two only. Man, walking on all-fours, could not see before him: It would even be painful to him to raise his head, which is very heavy, as its muscles are weak, and it wants the cervical ligament.

We observe, besides, some circumstances in the structure of man, which, though they do not assist him to stand upon his legs, prevent him from using the four extremities. His posterior members are very long in proportion to the anterior: in consequence of this, weak children, that cannot walk on their legs, are obliged to crawl on their knees, or to separate the legs,

in a manner that renders their position very constrained; but even then their head is so filled with blood, that they are obliged to seek something to cling to in raising themselves up.

The quadrupeds that sometimes try to stand on their hind feet only, in order that they may either employ their fore-feet in taking hold of some object, or avoid keeping their head too low, seem rather to sit than to stand. Their trunk rests at the same time on the hind feet, as far as the heel, and on the buttocks: it is still necessary, however, that their head and neck should be proportionally small, as in *monkies, squirrels, oppossums, &c.* otherwise the weight of those parts would be too great for the force employed in their elevation; but even when seated, the animal is generally obliged to rest on the fore-feet, as may be observed in *dogs, cats, &c.*

Some quadrupeds use their tail as a third foot, to enlarge the base of the body; and when it is strong, it is capable of contributing to their support for some time. We find examples of this in the *kanguroos* and *jerboas*.

B. *Standing on Two Feet, with the Body
not vertical.*

As the anterior extremities of birds constitute their wings, they cannot be employed by those animals, either in supporting themselves on the ground, or in seizing objects. This rendered it
necessary,

necessary, that, though standing on their posterior extremities, they should be able to reach the earth with their bill. It was also a necessary consequence, of the faculty of flying, that the body should have its centre of gravity nearly under the shoulders, in order that it might be sustained by the wings. It follows, therefore, that the bodies of birds must be heaviest anteriorly. These two requisites are the causes of all the peculiarities we observe in the skeleton of the animals of this class.

It must also be observed, that, to sustain the same centre by the feet, when standing, it was necessary that these members should be directed forward: hence the great flexion of the femur, and that of the tarsus on the leg. The length of the anterior toes also contributes to extend farther, in the same direction, the surface on which the line of gravitation falls; and in general, the length of these toes is such, that birds can easily stand upon one leg, without allowing the vacillatory motions of the body to remove that line beyond so broad a base.

The birds which have their feet situated far back on the body, as the *grebes*, and the *penguins*, are obliged to support themselves in nearly a vertical position.

The length and flexibility of the neck is also of very great use, in varying the position of the centre of gravity, so as to preserve the equilibrium of the body. In standing, birds generally

carry the head erect: in sleeping, they turn it towards the back, and place it under the wing, in order to lay the greatest weight on the point above the feet.

At the commencement of this Lecture we described the mechanical means by which the long-legged birds keep the tibia extended on the tarsus, without any voluntary contraction of their muscles. Borrelli long ago explained the mechanism by which perching birds clasp the branches of trees, and maintain their hold without a constant attention, and even sleep in that position. It consists in the tendons of the flexors of the toes passing over the articulation of the heel, and their union with a muscle which comes from the region of the pubis, and passes over the knee. By the flexion of these two articulations the tendons are necessarily drawn upward, which causes the toes to bend. In consequence of this conformation, the knee and the heel, even of a dead bird, cannot be bent without producing at the same time an inflexion of the toes. The mere weight of the body of birds, pressing down the femora, and tibiæ, is therefore sufficient to make their toes grasp any twig on which they choose to perch. I am not of opinion that the objections which have been made to this ingenious explanation are well founded, or that the theories which have been offered in its stead are admissible.

C. Standing

C. Standing on Four Feet.

We have already pointed out the causes which prevent quadrupeds from standing erect. These causes become the more powerful in proportion as the animals are more completely quadrupeds; that is to say, as they are less capable of dispensing with the use of their four feet in standing, and as these members are provided with a peculiar structure calculated to favour that position.

An animal which stands on four feet is supported on a very considerable base; but, in consequence of the weight of the head and neck, the centre of gravity is situated nearer to the fore than the hind legs. It follows, therefore, that the anterior extremities, which give no support to the human body, sustain almost the whole burthen in quadrupeds. They are therefore furnished with very strong muscles, particularly those of the fore-arm, as we have shewn in describing them. The situation of the scapulæ being very low, the body is sustained between them by the serratus magnus, which is much larger than it is found in man. In short, all that the posterior extremity seems to want in muscular force, appears to be transferred to the anterior.

As the head inclines towards the horizon, and is projected forward by a neck which is often
very

very long, it requires very powerful means to sustain it: they are found in the great size and extensive attachments of the muscles of the neck, and the strength of the cervical ligament. These are two peculiarities that do not exist in man, whose head is supported by its vertical position. The strength both of the muscles and ligament is in proportion to the weight of the head and the magnitude of the horns. But when they have to raise burthens of an extraneous nature, as is the case with the *mole*, the muscles are surprisingly strengthened, and the cervical ligament is ossified.

The body hangs between the four legs, and tends by its weight to bend the spine downward. This effect, however, is counteracted by the abdominal muscles, and particularly by the muscoli recti, which produce a curvature in the opposite direction. The extensors of the spine do not assist in the operation; on the contrary, their action aids that of the weight of the trunk. The abdominal muscles act with peculiar force in bending the vertebral column upward, and giving it an arched-like form in all the mammalia that are covered with scales or spines, and which are accustomed to roll themselves up on the approach of danger, as the *hedgehog*, the *armadillos*, and the *pangolins*. These muscles are therefore stronger in them than in the other families. The *long-tailed pangolin*, or *phatagin*, has two tendinous, and even almost ossified,

ossified, productions, which extend from the xiphoid cartilage nearly to the pelvis.

The legs of mammiferous quadrupeds move forward and backward in planes nearly parallel to the spine, and not far distant from the middle plane of the body upon which the weight operates. In oviparous quadrupeds, on the contrary, the thighs are directed outward, and the inflexions of the limbs take place in planes perpendicular to the spine. In the latter case, then, the weight of the body acts with a much longer lever in opposing the extension of the knee. These animals, therefore, have the knees always bent, and the belly dragging on the ground between their legs. On this account they have received the name of *reptiles*.

ARTICLE II.

Of Walking.

ALL the progressive motions by which man and the inferior animals remove their bodies from one place to another, require that a determinate velocity should be communicated, in a particular direction, to their centres of gravity. To effect this, it is necessary to extend a certain number of articulations, which have been more or less bent,

bent, and having such a position that their extension may be easy on the side to which the centre of gravity inclines, and difficult on the opposite side, in order that the principal part of the movement may take place in the former direction.

The body of an animal which attempts to make a complete change of position, may be compared to a spring divided into two branches, one of which rests upon a resisting body. If these branches, after being brought together by external force, are again set free, their elasticity will tend to make them recede equally, until they form the same angle with each other which they formed before their compression. But the branch which bears against the fixed body not being able to overcome its resistance, the movement will wholly take place in the opposite direction, and the spring's centre of gravity will be forced from the resisting body with more or less velocity.

This is the most simple and correct idea which can be formed of the progressive motion of animals. The flexor muscles of the part which they employ in each kind of movement, represent the external force that compresses the spring. The extensors correspond to the elasticity which tends to make the branches fly asunder, and the resistance of the ground, or that of the fluid in which they move, represents the obstructing body.

Walking is a motion on a fixed surface, in which the centre of gravity is alternately moved by one part of the extremities, and sustained by the other, the body never being at any time completely suspended over the ground. By this definition it is distinguished from *leaping*, in which the whole of the body is projected into the air; and from *running*, which is only a succession of short leaps.

A. Walking on Two Feet.

Animals which stand erect on two legs, such as man and birds, walk also on two legs. But several quadrupeds that cannot stand on two feet but with great difficulty, may yet move in that posture for some time with sufficient ease. This arises from its being in general less painful to walk than to stand, the same muscles not being continued so long in action; and also, it is less difficult to connect the unsteady motions of the body by contrary and alternate vacillations, (a thing easy in walking,) than it is to prevent them altogether.

When man intends to walk on even ground, he first advances one foot: his body then rests equally upon both legs, the advanced leg making an obtuse angle with the tarsus, and the other an acute angle. The ground not yielding to the point of the foot, the heel and the rest of the leg must of necessity be raised, otherwise
the

the heel could not be extended. The pelvis and trunk are consequently thrown upward, forward, and somewhat in a lateral direction. In this manner they move round the fixed foot as a centre, with a radius consisting of the leg belonging to that foot, which, during this operation, continually diminishes the angle formed with the tarsus. The leg which communicated this impulse is then thrown forward, and rests its foot upon the ground; while the other, which now forms an acute angle with its foot, has the heel extended in its turn, and in like manner makes the pelvis and trunk turn round upon the former leg.

It will be seen that by these movements the centre of gravity of the body is carried forward at each progressive step, inclining, however, at the same time, to the right and left alternately, so as to be supported by each leg in its turn. It will also be seen that each leg, immediately on extending its heel, bends and rises, in order to its being moved forward; extends in order to rest its foot upon the ground; turns upon this foot as on a fixed centre, so as to support the weight of the body; and then extends its heel anew, in order to transfer this weight to the other leg.

Each leg supporting the body in its turn, in the same manner as in the position of standing on one foot, the extensors of the thigh and the knee are then brought into action, to prevent
these

these articulations from giving way. The flexors, too, of the same articulations, act immediately after, when that leg, having thrown the weight of the body on the other, must be raised previously to its being carried forward. The three principal articulations of each leg are situated in contrary directions, in order that, during their flexion, the foot should be raised immediately over the place it occupied during their extension. Were not this the case, it would be impossible to bend them without throwing the foot forward or backward.

It is the impossibility of regulating this undulatory motion in a manner perfectly equal on both sides, that prevents man from walking in a straight line, or even from keeping an uniform direction, if he be not very careful to correct his deviations. This is the reason why a man cannot walk in a straight line with his eyes shut.

In walking down an inclined plane, or descending a stair-case, the advanced leg is placed lower than that which remains behind, and the body would fall on it with a fatiguing and dangerous rapidity, were it not carefully checked by means of the extensors of the hip, which permit it to descend only by degrees. This is the reason of the loins being fatigued in descending.

In walking upwards on an inclined plane, or in ascending a stair-case, it is requisite, at each step, not only to transport the body horizontally,

as in walking on level ground, but to bear it up against its own weight, by means of the extensors of the knee of the advanced leg, and those of the heel of that which is behind: this is the reason of the knee and calf of the leg being fatigued in ascending. We have then an advantage in inclining the body forward, because the lever by which its weight acts on the knee is shortened in an equal proportion.

In walking with a very wide step, one feels a fatigue similar to that produced by the action of ascending; because the legs being considerably apart, the body sinks lower at the moment of their separation, and it is necessary that it should be proportionally raised when turning alternately on each leg.

Man seldom swings his arms in order to assist his walking, except in a very narrow path from which he cannot depart; and then he employs all possible means to correct the vacillatory motion of the body. But apes always require the assistance of these extremities in walking, and those which have the longest arms use them with the greatest advantage, as the *long-armed monkey*, and the *orang outang*.

B. *Walking on Four Feet.*

In the action of walking, a quadruped first slightly bends the articulations of the hind legs, and then extends them in order to carry forward
the

the body. The breast being thrown forward by this movement, to which the extensors of the knee and the heel particularly contribute, the fore-legs become inclined backward; and the animal would certainly fall, did it not instantly throw them forward in order to support itself. It then draws up the trunk upon the fore-legs fixed in this position, and the hind-legs are again brought into action.

But it must be observed, that these movements are not performed at the same moment, by the two legs of each pair in the action of walking; for, in that case, the animal would necessarily be completely suspended for a moment over the ground; and its motion would then be no longer a *walk*, but a succession of leaps, particularly denominated a *full-gallop*, of which we shall treat in the sequel.

Each step is executed by two legs only; one belonging to the fore-pair, and the other to the hind-pair; but sometimes they are those of the same side, and sometimes those of the opposite sides.

The latter is that kind of motion in horses which grooms term a *pace*. The right fore-leg is advanced so as to sustain the body, which is thrown upon it by the extension of the left hind-foot; and at the same time the latter bends in order to its being moved forward. While they are off the ground, the right hind-foot begins to extend itself, and the moment they touch it the

left fore-foot moves forward to support the impulse of the right foot, which likewise moves forward. The body is thus supported alternately by two legs placed in a diagonal manner.

When the right fore-foot moves in order to sustain the body, pushed forward by the right hind-foot, the motion is then called an *amble*. The body being alternately supported by two legs of the same side, is obliged to balance itself to the right and left, in order to avoid falling; and it is this balancing movement which renders the gait so soft and agreeable to women and persons in a weak state of body.

In the animals that have the fore-feet longer than the hind, and have their strength chiefly in the anterior part of the body, the principal impulse is given by extending the fore-foot. The hind-foot then rises to follow it, and it is not until the moment that the latter extends itself in its turn, that the fore-foot is raised. This is the manner in which the *giraffe* is said to move.

But when the fore-legs are greatly disproportionate to the others, and particularly when the posterior extremities are feeble and badly articulated, as in the *slots*, the animal is obliged to drag itself onward, by first extending the anterior legs, and then bending them so as to draw the body after them; the hind-legs affording but very little assistance by their impulsion. It is this circumstance which renders the progression of the *slots* so laborious.

Those

Those animals which have their fore-legs very short in proportion to their hind ones, would be incapable of sufficiently supporting their bodies, and must fall down forward on each impulse of the latter, had they not the precaution to make a prancing movement; that is, to raise the anterior extremities entirely off the ground, previously to their being impelled onward by means of the hind-feet. Accordingly such animals cannot in propriety of language be said to walk; they only move forward by leaps. This is the case with the greater part of the Rodentia, such as the *hares*, the *rats*, and particularly the *jerboas*. Indeed these animals cannot be said to walk at all, except in the action of ascending. When they attempt to walk slowly on level ground, they are obliged to move themselves by the fore-feet, and merely to drag after them the hind-pair. This may be observed in *rabbits*, and still more distinctly in *frogs*.

When the hind-feet are very much separated, their impulse becomes more lateral. It thence results that, at each step, the trunk is alternately impelled side-ways, and that the line of motion becomes crooked. This may be remarked in the swimming animals, whose manner of life requires that there should be a considerable space between the hind-legs; such as the *otters*, the *beavers*, the *tortoises*, &c.

ARTICLE III.

Of the Actions of Seizing and Climbing.

MAN, and a certain number of other animals, are capable of seizing objects, by surrounding and grasping them with their fingers. For this purpose it is necessary that their fingers should be separate, free, flexible, and of a certain length. Man has such fingers on his hand only; but *apes* and some other kinds of animals have them both on their hands and feet.

Only *man*, *apes*, and *lemurs*, have the thumb separate, and capable of being opposed to the other fingers, so as to form a kind of forceps. These are therefore the only animals that can hold moveable objects in a single hand. We shall shew hereafter the great difference between the hand of the ape and that of man, and the advantage which the latter possesses for all delicate operations, in which it is necessary to handle, or pinch minute bodies. The other animals, that have the fingers sufficiently small and flexible to enable them to take up objects, are obliged to hold them in both hands. This is the case with *squirrels*, *rats*, *oppossums*, &c. Others which have the toes shorter, and which besides are under the necessity of resting on their fore-feet, as *dogs* and *cats*, can only hold substances by fixing them upon the ground with their paws. Lastly, those that have the toes united and drawn together under

der the skin, or enveloped in corneous hoofs, are incapable of exercising any prehensile power.

We have already shewn that perfect prehension always requires the power of rotating the hand upon the fore-arm, and that in all the animals which possess these faculties, the bones of the shoulders should be so situated as to prevent the displacing of the scapula forward.

The faculty of seizing or grasping firmly is particularly useful to animals in that species of progression called *climbing*. This motion consists in hanging from, and strongly grasping the inequalities of branches, or any other object susceptible of being seized or grasped, and rising in this manner by successive efforts, in a direction opposite to the animal's weight.

Man is a very indifferent climber, because he can only grasp with his hands. His feet are merely fitted for supporting him, and this circumstance gives them much less security in elevating the body by the extension of the heels and knees. He is obliged to employ his arms chiefly by extending them forward, and drawing up his body after them when he has fixed his hands.

Of all climbers the quadrumanous animals are the best. They can seize equally well with their four extremities; and the position of their hind-feet, the soles of which turn inward, instead of being directed downward, is still farther favourable to them.

The other animals that climb constantly, as the *oppossums*, the *phalangers*, the *ant-eaters*, and the *sloths*, have a similar conformation. The two first have the thumb almost always directed backward, and forming a kind of heel, very powerful in its operations. The *sloths* and the *ant-eaters* have a considerable protuberance on the heel, which accomplishes in a certain degree the same effect.

Several *Quadrumana*, the *oppossums*, *phalangers*, and *ant-eaters*, may be said to have a fifth member which assists them in climbing. They can seize bodies with their tail almost as powerfully as with the hand. The muscles which produce this motion do not differ from those of other tails, except in possessing a greater degree of force.

The animals of the *cat* genus climb by fixing their sharp cutting and hooked claws into substances. We have already explained the manner in which their nails are retained between the toes, with the point elevated, independently of the will of the animal, by two elastic ligaments. When they wish to use them, they are protruded by the action of the flexor profundus digitorum, which moves the last phalanx on the preceding one, and directs the point of the nail downward. This is the mechanism which enables *cats* to seize moveable objects, and to tear their prey.

The disposition of the ligaments is very different in the *sloths*. Their nails are naturally inflected
ed

ed under the toes, and when the animal wishes to use them, it is obliged to raise them by the extensor muscles. These toes, besides, are not very convenient, as they are composed of only two phalanges; one of which is very short, and the other entirely covered with the nail. The metacarpal bones, too, are ossified together, and immoveable.

The climbing birds likewise fix themselves to the inequalities of the bark of trees by their claws. It is the posterior toes which are chiefly used in supporting them, and preventing them from falling. Some genera, as the *creepers* and the *nut-batches*, have only one posterior toe; the greater part have two. The *wood-peckers*, and the *creepers*, have another support in their tail, the quills of which are very stiff, and capable of being strongly fixed upon the surfaces over which these birds climb.

Birds can only exercise the faculty of prehension with their feet; but as these are necessary to sustain them, few genera employ their toes in this manner, except when flying, because then their feet are free, or sometimes in swimming with a single foot, as the *pelicans* and the *cormorants*.

Some birds can lift food to the mouth with one foot, while they stand upon the other. The *parrots* and the *owls* are most remarkable for the exercise of this faculty; the former on account of the convenient disposition of the toes, and the latter in consequence of the weight of the head,

which would occasion them to fall frequently were they always to extend it downward in order to peck.

Wading birds, being capable of preserving the articulations of their legs in an extended state, without much effort, are also frequently accustomed to stand on one foot: to balance themselves more perfectly in this position, they hold a stone or some other heavy substance in the other.

The forceps, like hands, and prehensile tail of the camelion, seem to give to that animal, though belonging to the class Amphibia, a form not less advantageous for climbing than that of the Quadrumana among mammalia.

ARTICLE IV.

Of Leaping.

LEAPING is a motion in which the body rises completely from the earth, darts as it were into the air, and remains without any support for a momentary period, the duration of which depends upon the force of the projection.

Leaping is performed by a sudden extension of all the inferior articulations, immediately after they have undergone an unusual degree of flexion. This extension gives to the bones that compose these articulations, a violent motion, the impulse of which being communicated to the
centre

centre of gravity of the body, it is projected with a determined velocity, which is more or less in opposition to its weight.

A leaping body may then be considered as a projectile which gradually loses the acquired velocity by which it ascended, because the power of gravity is every moment counteracting that velocity. The projectile force therefore being given, we may ascertain the arch a leaping body will describe in the air, and the time and place of its descent.

The projectile force, and consequently the extent of the leap, depends on the proportional length of the bones and the strength of the muscles. The animals therefore that leap best, are those which have the posterior legs and thighs longer and thicker than the anterior, as the *kanguroos*, *jerboas*, *frogs*, *alticæ*, *grylli*, *fleas*, &c.

The small animals leap proportionally much farther than the larger. This must be obvious, if we consider, that when the projectile force impressed on two bodies is in proportion to their different magnitudes, their velocity will be equal, and that the extent of the space through which they will pass depends entirely upon their respective velocities. The leaps of small and large animals are therefore nearly equal.

The direction of a leap depends on the situation of the centre of gravity, with respect to the member by which the impulse is given. This is the reason why man and birds are the
only

only animals which can leap vertically, because they only have the trunk situated above the members, by which the leap is effected. They may, however, leap forward, by impressing a greater degree of force on the rotatory motion of the thigh than on that of the leg; or they may even leap backward, by making a contrary exertion.

Quadrupeds and most insects can only leap forward. *Spiders*, however, which have several long feet on each side of their bodies, can leap sideways, as well as forward.

Running is a series of low leaps performed alternately by each leg. It only differs from walking in the body being projected forward at each step, and in the posterior foot being raised before the anterior touches the ground. It is more rapid than the quickest walking step, because the acquired velocity is preserved and augmented at each bound by the new velocity which is added to it. An animal therefore cannot stop instantaneously when running, though a stop may be made in walking at each step. The velocity acquired by running is advantageous in leaping forward, as it adds to the velocity of the leap itself in the same direction, but it would prove unfavourable to a vertical leap, and even entirely prevent it. An animal in running inclines its body forward, in order that the centre of gravity may be in the proper position for receiving an impulse in that direction from the posterior leg.

leg. It is also obliged to move the anterior leg rapidly forward, to guard against falling. The least obstacle which would stop this leg, and prevent it from reaching the ground soon enough to support the body, would occasion a fall.

Interruptions of this kind are, on account of the greater velocity, much more dangerous in running than in walking. On that account, too, falls occur most frequently in the former motion.

Man never varies his manner of running, except in taking longer or shorter steps, or in giving to his motion a greater or less degree of rapidity; but quadrupeds vary their mode of running by the different order in which they raise each foot, or bring it to the ground.

Trotting is a mode of running in which the feet diagonally opposite rise at once, and fall at once, each pair alternately, but in such a manner that, for a moment, all the four feet are off the ground. This produces a regular motion, and the sound of the animals steps are heard two and two in succession.

Galloping is a running motion in which the animal raises the anterior feet at each step, and throws the body forward by the extension of the posterior feet. When the two fore-feet descend at the same time, and are followed by the two hind-feet also descending together, the motion is called a *full gallop*, which is the most rapid a horse can perform, and the only mode of running in dogs, hares, &c. In this kind of gallop the

4

steps

steps of the horse are likewise heard by two beats at a time. The *common gallop* is when the two fore-feet are lifted unequally and fall one after another. This may be divided into *gallops* in which the horses footsteps are heard by a series of *three* or of *four* beats, because the posterior feet may fall to the ground either both together, or one after the other. All these circumstances have been sufficiently explained by riding-masters and hippotomists.

There are several kinds of animals which leap by the means of organs different from feet, but always by a sudden extension of several articulations.

Serpents leap by folding their bodies into several undulations, which they unbend all at once, according as they wish to give more or less velocity to their motion; some may be assisted by the scales of their belly, which they can elevate and depress, but only a few genera are capable of employing this means.

Some fishes also leap to the tops of cataracts by bending their bodies strongly, and afterwards unbending them with an elastic spring.

The long-tailed *cray-fishes*, particularly the *shrimps*, leap by extending the tail after it has been previously bent under the body.

The larva of the *fly*, vulgarly called the maggot, forms itself into a circle, contracts itself as much as possible, then suddenly unbending, darts forward to a considerable distance.

The

The *poduræ* have a tail formed of two articulations, which being inflected under their abdomen, and afterwards extended, enables them to make very considerable leaps.

ARTICLE V.

Of Swimming.

LEAPING commonly takes place on a fixed surface, which possesses the power of resistance, in consequence of its magnitude and its firmness. Though this surface yield to a certain degree, in consequence of being either soft or elastic, leaping can still be performed; but the retrograde motion of the surface produces a diminution in the velocity of the leap, compared with that which is made from firm ground; and the velocity is always greater in proportion as the resistance is perfect. To continue the example which we before adopted, of a spring of two branches tending to separate from each other, it is evident that if one extremity did not experience a greater resistance than the other, the middle of the spring would not change its place: but in proportion as there is a difference in the resistance, a motion must be produced in the direction opposite to the resisting body.

Swimming and flying are leaps which take place

place in fluids, and are produced by the resistance these fluids make to the impulse of certain surfaces, which swimming or flying animals move with great rapidity.

This velocity is necessarily great in proportion to the rarity of the medium. The muscles which produce it require, therefore, a force vastly superior to that which is necessary for a simple leap upon a solid surface; but there is still another requisite for motions which take place in fluids: The body being entirely surrounded by these mediums, would find an equal resistance on all sides, and the velocity acquired by striking the fluid posteriorly, would soon be overcome by the quantity that must be displaced anteriorly, if the animal had not the power of considerably diminishing its surface immediately after it has struck the fluid.

Swimming and flying belong to different classes of animals. There are some, however, which unite both these species of motions; but the one is performed in the most perfect manner by fishes, and the other by birds. We shall, in the first place, consider the means which these two classes employ, and compare them afterwards with those employed by the species of other classes.

As all birds do not fly, so all fishes do not swim. Those which swim best have the body somewhat elongated, and moderately compressed.

An animal may either swim in an horizontal plane,

plane, or in a direction more or less inclined. We shall, in the first place, consider this motion as it takes place in a horizontal plane. A fish, when in equilibrium with the water, (a state in which it can place itself by means which we shall hereafter explain,) and wishing to advance, bends its tail in two different directions, similar to the figure of the letter S, by the means of those strong and complicated lateral muscles which we have already described. The animal then extends the dorsal, the anal, and the caudal fins, as much as possible, in order to augment the surface of the tail. This member is next extended with great velocity, and according to the principle we have established above, the resistance of the fluid, that is to say, the difference of the velocity it admits, with that which the effort of the fish tends to impress upon it, answers, as it were, instead of a solid surface. The body of the fish is therefore impelled forward by the remainder of that velocity.

The water before the fish gives less resistance to its progressive motion; 1st, because the velocity by which it advances is much less than that which it employs to extend the tail; 2d, because when the tail returns to a right line, the fish presents to the fluid only the thickness of its body, which is far from being considerable.

It is necessary that the fish should bend its tail again to give a second stroke to the water. This motion, however, is directly contrary to
that

that by which the tail is extended, and produces, in the fluid, a resistance in the opposite direction, which would be equally powerful, and would completely counteract the animal's progressive motion, if the surfaces of the body remained the same; but the dorsal and anal fins are then laid down upon the body; the caudal fin becomes folded and narrow; besides, the curvature of the tail takes place very slowly, while its extension is sudden and violent. After having returned to the right line, the tail is incurvated a second time; it then bends precisely in the opposite direction, and the impulse which results from it having an equal obliquity, but opposite to that which resulted from the first stroke, the course of the body is rendered straight.

It is by striking the water with more force on one side than on the other, that the fish is enabled to move to the right or the left, and to turn horizontally.

With respect to the power of rising or sinking in the water, it appears in the greater number of fishes to depend on the air-bag or swimming-bladder. We shall describe the form, the connection, and the structure of this important organ, when we treat of secretions. At present we can only consider its use in progressive motion. It is sufficient to observe, that it is a bladder of greater or less magnitude, situated within the abdomen, close to the spine, sometimes simple, sometimes double; but, in the latter case, the two parts communicate

communicate by a small canal. There is frequently a duct which leads from this bladder into the œsophagus or the stomach; but it appears that the air contained in the bag cannot pass through this duct without the consent of the animal. This air is produced, as I think I shall be able to prove in the Lecture already referred to, by the means of certain organs, which separate it from the blood, and in a healthy fish it keeps the bag always distended.

When the air-bag is burst, the fish is no longer able to rise in the water, but remains always on its back. It follows, therefore, that this bag communicates to the back the degree of levity proper to preserve it uppermost, and that in the state of its greatest extension, it renders the whole body sufficiently light to enable it to ascend in the water. There are even some fishes which are capable of being so dilated by the heat, that when they remain for some time on the surface of the water, acted upon by an ardent sun, they cannot sufficiently compress this bag to enable them to descend again. But in an ordinary state the fish can compress the bag precisely to that degree which is necessary to preserve an equilibrium with the water when it wishes to remain in an horizontal plane. It compresses the bag still more when it wishes to descend.

This compression is accomplished by the lateral muscles of the body, which tend to con-

tract the bladder by elongating it. In this manner, though its surface remains equal, its capacity is diminished, since it is farther removed from a spherical form.

Fishes that have no air-bags, possess less facility in changing their elevation in the water. The greater part remain at the bottom, unless the disposition of their body enable them to strike the water from above downwards, with great force. This the *rays* do with their large pectoral fins, which are very properly called wings, since the means these fishes employ in elevating themselves, are precisely the same as those employed by birds in flying.

The *pleuroneêtes* strike the water from above downwards, with the sides of their bodies, because they do not swim like other fish, with the back upward, and the belly downward, but in a very oblique position, which they are compelled to take in consequence of their eyes being both situated on the same side of the head.

As the *rays* and the *pleuroneêtes* cannot conveniently strike the water on the right and left, they are obliged to make a succession of leaps, in order that the whole of their motions may have a horizontal direction. They strike the tail downward with great force, which elevates them a little, and this motion combining with the power of gravity, brings them back after describing a curve to the horizontal line. They depart from this line by a new leap, as we shall explain

explain hereafter when we treat of the flight of birds.

The Cetacea employ the same means. Their bodies, it may be observed, are as perfectly organised for swimming as those of fishes. They differ, however, in this respect, that in the Cetacea the principal efforts of the tail are made in a vertical direction. The use of the air-bag is in them supplied by the lungs, which are compressed and dilated by the action of the intercostal muscles and the diaphragm.

The pectoral and ventral fins do not appear to be of much use in the progression of fishes, but they employ them to preserve themselves in equilibrio, or a state of rest, and they extend them whenever they find it necessary to correct the vacillations of the body. They employ them likewise in the slight turnings of their progressive motion, and to prevent themselves from falling on one side when swimming. Those, however, which have them very large, doubtless make a more efficacious use of them, but our observations on this subject are not yet sufficiently accurate.

There are several classes of animals which swim in the manner of fishes, that is to say, by inflecting the body, such are serpents, and the larvæ of insects, that have long bodies and no fins, as those of the *water beetles*, the *hydrophilus*, the *day flies*, the *aquatic tipulæ*, and *gnats*.

But the *mammiferous quadrupeds*, the *water*
M m 2 *birds*,

birds, the *oviparous quadrupeds*, and the *Crustacea*, swim by the help of their feet, which are to them what oars are to a boat.

The oar in a state of rest forms two angles with the side of the boat; one anterior, and the other posterior, which may either correspond or be unequal. The boatman moves the oar so as to render the anterior angle more obtuse, and the posterior more acute. If the water did not resist, the boat would not change its place; but its resistance opposing the oar, the angle in question widens by the progressive motion of the boat. This impulse once given, the boatman draws back his oar or turns its edge that it may not interrupt the motion, and then recommences the same operation to give the boat a second impulse.

The body of aquatic birds is naturally lighter than the water, on account of their feathers, which are oily and impervious to moisture, and on account of the great quantity of air contained in the cells of their abdomen. They are therefore precisely in the situation of a boat, and have no occasion to employ their feet, except in moving forward. The feet are situated farther back than those of other birds, because their effort is more direct; and there is no necessity for their giving any support to the anterior part of the body, which is sufficiently sustained by the water. The thighs and legs are short, that the resistance of the water on the muscles may be

as little as possible. The tarsus is compressed for cutting the water, and the toes are very much expanded, or even united by a membrane, in order to form an oar of greater breadth, and capable of acting upon a greater surface of the water. But when the bird inflects its foot in order to give a new stroke to the water, it closes the toes upon each other to diminish the resistance.

When these birds wish to dive, they are obliged to compress with much force their breast in order to expel the air it contains, to elongate the neck in order that the body may acquire an inclination forward, and to strike with their feet upward in order that they may be forced downward.

Some aquatic birds, particularly the *swan*, spread their wings to the wind in swimming, and use them as sails.

The quadrupeds which are the most perfect swimmers, are furnished with membranes between the toes, as the *otter*, the *beaver*, &c.; but the others may also swim with more or less facility, by using their four feet. The posterior serve to push them forward, and the anterior to sustain the fore-part of the body, which is heaviest. Of all the mammalia man has most occasion to make use of his hands in swimming, on account of the weight of his head. He is even almost the only animal of this class which cannot swim naturally.

The *seals* and the *morses*, which have the greatest resemblance to the Cetacea, and fishes in the form of their body, are the best swimmers of all the mammalia, and they are properly called amphibious.

ARTICLE VI.

Of Flying.

WHEN a bird wishes to fly, it first darts itself into the air, either by leaping from the ground, or throwing itself from some height; meanwhile it elevates the humerus, and with it the whole of the wing, which hitherto remained folded. It afterwards unfolds it in a horizontal direction, by extending the fore-arm and the hand. The wing having thus acquired all the superficial extent it is capable of attaining, the bird suddenly depresses it, that is to say, it moves it downward, until it forms, with the vertical plane of the body, an angle more obtuse superiorly, and more acute inferiorly. The resistance of the air to this motion, which is suddenly performed in it, produces a re-action of part of the effort upon the body of the bird, which is moved in the same manner as in other leaps. The impulse once given, the bird re-folds the wing by bending the articulations, and

and elevates it again to give a new stroke to the air.

The velocity which the bird thus acquires in ascending, is, like that of every other projectile, gradually diminished by the effect of gravitation; and a moment occurs in which the velocity ceases, and the bird neither tends to ascend nor to descend. If the animal seizes precisely this moment to give a new stroke with the wing, it will acquire a new ascending velocity which will carry it as far as the first, and by repeating this it will ascend in a uniform manner.

If the second stroke of the wing takes place before the velocity obtained by the first is lost, an additional impulse will be received, and by continuing this action the bird will ascend with an accelerated motion.

If the wings do not vibrate at the moment when the ascending velocity is lost, the bird will begin to descend with greater rapidity. If it allows itself to fall down to the point from which it departed, it cannot ascend as high as before, except by a much stronger exertion of the wings; but if a point is seized in the fall, so situated, that the acquired descending velocity and the small space there is to re-descend reciprocally compensate each other, the bird may, by a series of equal vibrations, keep itself always at the same height.

When a bird wishes to descend, it has only to repeat the vibrations of its wings less frequently,

or even to suppress them altogether. In the latter case it comes down with all the acceleration of gravity, as in the *darting* of birds of prey.

A bird, when descending, may also suddenly break its fall by extending its wings; because the resistance of the air augments in proportion to the square of the velocity, and by adding some movement of the wings, it may enable itself to rise again. This is called a *recover*.

We have hitherto regarded flight as simply vertical, without considering its other directions. It can be of this kind only in the birds which have the wings entirely horizontal: such they probably are in *larks*, *quails*, and the other birds which we observe to fly straight upwards; but in the greater part the wing is always more or less inclined and turned backward. This chiefly arises from the length of the quills, which afford much advantage to the resistance of the air acting on their extremities, and which are the more elevated by it, on account of their fixed points being at the roots. It appears, however, that this inclination may be varied to a certain degree at the will of the bird.

Be this as it may, we may consider the oblique motions as consisting of a vertical one, upon which gravity alone can act, and of a horizontal motion which it cannot affect.

When a bird therefore wishes to fly horizontally, it must rise in an oblique direction, and make a second movement of the wings when it

is

is ready to descend below the point from which it departed. It will not fly in a straight line, but will describe a series of curves so very much depressed, that the horizontal motion will overcome the vertical.

If it wish to ascend obliquely, it is necessary that the wings should vibrate quicker; if it wish to descend obliquely, they should move slower; but these two motions are both performed by a series of curves.

It appears that there are birds which have not the power of diminishing as much as they wish the obliquity of the wings, and in which the horizontal motion is always very considerable. If this motion be favoured by the wind, these birds are obliged to ascend by a very inclined line; for this reason, the birds of prey called *noble* by the falconers, are under the necessity of flying against the wind when they wish to rise perpendicularly, otherwise they would be carried to great distances.

They have a proportionally greater horizontal motion than other birds, because the *anterior* quills of their wings are very long, and their extremities press close upon each other. In the *ignoble* birds, the quills at the end of the wing have their extremities separate, and allow the air to pass between them. This renders the wing less capable of assuming an oblique position.

The deviations of flight, to the right or left,
6 are

are principally produced by the vibrations of the wings. In turning to the right, the left wing vibrates ofteneft, or with the greateft force; the left fide then moves moft rapidly, and the body muft of neceffity turn. The right wing produces the fame motion towards the left fide. The more rapid the flight is forward, the greater is the difficulty of one wing furpaffing the other in velocity, and the deviations are lefs fudden. This is the reafon why the birds which fly with the greateft velocity make large circuits in turning.

The tail, when fpread out, contributes to fustain the posterior part of the body. If it is depressed when the bird has acquired a progrefive velocity, it presents an obftacle which elevates the posterior part of the body, and depresses the anterior. If it is turned up, the contrary effect is produced. Some birds incline it to one fide, to affift them like a rudder, when they wifh to change their horizontal direction.

The firft motion of a bird is an ordinary leap with the feet. Thofe which have the feet very fhort, and the wings very long, like the *martins*, the *booby*, &c. cannot leap fufficiently high to obtain the neceffary fpace for the extension of their wings. When on the ground they therefore commence their flight with confiderable difficulty.

It is fcarcely neceffary to obferve, that the refiftance of the air is in proportion to the mafs which is ftruck at one time, and that it is on
this

this account the short-winged birds are obliged to repeat their vibrations very frequently, which soon fatigues them, and prevents them from flying long at a time. These are the motions which constitute flying in birds. Let us now consider how these animals are enabled to execute them.

Their trunk is an oval, which is broadest anteriorly, and narrowest posteriorly. Their spine is almost inflexible, and proportionally shorter than that of quadrupeds. This gives less fatigue to the spinal muscles, and renders it more easy to change the position of the centre of gravity, which must be between the wings in flying, and under the feet in standing. The head is generally small, and the bill tapering to a point, which is a convenient form for cleaving the air. Their neck is longer, and more flexible than that of the mammalia. It therefore supplies the want of arms, and that of flexibility in the trunk, and enables them, when necessary, to change the centre of gravity, by moving the head forward, or drawing it backward.

It is necessary that the centre of gravity should constantly reside in the inferior part of the body, otherwise the bird would fall upon its back. This is produced by the magnitude of the pectoral muscles that depress the wing, and the position of the levators, which are situated under the thorax, and not above it, as in quadrupeds.

The levity of the body of birds, likewise, gives
more

more facility to their elevation. It is occasioned by their bones being hollow, which renders them light without weakening them, an empty cylinder being stronger than a full one of the same weight and length; and still more by the large air cells contained in several parts of the body, and which all communicate with the lungs. The air which birds respire distends them in every part, particularly on being dilated by the warmth of their body. We shall describe all those cells when we treat of the organs of respiration.

Finally, the texture of the feathers, especially that of the quills, and their elasticity, greatly promote flight by the lightness and extent which they give to the wings. We shall describe them in detail when we treat of the teguments of these animals. But it is not the feathers only which serve to increase the wing. The angles included between the humerus and the fore-arm, and between the humerus and the trunk, are furnished with an expansion of the skin, extended by particular muscles, which we shall describe in treating of the panniculus carnosus.

There are birds which never fly. These are, *ostriches*, among the terrestrial birds; and the *penguins*, and the *manchots*, among the aquatic. Their wings are so small that they appear only to possess them, that they may not form too marked an exception to the rules of resemblance in the different classes of animals.

On

On the contrary, there are mammalia which fly pretty well although they have no wings; these are the *bats*: their humerus and fore-arm, and particularly their four fingers, are greatly elongated, and include a large space occupied by a fine membrane which extends to the feet and both sides of the tail. It forms a surface of sufficient extent and firmness to raise the animal to which it belongs into the air. The bats have, besides, very strong pectoral muscles; their body is short, narrow, and slender behind, in such a manner that the centre of gravity is situated under the wings; but this disposition of the body, which fits them for flying, confines them also to crawling, because their hind legs alone are not capable of sustaining them.

The other mammalia, *viz.* the *flying lemurs*, the *polatouches*, or *flying squirrels*, and the *flying phalangers*, have membranes between the feet, but no elongation of the toes. They cannot employ these membranes in raising themselves, but they serve to support them for a certain time in the air, and enable them to take great leaps in descending, which, however, ought not to come under the denomination of flying.

The *dragon* is a small lizard of the East Indies, which supports itself for some moments by a membrane sustained like a fan on a few osseous radii, articulated to the spine of the back.

The wings of flying fishes are somewhat analogous in their structure to those of the dragon,
but

but they are formed by the extension of the pectoral fins, or by some radii situated under these fins. They only enable the animal to fly for a short time.

N. B. In describing the muscles and other organs of motion in white-blooded animals, we have sufficiently explained the manner in which they are employed, and have therefore no occasion to return to that subject.

END OF THE FIRST VOLUME.

GENERAL TABLE OF THE CLASSES OF ANIMALS.

ANIMALS.	With Vertebrae	Warm blood : a heart with two ventricles.	Viviparous : with mammae	1 MAMMALIA.
		Cold blood : a heart with one ventricle.	Oviparous : no mammae	2 AVES.
	Without Vertebrae	Blood vessels.	Long, sometimes accompanied by branchiae	3 AMPHIBIA.
		No blood vessels.	Branchiae without lungs	4 PISCES.
			A knotted spinal marrow : no articulated members	5 MOLLUSCA.
			A knotted spinal marrow : articulated members	6 VERMES.
			A knotted spinal marrow : articulated members	7 CRUSTACEA.
			No knotted spinal marrow : articulated members	8 INSECTA.
			No spinal marrow : no articulated members	9 ZOOPHYTES.

TABLE I.

CLASSIFICATION OF MAMMIFEROUS ANIMALS.

MAMMALIA.	With Claws or Nails	Having three sorts of teeth	FAMILY I. BIMANUM. Thumbs separate on the anterior extremities only.		Homo	Man.	Pithecius	Orang.
			F. II. QUADRUMANA. The thumbs, or great toes, separate on each of the four feet		Simia	Ape	Gallina	Chicken.
					Lenor	Monkey	Canis	Dog.
			F. III. SARCO-PHAGA. No separate thumbs or great toes on the anterior extremities.		Ursus	Bear	Ursus	Bear.
					Canis	Dog	Canis	Dog.
			F. IV. RODENTIA. Want the canine teeth only		Castor	Beaver	Castor	Beaver.
					Sciurus	Squirrel	Sciurus	Squirrel.
			F. V. EDENTATA. Want the incisive and canine teeth		Myrmecophaga	Ant-eater	Myrmecophaga	Ant-eater.
					Oryzomys	Rice-eater	Oryzomys	Rice-eater.
			F. VI. TARDIGRADA. Want only the incisive teeth		Didymus	Two-toed Sloth	Didymus	Two-toed Sloth.
					Bradypus	Three-toed Sloth	Bradypus	Three-toed Sloth.
MAMMALIA.	With Hoofs	Wanting at least, one kind of teeth	F. VII. PACHYDERMATA. More than two toes : more than two hoofs		Elephas	Elephant	Elephas	Elephant.
					Tapir	Reindeer	Tapir	Reindeer.
			F. VIII. RUMINANTIA. Two toes : two hoofs		Cervus	Deer	Cervus	Deer.
					Capra	Goat	Capra	Goat.
			F. IX. SOLIPEDA. One toe : one hoof		Equus	Horse	Equus	Horse.
					Phoca	Seal	Phoca	Seal.
			F. X. AMPHIBIA. Four feet		Trichechus	Manatee	Trichechus	Manatee.
					Manatus	Manatee	Manatus	Manatee.
			F. CETACEA		Dolphin	Dolphin	Dolphin	Dolphin.
					Phoca	Seal	Phoca	Seal.

... *Lamans.*

...

... *Camels* { *Camelus* *Camels.*
 Lama *Peruvian Camels.*

... *Chevrotins,* or
 Musks.

... *Deer.*

is *Giraffe.*

...

... *Goats.*

... *Sheep.*

... *Oxen.*

... *Horse.*

... *Seals.*

... *Morses.*

... *Lamantins.*

... *Dolphins.*

... *Cachalots.*

... *Whales.*

... *Narwhal.*

... PINNIFEDES ...

y
... MACROPTERÆ

of
... SERRIROSTRES

r-
... BRACHYPTERÆ

TABLE III.

CLASSIFICATION OF REPTILES.

AMPHIBIA	Two Auricles to the heart ..	{	A back shell; the jaws invested with horn.....	CHELONIA.....	Tortoise.....	Turtles.....	Turtles.....	
			The body covered with scales; teeth	SAURIA	Lacerta.....	Lizards.....	Lizards.....	
	One Auricle to the heart.....	{	Body covered with scales; no feet; never branchiae.....	OPHIDIA.....	Anguis.....	Snakes.....	Vipers.....	Vipers.....
					Crotalus.....	Rattle Snakes.....	Colubers.....	Colubers.....
			Skin naked; feet; branchiae in the young.....	BATRACHIA ..	Rana.....	Frogs.....	Frogs.....	
					Salamandra.....	Salamanders.....	Salamanders.....	

TABLE IV.

CLASSIFICATION OF FISHES.

PISCES.

Fixed branchiae CHONDROPTERYGII

With a cartilaginous skeleton

Free branchiae BRANCHIOSTEGI

No ventral fins APODES

The ventral fins situated before the pectoral JUGULARES

With an Osseous Skeleton

The ventral fins situated under the pectoral THORACICI

The ventral fins situated behind the pectoral ABDOMINALES

Round mouth at the end of the snout or snout.....	Petromyzon.....	Lampreys.....
Transverse mouth under the snout.....	Haia.....	Sharks.....
Transverse mouth under the snout; teeth.....	Acipenser.....	Sturgeons.....
Transverse mouth under the snout; no teeth.....	Synbranchia.....	Pike.....
Mouth at the end of the snout; no teeth.....	Contrifidus.....	Belontiids.....
Mouth at the end of the snout; teeth.....	Rafines.....	Harporhamphids.....
The bones of the jaws answering instead of teeth.....	Diadema.....	Paracanthopterygians.....
Mouth very wide; a number of small teeth.....	Lophius.....	Monacanthids.....
	Muraena.....	Eels.....
	Gymnathorax.....	Sticklebacks.....
	Sphyracanthus.....	Crabs.....
	Gymnallus.....	Electric Eels.....
Mouth at the end of the snout.....	Trachurus.....	King of the Herring.....
	Ophiodon.....	Sardines or Herrings.....
	Anchovy.....	Sea Anchovy.....
	Kipha.....	Swordfish.....
	Gadus.....	Haddock.....
	Merluccius.....	Black Sea Bass.....
	Callinectes.....	Dragonets.....
	Trachinus.....	Wrasse or Sea Dragon.....
	Urolophus.....	Sturgeons.....
	Cottus.....	Ball-heads.....
	Scorpaena.....	Scorpions.....
	Trigla.....	Gobies.....
	Gobius.....	Gobies.....
	Mollus.....	Serranids.....
	Scorpaena.....	Blackfish.....
	Macrurus.....	Sticklebacks.....
	Loxosteichus.....	Longtails.....
	Johnius.....	Johnies.....
	Sciaenops.....	Sea Breams.....
	Zoarces.....	Dorsetts.....
	Serranus.....	Serranids.....
	Theraps.....	Theraps.....
	Cyprinodontes.....	Minnows.....
	Coryphæna.....	Devils.....
	Bolus.....	Boluses.....
	Holocentrus.....	Surgeons.....
	Lutjanus.....	Lutjanids.....
	Perca.....	Perches.....
	Amia.....	Amias.....
	Labeo.....	Carps.....
	Serras.....	Serras.....
	Fluviatilis.....	Fluviatilis.....
	Cepola.....	Sea Serpents.....
	Echeneis.....	Remoras.....
	Mormyrus.....	Mormyrs.....
	Cyprinus.....	Carps.....
	Magal.....	Magals.....
	Eucetis.....	Flying Fish.....
	Polyodon.....	Herring.....
	Chipea.....	Herring.....
	Argentinus.....	Argentinids.....
	Silurus.....	Silurids.....
	Eloa.....	Pilchard.....
	Cobitis.....	Loaches.....
	Anabaspis.....	Loaches.....
	Silurus.....	Silurids.....
	Platypharodon.....	Platypharodon.....
	Cataphractes.....	Armored Fish.....
	Lamprologus.....	Cichlids.....
	Amia.....	Amias.....
	Agonostomus.....	Agonostomus.....
	Filularia.....	Tubicolous Fish.....

the jaws naked, and answering instead
s on the same side.....
r very long.....
ted discus on the head.....
culum to the branchiæ.....

th; no cirri.....

pressed; cirri.....

ee on the back.....
t the end of a long nose.....

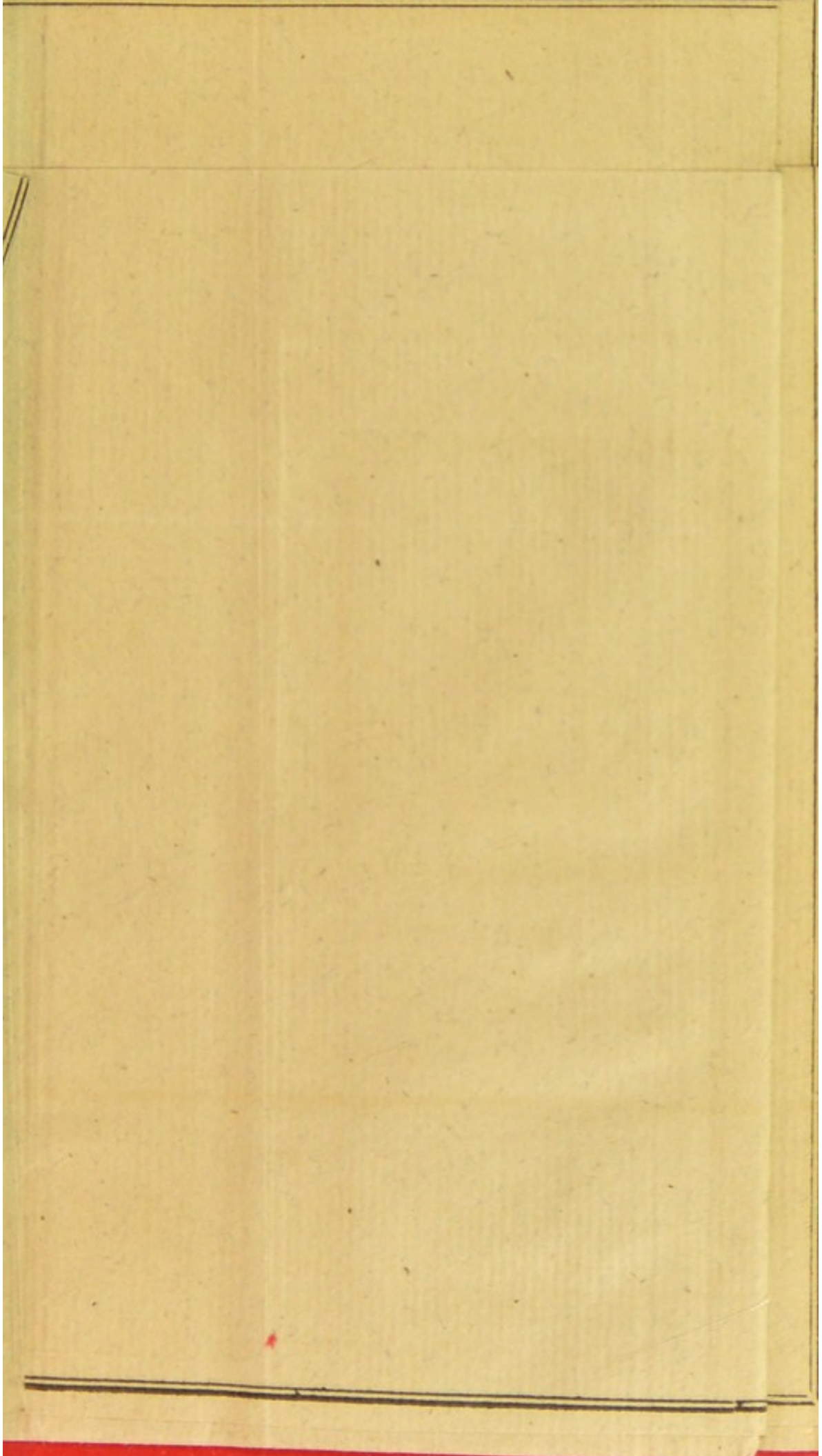


TABLE VI. CLASSIFICATION OF WORMS.

VERMES.....	External organs for respiration	Setæ upon the sides of the body	Aphrodita..... <i>Aphrodites</i> .
			Terebella..... Nereis..... Serpula..... Pencilulus..... Siliquaria..... Amphitrite..... Dentalium..... <i>Tooth shells</i> .
	No external organs for respiration	Setæ upon the sides of the body	Nais..... Lumbricus..... <i>Common Worms</i> . Tubificora.....
		Without setæ upon the sides of the body	Hirudo..... <i>Leeches</i> . Fasciola..... <i>Flukes</i> . Planaria..... Gordius..... <i>Animated Hair</i> .
Animals similar to Worms, the organization of which is not yet sufficiently known to determine whether they should be included in the above class, or form one next to the Zoophytes			First Family..... Terebra..... <i>Tapeworms</i> . Hydatigena..... <i>Hydatids</i> . Ligula..... Lingualula..... Second Family..... Ascaris..... <i>Ascarides</i> . And all the other intestinal worms.

TABLE VII. CLASSIFICATION OF THE CRUSTACEA.

CRUSTACEA	MONOCULUS.....	Limulus..... Calyptra..... Apus..... Cyclops..... Polyphemus.....
	CANCER	Cancer..... <i>Crabs</i> . Inachus..... <i>Sea Spiders</i> . Pagurus..... <i>Hermit</i> . Alpheus..... <i>Cray-fish</i> . Palinurus..... <i>Some Lobsters</i> . Squilla..... <i>Shrimps</i> .

TABLE VIII. CLASSIFICATION OF INSECTS.

No Wings	GNATHAPTERA	Several pair of jaws	POGONATRA	Phyllos	Phyllos
		Two jaws; feet to each anular segment of the body	MALLESIA	Mallesia	Mallesia
Four Reticulated Wings	NEUROPTERA	Head united to the coracoid; eight feet; abdomen without feet	ARANEIDA	Araneida	Araneida
		Head distinct; six feet; abdomen terminated by feet	SETIMEDIA	Setimidia	Setimidia
Four venous Wings	HYMENOPTERA	Head distinct; six feet; abdomen without hairs	ODONATA	Odontata	Odontata
		Lip covering the mouth; wings extended in repose	TEUTHERATA	Teutheata	Teutheata
With a pedunculated abdomen		Mouth projecting; wings lying on the body when the insect rests	ANATRA	Anatra	Anatra
		Mouth very small; no mandibles	MELLETA	Mellesta	Mellesta
With a filiform abdomen		Lip prolonged, forming a proboscis	DUPLETERATA	Dupleterata	Dupleterata
		Superior wings folded throughout their whole length; Antennae enlarged at the extremity	ANTHOPHILA	Anthophila	Anthophila
		Antennae as if broken; abdomen concave inferiorly	FOSSATA	Fossata	Fossata
		Antennae filiform; wings not folded; abdomen round; lip short	MYMERA	Mymera	Mymera
		Antennae setaceous, twelve or thirteen joints, rolling into a spiral	INTEGRO	Integro	Integro
		Antennae setaceous, and as if broken; abdomen round; a flag	CACTOIRA	Cactoiria	Cactoiria
		Antennae as if broken, with thirty articulations; terebra projecting	LANULICORNEA	Langulicornea	Langulicornea
		Antennae either filiform or clavate; terebra spiral	CLAVICORNEA	Clavicornea	Clavicornea
		Palpi three; palpae; terebra very projecting	BRACHYSTRA	Brachystra	Brachystra
		Palpi very apparent; terebra flattened	LEUCOSTRA	Leucostra	Leucostra
With Jaws	COLEOPTERA	With six palpi	LEUCOSTRA	Leucostra	Leucostra
		Antennae club-shaped; the end lamellated	LEUCOSTRA	Leucostra	Leucostra
Four wings; the superior hard, the inferior folded transversely		Antennae club-shaped and pediform or solid	CLAVICORNEA	Clavicornea	Clavicornea
		Tarsi 5, 3, 3	BRACHYSTRA	Brachystra	Brachystra
		Antennae moniliform; elytra short	LEUCOSTRA	Leucostra	Leucostra
		Antennae filiform	LEUCOSTRA	Leucostra	Leucostra
		With hard elytra	LEUCOSTRA	Leucostra	Leucostra
		With soft elytra	LEUCOSTRA	Leucostra	Leucostra
		With hard elytra	LEUCOSTRA	Leucostra	Leucostra
		With soft elytra	LEUCOSTRA	Leucostra	Leucostra
		With four palpi	LEUCOSTRA	Leucostra	Leucostra
		Antennae fixed on the substrate	LEUCOSTRA	Leucostra	Leucostra
		Antennae setaceous	LEUCOSTRA	Leucostra	Leucostra
		Antennae club-shaped; body often cylindrical	LEUCOSTRA	Leucostra	Leucostra
		Antennae granular, enlarged at the end; body flat	LEUCOSTRA	Leucostra	Leucostra
		Antennae filiform or moniliform; body convex	LEUCOSTRA	Leucostra	Leucostra
Four Wings, the superior hard, the inferior folded longitudinally	ORTHOPTERA	Tarsi 5, 3, 3	LEUCOSTRA	Leucostra	Leucostra
		Wings folding longitudinally and transversely; arms terminated by a foot	LEUCOSTRA	Leucostra	Leucostra
		Body flat; head inserted under the coracoid	LEUCOSTRA	Leucostra	Leucostra
		Coracoid much elongated	LEUCOSTRA	Leucostra	Leucostra
		Posterior feet fitted for leaping; body cylindrical	LEUCOSTRA	Leucostra	Leucostra
		Rostrum arising from the anterior part of the head	LEUCOSTRA	Leucostra	Leucostra
		Rostrum apposing to rife from the neck	LEUCOSTRA	Leucostra	Leucostra
		Wings not crossed; extended	LEUCOSTRA	Leucostra	Leucostra
		Antennae terminated by a fold mass	LEUCOSTRA	Leucostra	Leucostra
		Antennae bent at their extremity	LEUCOSTRA	Leucostra	Leucostra
		Antennae enlarged towards the middle	LEUCOSTRA	Leucostra	Leucostra
		Antennae setaceous	LEUCOSTRA	Leucostra	Leucostra
		Antennae filiform or peniform; a proboscis	LEUCOSTRA	Leucostra	Leucostra
		Proboscis fleshy, retractile, and terminated by two tips	LEUCOSTRA	Leucostra	Leucostra
		Antennae very short; sucker honey and projecting; no proboscis	LEUCOSTRA	Leucostra	Leucostra
		Antennae short; neither sucker nor proboscis	LEUCOSTRA	Leucostra	Leucostra
		Antennae short; neither sucker nor proboscis	LEUCOSTRA	Leucostra	Leucostra
No Wings	APTERA	Antennae short; neither sucker nor proboscis	LEUCOSTRA	Leucostra	Leucostra
		Antennae short; neither sucker nor proboscis	LEUCOSTRA	Leucostra	Leucostra

Four Wings, the superior hard, the i

cket

ri.

Four Wings frequently crossed ; r

Four Wings covered with scales ; l

Without Jaws .

Only two Wings

No Wings

TABLE IX. AND LAST.
CLASSIFICATION OF THE ZOOPHYTES.

ZOOPHYTA	Unattached	With a calcareous or coriaceous covering; the intestines floating in the internal cavity.....	ECHINODERMATA	<ul style="list-style-type: none"> Echinus..... <i>Urchins.</i> Asterias..... <i>Star-fish.</i> Holothuria..... Sipuncula..... <i>Sipuncules.</i> 	<ul style="list-style-type: none"> Echinus..... <i>Urchins.</i> Britulus..... <i>Flower-like Echin.</i> Spatagus..... <i>Sea Eggs.</i>
		With a fleshy or gelatinous covering; intestines wide and adherent within the mass of the body.....	URTICA-MARINA	<ul style="list-style-type: none"> Actinia..... <i>Anemonies.</i> Medusa..... <i>Medusae, or Sea Nettles.</i> 	<ul style="list-style-type: none"> Actinia..... <i>Anemonies.</i> Medusa..... <i>Sea Nettles.</i> Beroe..... Rhizothoma.....
		Very small; swimming in liquors.....	INFUSORIA	<ul style="list-style-type: none"> Rotifer..... <i>Wheel Animals.</i> Brachionus..... Trichocerca..... Trichoda..... Leuchophrys..... And all the other Animalcula Infusoria. 	
		With a gelatinous body; propagating by shoots or branches.....	POLYPA	<ul style="list-style-type: none"> Hydra..... <i>Polyps with arms.</i> Verticilla..... <i>Flower-polyps.</i> 	
	Attached to a solid trunk	In which the medullary substance traverses a horny axis, and terminates in polyps upon its branches.....	ZOOPHYTA properly so called.....	<ul style="list-style-type: none"> Flabularia..... Tubularia..... <i>Tubular Corallines.</i> Capitata..... Sertularia..... <i>Sea-moss.</i> 	
		In which each polyp is inclosed in a horny or calcareous cell; without being connected to a medullary axis. ESCARA.....		<ul style="list-style-type: none"> Cellularia..... Fialia..... <i>Mat-weed.</i> Corallina..... <i>Common Corallines.</i> 	
		In which the solid axis is covered with sensible flesh, from the hollows of which proceed polyps.....	CERATOPHYTA	<ul style="list-style-type: none"> Antipathes..... Gorgonia..... Corallium..... <i>Coral.</i> Isis..... <i>Framed Coral.</i> Pennatulid..... <i>Feather-like Corallines.</i> Veretillum..... Umbellula..... <i>Umbelliferous Corallines.</i> 	
		In which the axis or stony basis has cavities, which serve as receptacles for the polyps.....	LYTHOPHYTA	<ul style="list-style-type: none"> Madrepora..... <i>Madrepores.</i> Millepora..... <i>Millepores.</i> 	
		In which the basis is spongy, friable, or fibrous.....	SPONGIA	<ul style="list-style-type: none"> Alcyonium..... Spongia..... <i>Sponge.</i> 	

