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FATHERS OF BIOLOGY

BY

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Minor typographical errors have been corrected without note. Archaic

and variant spellings remain as originally printed. Greek text

appears as originally printed.

PREFACE.

It is hoped that the account given, in the following pages, of the lives

of five great naturalists may not be found devoid of interest. The work

of each one of them marked a definite advance in the science of Biology.

There is often among students of anatomy and physiology a tendency to

imagine that the facts with which they are now being made familiar have

all been established by recent observation and experiment. But even the

slight knowledge of the history of Biology, which may be obtained from a

perusal of this little book, will show that, so far from such being the

case, this branch of science is of venerable antiquity. And, further, if

in the place of this misconception a desire is aroused in the reader for

a fuller acquaintance with the writings of the early anatomists the

chief aim of the author will have been fulfilled.

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HIPPOCRATES.

\_HIPPOCRATES.\_

Owing to the lapse of centuries, very little is known with certainty of

the life of Hippocrates, who was called with affectionate veneration by

his successors "the divine old man," and who has been justly known to

posterity as "the Father of Medicine."

He was probably born about 470 B.C., and, according to all accounts,

appears to have reached the advanced age of ninety years or more. He

must, therefore, have lived during a period of Greek history which was

characterized by great intellectual activity; for he had, as his

contemporaries, Pericles the famous statesman; the poets Æschylus,

Sophocles, Euripides, Aristophanes, and Pindar; the philosopher

Socrates, with his disciples Xenophon and Plato; the historians

Herodotus and Thucydides; and Phidias the unrivalled sculptor.

In the island of Cos, where he was born, stood one of the most

celebrated of the temples of Æsculapius, and in this temple--because he

was descended from the Asclepiadæ--Hippocrates inherited from his

forefathers an important position. Among the Asclepiads the habit of

physical observation, and even manual training in dissection, were

imparted traditionally from father to son from the earliest years, thus

serving as a preparation for medical practice when there were no written

treatises to study.[1]

Although Hippocrates at first studied medicine under his father, he had

afterwards for his teachers Gorgias and Democritus, both of classic

fame, and Herodicus, who is known as the first person who applied

gymnastic exercises to the cure of diseases.

The Asclepions, or temples of health, were erected in various parts of

Greece as receptacles for invalids, who were in the habit of resorting

to them to seek the assistance of the god. These temples were mostly

situated in the neighbourhood of medicinal springs, and each devotee at

his entrance was made to undergo a regular course of bathing and

purification. Probably his diet was also carefully attended to, and at

the same time his imagination was worked upon by music and religious

ceremonies. On his departure, the restored patient usually showed his

gratitude by presenting to the temple votive tablets setting forth the

circumstances of his peculiar case. The value of these to men about to

enter on medical studies can be readily understood; and it was to such

treasures of recorded observations--collected during several

generations--that Hippocrates had access from the commencement of his

career.

Owing to the peculiar constitution of the Asclepions, medical and

priestly pursuits had, before the time of Hippocrates, become combined;

and, consequently, although rational means were to a certain extent

applied to the cure of diseases, the more common practice was to resort

chiefly to superstitious modes of working upon the imagination. It is

not surprising, therefore, to find that every sickness, especially

epidemics and plagues, were attributed to the anger of some offended

god, and that penance and supplications often took the place of personal

and domestic cleanliness, fresh air, and light.

It was Hippocrates who emancipated medicine from the thraldom of

superstition, and in this way wrested the practice of his art from the

monopoly of the priests. In his treatise on "The Sacred Disease"

(possibly epilepsy), he discusses the controverted question whether or

not this disease was an infliction from the gods; and he decidedly

maintains that there is no such a thing as a sacred disease, for all

diseases arise from natural causes, and no one can be ascribed to the

gods more than another. He points out that it is simply because this

disease is unlike other diseases that men have come to regard its cause

as divine, and yet it is not really more wonderful than the paroxysms

of fevers and many other diseases not thought sacred. He exposes the

cunning of the impostors who pretend to cure men by purifications and

spells; "who give themselves out as being excessively religious, and as

knowing more than other people;" and he argues that "whoever is able, by

purifications and conjurings, to drive away such an affection, will be

able, by other practices, to excite it, and, according to this view, its

divine nature is entirely done away with." "Neither, truly," he

continues, "do I count it a worthy opinion to hold that the body of a

man is polluted by the divinity, the most impure by the most holy; for,

were it defiled, or did it suffer from any other thing, it would be like

to be purified and sanctified rather than polluted by the divinity." As

an additional argument against the cause being divine, he adduces the

fact that this disease is hereditary, like other diseases, and that it

attacks persons of a peculiar temperament, namely, the phlegmatic, but

not the bilious; and "yet if it were really more divine than the

others," he justly adds, "it ought to befall all alike."

Again, speaking of a disease common among the Scythians, Hippocrates

remarks that the people attributed it to a god, but that "to me it

appears that such affections are just as much divine as all others are,

and that no one disease is either more divine or more human than

another, but that all are alike divine, for that each has its own

nature, and that no one arises without a natural cause."

From this it will be seen that Hippocrates regarded all phenomena as at

once divine and scientifically determinable. In this respect it is

interesting to compare him with one of his most illustrious

contemporaries, namely, with Socrates, who distributed phenomena into

two classes: one wherein the connection of antecedent and consequent was

invariable and ascertainable by human study, and wherein therefore

future results were accessible to a well-instructed foresight; the

other, which the gods had reserved for themselves and their

unconditional agency, wherein there was no invariable or ascertainable

sequence, and where the result could only be foreknown by some omen or

prophecy, or other special inspired communication from themselves. Each

of these classes was essentially distinct, and required to be looked at

and dealt with in a manner radically incompatible with the other.

Physics and astronomy, in the opinion of Socrates, belonged to the

divine class of phenomena in which human research was insane, fruitless,

and impious.[2]

Hippocrates divided the causes of diseases into two classes: the one

comprehending the influence of seasons, climates, water, situation, and

the like; the other consisting of such causes as the amount and kind of

food and exercise in which each individual indulges. He considered that

while heat and cold, moisture and dryness, succeeded one another

throughout the year, the human body underwent certain analogous changes

which influenced the diseases of the period. With regard to the second

class of causes producing diseases, he attributed many disorders to a

vicious system of diet, for excessive and defective diet he considered

to be equally injurious.

In his medical doctrines Hippocrates starts with the axiom that the body

is composed of the four elements--air, earth, fire, and water. From

these the four fluids or humours (namely, blood, phlegm, yellow bile,

and black bile) are formed. Health is the result of a right condition

and proper proportion of these humours, disease being due to changes in

their quality or distribution. Thus inflammation is regarded as the

passing of blood into parts not previously containing it. In the course

of a disorder proceeding favourably, these humours undergo spontaneous

changes in quality. This process is spoken of as \_coction\_, and is the

sign of returning health, as preparing the way for the expulsion of the

morbid matters--a state described as the \_crisis\_. These crises have a

tendency to occur at certain periods, which are hence called \_critical

days\_. As the critical days answer to the periods of the process of

coction, they are to be watched with anxiety, and the actual condition

of the patient at these times is to be compared with the state which it

was expected he ought to show. From these observations the physician may

predict the course which the remainder of the disease will probably

take, and derive suggestions as to the practice to be followed in order

to assist Nature in her operations.

Hippocrates thus appears to have studied "the natural history of

diseases." As stated above, his practice was to watch the manner in

which the humours were undergoing their fermenting coction, the

phenomena displayed in the critical days, and the aspect and nature of

the critical discharges--not to attempt to check the process going on,

but simply to assist the natural operation. His principles and practice

were based on the theory of the existence of a restoring essence (or

φύσις) penetrating through all creation; the agent which is constantly

striving to preserve all things in their natural state, and to restore

them when they are preternaturally deranged. In the management of this

\_vis medicatrix naturæ\_ the art of the physician consisted. Attention,

therefore, to regimen and diet was the principal remedy Hippocrates

employed; nevertheless he did not hesitate, when he considered that

occasion required, to administer such a powerful drug as hellebore in

large doses.

The writings which are extant under the name of Hippocrates cannot all

be ascribed to him. Many were doubtless written by his family, his

descendants, or his pupils. Others are productions of the Alexandrian

school, some of these being considered by critics as wilful forgeries,

the high prices paid by the Ptolemies for books of reputation probably

having acted as inducements to such fraud. The following works have

generally been admitted as genuine:--

1. On Airs, Waters, and Places.

2. On Ancient Medicine.

3. On the Prognostics.

4. On the Treatment in Acute Diseases.

5. On Epidemics [Books I. and III.].

6. On Wounds of the Head.

7. On the Articulations.

8. On Fractures.

9. On the Instruments of Reduction.

10. The Aphorisms [Seven Books].

11. The Oath.

The works "On Fractures," "On the Articulations," "On Injuries to the

Head," and "On the Instruments of Reduction," deal with anatomical or

surgical matters, and exhibit a remarkable knowledge of osteology and

anatomy generally. It has sometimes been doubted if Hippocrates could

ever have had opportunities of gaining this knowledge from dissections

of the human body, for it has been thought that the feeling of the age

was diametrically opposed to such a practice, and that Hippocrates would

not have dared to violate this feeling. The language used, however, in

some passages in the work "On the Articulations," seems to put the

matter beyond doubt. Thus he says in one place, "But if one will strip

the point of the shoulder of the fleshy parts, and where the muscle

extends, and also lay bare the tendon that goes from the armpit and

clavicle to the breast," etc. And again, further on in the same

treatise, "It is evident, then, that such a case could not be reduced

either by succussion or by any other method, unless one were to cut open

the patient, and then, having introduced the hand into one of the great

cavities, were to push outwards from within, which one might do in the

dead body, but not at all in the living."

His descriptions of the vertebræ, with all their processes and

ligaments, as well as his account of the general characters of the

internal viscera, would not have been as free from error as they are if

he had derived all his knowledge from the dissection of the inferior

animals. Moreover, it is indisputable that, within less than a hundred

years from the death of Hippocrates, the human body was openly dissected

in the schools of Alexandria--nay, further, that even the vivisection of

condemned criminals was not uncommon. It would be unreasonable to

suppose that such a practice as the former sprang up suddenly under the

Ptolemies, and it seems, therefore, highly probable that it was known

and tolerated in the time of Hippocrates. It is not surprising, when we

remember the rude appliances and methods which then obtained, that in

his knowledge of minute anatomy Hippocrates should compare unfavourably

with anatomists of the present day. Of histology, and such other

subjects as could not be brought within his direct personal observation,

the knowledge of Hippocrates was necessarily defective. Thus he wrote of

the tissues without distinguishing them; confusing arteries, veins, and

nerves, and speaking of muscles vaguely as "flesh." But with matters

within the reach of the Ancient Physician's own careful observation, the

case is very different. This is well shown in his wonderful chapter on

the club-foot, in which he not only states correctly the true nature of

the malformation, but gives some very sensible directions for rectifying

the deformity in early life.

When human strength was not sufficient to restore a displaced limb, he

skilfully availed himself of all the mechanical powers which were then

known. He does not appear to have been acquainted with the use of

pulleys for the purpose, but the axles which he describes as being

attached to the bench which bears his name (\_Scamnum Hippocratis\_) must

have been quite capable of exercising the force required.

The work called "The Aphorisms," which was probably written in the old

age of Hippocrates, consists of more than four hundred short pithy

sentences, setting forth the principles of medicine, physiology, and

natural philosophy. A large number of these sentences are evidently

taken from the author's other works, especially those "On Air," etc.,

"On Prognostics," and "On the Articulations." They embody the result of

a vast amount of observation and reflection, and the majority of them

have been confirmed by the experience of two thousand years. A proof of

the high esteem in which they have always been held is furnished by the

fact that they have been translated into all the languages of the

civilized world; among others, into Hebrew, Arabic, Latin, English,

Dutch, Italian, German, and French. The following are a few examples of

these aphorisms:--

"Spontaneous lassitude indicates disease."

"Old people on the whole have fewer complaints than the young; but

those chronic diseases which do befall them generally never leave

them."

"Persons who have sudden and violent attacks of fainting without any

obvious cause die suddenly."

"Of the constitutions of the year, the dry upon the whole are more

healthy than the rainy, and attended with less mortality."

"Phthisis most commonly occurs between the ages of eighteen and

thirty-five years."

"If one give to a person in fever the same food which is given to a

person in good health, what is strength to the one is disease to the

other."

"Such food as is most grateful, though not so wholesome, is to be

preferred to that which is better, but distasteful."

"Life is short and the art long; the opportunity fleeting;

experience fallacious and judgment difficult. The physician must not

only do his duty himself, but must also make the patient, the

attendants and the externals, co-operate."

Hippocrates appears to have travelled a great deal, and to have

practised his art in many places far distant from his native island. A

few traditions of what he did during his long life remain, but

differences of opinion exist as to the truth of these stories.

Thus one story says that when Perdiccas, the King of Macedonia, was

supposed to be dying of consumption, Hippocrates discovered the disorder

to be love-sickness, and speedily effected a cure. The details of this

story scarcely seem to be worthy of credence, more especially as similar

legends have been told of entirely different persons belonging to widely

different times. There are, however, some reasons for believing that

Hippocrates visited the Macedonian court in the exercise of his

professional duties, for he mentions in the course of his writings,

among places which he had visited, several which were situated in

Macedonia; and, further, his son Thessalus appears to have afterwards

been court physician to Archelaus, King of Macedonia.

Another story connects the name of Hippocrates with the Great Plague

which occurred at Athens in the time of the Peloponnesian war. It is

said that Hippocrates advised the lighting of great fires with wood of

some aromatic kind, probably some species of pine. These, being kindled

all about the city, stayed the progress of the pestilence. Others

besides Hippocrates are, however, famous for having successfully adopted

this practice.

A third legend states that the King of Persia, pursuing the plan (which

in the two celebrated instances of Themistocles and Pausanias had proved

successful) of attracting to his side the most distinguished persons in

Greece, wrote to Hippocrates asking him to pay a visit to his court, and

that Hippocrates refused to go. Although the story is discarded by many

scholars, it is worthy of note that Ctesias, a kinsman and contemporary

of Hippocrates, is mentioned by Xenophon in the "Anabasis" as being in

the service of the King of Persia. And, with regard to the refusal of

the venerable physician to comply with the king's request, one cannot

lose sight of the fact that such refusal was the only course consistent

with the opinions he professed of a monarchical form of government.

After his various travels Hippocrates, as seems to be pretty generally

admitted, spent the latter portion of his life in Thessaly, and died at

Larissa at a very advanced age.

It is difficult to speak of the skill and painstaking perseverance of

Hippocrates in terms which shall not appear exaggerated and

extravagant. His method of cultivating medicine was in the true spirit

of the inductive philosophy. His descriptions were all derived from

careful observation of its phenomena, and, as a result, the greater

number of his deductions have stood unscathed the test of twenty

centuries.

Still more difficult is it to speak with moderation of the candour which

impelled Hippocrates to confess errors into which in his earlier

practice he had fallen; or of that freedom from superstition which

entitled him to be spoken of as a man who knew not how to deceive or be

deceived ("qui tam fallere quam falli nescit"); or, lastly, of that

purity of character and true nobility of soul which are brought so

distinctly to light in the words of the oath translated below:--

"I swear by Apollo the Physician and Æsculapius, and I call Hygeia

and Panacea and all the gods and goddesses to witness, that to the

best of my power and judgment I will keep this oath and this

contract; to wit--to hold him, who taught me this Art, equally dear

to me as my parents; to share my substance with him; to supply him

if he is in need of the necessaries of life; to regard his offspring

in the same light as my own brothers, and to teach them this Art, if

they shall desire to learn it, without fee or contract; to impart

the precepts, the oral teaching, and all the rest of the instruction

to my own sons, and to the sons of my teacher, and to pupils who

have been bound to me by contract, and who have been sworn according

to the law of medicine.

"I will adopt that system of regimen which, according to my ability

and judgment, I consider for the benefit of my patients, and will

protect them from everything noxious and injurious. I will give no

deadly medicine to any one, even if asked, nor will I give any such

counsel, and similarly I will not give to a woman the means of

procuring an abortion. With purity and with holiness I will pass my

life and practise my art.... Into whatever houses I enter I will go

into them for the benefit of the sick, keeping myself aloof from

every voluntary act of injustice and corruption and lust. Whatever

in the course of my professional practice, or outside of it, I see

or hear which ought not to be spread abroad, I will not divulge, as

reckoning that all such should be kept secret. If I continue to

observe this oath and to keep it inviolate, may it be mine to enjoy

life and the practice of the Art respected among all men for ever.

But should I violate this oath and forswear myself, may the reverse

be my lot."

FOOTNOTES:

[1] Grote's "Aristotle," vol. i. p. 3.

[2] Grote's "History of Greece," vol. i. p. 358.

ARISTOTLE.

\_ARISTOTLE.\_

About the time that Hippocrates died, Aristotle, who may be regarded as

the founder of the science of "Natural History," was born (B.C. 384) in

Stagira, an unimportant Hellenic colony in Thrace, near the Macedonian

frontier. His father was a distinguished physician, and, like

Hippocrates, boasted descent from the Asclepiadæ. The importance

attached by the Asclepiads to the habit of physical observation, which

has been already referred to in the life of Hippocrates, secured for

Aristotle, from his earliest years, that familiarity with biological

studies which is so clearly evident in many of his works.

Both parents of Aristotle died when their son was still a youth, and in

consequence of this he went to reside with Proxenus, a native of

Atarneus, who had settled at Stagira. Subsequently he went to Athens and

joined the school of Plato. Here he remained for about twenty years, and

applied himself to study with such energy that he became pre-eminent

even in that distinguished band of philosophers. He is said to have

been spoken of by Plato as "the intellect" of the school, and to have

been compared by him to a spirited colt that required the application of

the rein to restrain its ardour.

Aristotle probably wrote at this time some philosophical works, the fame

of which reached the ears of Philip, King of Macedonia, and added to the

reputation which the young philosopher had already made with that

monarch; for Philip is said to have written to him on the occasion of

Alexander's birth, B.C. 356: "King Philip of Macedonia to Aristotle,

greeting. Know that a son has been born to me. I thank the gods not so

much that they have given him to me, as that they have permitted him to

be born in the time of Aristotle. I hope that thou wilt form him to be a

king worthy to succeed me and to rule the Macedonians."

After the death of Plato, which occurred in 347 B.C., Aristotle quitted

Athens and went to Atarneus, where he stayed with Hermias, who was then

despot of that town. Hermias was a remarkable man, who, from being a

slave, had contrived to raise himself to the supreme power. He had been

at Athens and had heard Plato's lectures, and had there formed a

friendship for Aristotle. With this man the philosopher remained for

three years, and was then compelled suddenly to seek refuge in Mitylene,

owing to the perfidious murder of Hermias. The latter was decoyed out of

the town by the Persian general, seized and sent prisoner to

Artaxerxes, by whom he was hanged as a rebel. On leaving Atarneus,

Aristotle took with him a niece of Hermias, named Pythias, whom he

afterwards married. She died young, leaving an infant daughter.

Two or three years after this, Aristotle became tutor to Alexander, who

was then about thirteen years old. The philosopher seems to have been a

favourite with both the king and the prince, and, in gratitude for his

services, Philip rebuilt Stagira and restored it to its former

inhabitants, who had either been dispersed or carried into slavery. The

king is said also to have established there a school for Aristotle. The

high respect in which Alexander held his teacher is expressed in his

saying that he honoured him no less than his own father, for while to

one he owed life, to the other he owed all that made life valuable.

In 336 B.C. Alexander, who was then only about twenty years of age,

became king, and Aristotle soon afterwards quitted Macedonia and took up

his residence in Athens once more, after an absence of about twelve

years. Here he opened a school in the Lycæum, a gymnasium on the eastern

side of the city, and continued his work there for about twelve years,

during which time Alexander was making his brilliant conquests. The

lectures were given for the most part while walking in the garden, and

in consequence, perhaps, of this, the sect received the name of the

Peripatetics. The discourses were of two kinds--the \_esoteric\_, or

abstruse, and the \_exoteric\_, or familiar; the former being delivered to

the more advanced pupils only. During the greater part of this time

Aristotle kept up correspondence with Alexander, who is said[3] to have

placed at his disposal thousands of men, who were busily employed in

collecting objects and in making observations for the completion of the

philosopher's zoological researches. Alexander is, moreover, said to

have given the philosopher eight hundred talents for the same purpose.

In spite of these marks of friendship and respect, Alexander, who was

fast becoming intoxicated with success, and corrupted by Asiatic

influences, gradually cooled in his attachment towards Aristotle. This

may have been hastened by several causes, and among others by the

freedom of speech and republican opinions of Callisthenes, a kinsman and

disciple of Aristotle, who had been, by the latter's influence,

appointed to attend on Alexander. Callisthenes proved so unpopular, that

the king seems to have availed himself readily of the first plausible

pretext for putting him to death, and to have threatened his former

friend and teacher with a similar punishment. The latter, for his part,

probably had a deep feeling of resentment towards the destroyer of his

kinsman.

Meanwhile the Athenians knew nothing of these altered relations between

Aristotle and Alexander, but continued to regard the philosopher as

thoroughly imbued with kingly notions (in spite of his writings being

quite to the contrary); so that he was an object of suspicion and

dislike to the Athenian patriots. Nevertheless, as long as Alexander was

alive, Aristotle was safe from molestation. As soon, however, as

Alexander's death became known, the anti-Macedonian feeling of the

Athenians burst forth, and found a victim in the philosopher. A charge

of impiety was brought against him. It was alleged that he had paid

divine honours to his wife Pythias and to his friend Hermias. Now, for

the latter, a eunuch, who from the rank of a slave had raised himself to

the position of despot over a free Grecian community, so far from

coupling his name (as Aristotle had done in his hymn) with the greatest

personages of Hellenic mythology, the Athenian public felt that no

contempt was too bitter. To escape the storm the philosopher retired to

Chalcis, in Eubœa, then under garrison by Antipater, the Governor of

Macedonia, remarking in a letter, written afterwards, that he did so in

order that the Athenians might not have the opportunity of sinning a

second time against philosophy (the allusion being, of course, to the

fate of Socrates).

He probably intended to return to Athens again so soon as the political

troubles had abated, but in September, 322 B.C., he died at Chalcis. An

overwrought mind, coupled with indigestion and weakness of the stomach,

from which he had long suffered, was most probably the cause of death.

Some of his detractors, however, have asserted that he took poison, and

others that he drowned himself in the Eubœan Euripus.

It is not easy to arrive at a just estimate of the character of

Aristotle. By some of his successors he has been reproached with

ingratitude to his teacher, Plato; with servility to Macedonian power,

and with love of costly display. How far these two last charges are due

to personal slander it is impossible to say. The only ground for the

first charge is, that he criticised adversely some of Plato's doctrines.

The manuscripts of Aristotle's works passed through many vicissitudes.

At the death of the philosopher they were bequeathed to Theophrastus,

who continued chief of the Peripatetic school for thirty-five years.

Theophrastus left them, with his own works, to a philosophical friend

and pupil, Neleus, who conveyed them from Athens to his residence at

Scepsis, in Asia Minor. About thirty or forty years after the death of

Theophrastus, the kings of Pergamus, to whom the city of Scepsis

belonged, began collecting books to form a library on the Alexandrian

plan. This led the heirs of Neleus to conceal their literary treasures

in a cellar, and there the manuscripts remained for nearly a century

and a half, exposed to injury from damp and worms. At length they were

sold to Apellicon, a resident at Athens, who was attached to the

Peripatetic sect. Many of the manuscripts were imperfect, having become

worm-eaten or illegible. These defects Apellicon attempted to remedy;

but, being a lover of books rather than a philosopher, he performed the

work somewhat unskilfully. When Athens was taken by Sylla, 86 B.C., the

library of Apellicon was transported to Rome. There various literary

Greeks obtained access to it; and, among others, Tyrannion, a grammarian

and friend of Cicero, did good service in the work of correction.

Andronicus of Rhodes afterwards arranged the whole into sections, and

published the manuscripts with a tabulated list.

The three principal works on biology which are extant are: "The History

of Animals;" "On the Parts of Animals;" "On the Generation of Animals."

The other biological works are: "On the Motion of Animals;" "On

Respiration;" "Parva Naturalia;"--a series of essays which are planned

to form an entire work on sense and the sensible.

"The History of Animals" is the largest and most important of

Aristotle's works on biology. It contains a vast amount of information,

not very methodically arranged, and spoiled by the occurrence here and

there of very gross errors. It consists of nine books.

The first book opens with a division of the body into similar and

dissimilar parts. Besides thus differing in their parts, animals also

differ in their mode of life, their actions and dispositions. Thus some

are aquatic, others terrestrial; of the former, some breathe water,

others air, and some neither. Of aquatic animals, some inhabit the sea,

and others rivers, lakes, or marshes. Again, some animals are

locomotive, and others are stationary. Some follow a leader, others act

independently. Various differences are in this way pointed out, and

there is no lack of illustration and detail, but a suspicion is excited

that the generalizations are sometimes based upon insufficient facts.

The book closes with a description of the different parts of the human

body, both internal and external. In speaking of the ear, Aristotle

seems to have been aware of what we now call the Eustachian tube, for he

says, "There is no passage from the ear into the brain, but there is to

the roof of the mouth."[4]

In the second book he passes on to describe the organs of animals. The

animals are dealt with in groups--viviparous and oviparous quadrupeds,

fish, serpents, birds, etc. The ape, elephant, chameleon, and some

others are especially noticed.

The third book continues the description of the internal organs.

References which are made to a diagram by letters, \_a\_, \_b\_, \_c\_, \_d\_,

show that the work was originally illustrated. At the close of this

book Aristotle has some remarks on milk, and mentions the occasional

appearance of milk in male animals. He speaks of a male goat at Lemnos

which yielded so much that cakes of cheese were made from it. Similar

instances of this phenomenon have been recorded by Humboldt, Burdach,

Geoffroy St. Hilaire, and others.

In the first four chapters of the fourth book the anatomy of the

invertebrata is dealt with, and the accounts given of certain mollusca

and crustacea are very careful and minute. The rest of the book is

devoted to a description of the organs of sense and voice; of sleep, and

the distinctions of sex. The accurate knowledge which Aristotle exhibits

of the anatomy and habits of marine animals, such as the Cephalopoda and

the larger Crustacea, leaves no doubt that he derived it from actual

observation. Professor Owen says, "Respecting the living habits of the

Cephalopoda, Aristotle is more rich in detail than any other zoological

author." What is now spoken of as the \_hectocotylization\_ of one or more

of the arms of the male cephalopod did not escape Aristotle's eye. And

while he speaks of the teeth and that which serves these animals for a

tongue, it is plain from the context that he means in the one case the

two halves of the parrot-like beak, and in the other the anterior end of

the odontophore.

Books five to seven deal with the subject of generation.

The eighth book contains a variety of details respecting animals, their

food, migrations, hibernation, and diseases; with the influence of

climate and locality upon them.

The ninth book describes the habits and instincts of animals. The

details are interesting; but there is, as usual, very little attempt at

classification. Disjointed statements and sudden digressions occur, the

subjects being treated in the order in which they presented themselves

to the author. Such curious statements as the following are met with:

"The raven is an enemy to the bull and the ass, for it flies round them

and strikes their eyes." "If a person takes a goat by the beard, all the

rest of the herd stand by, as if infatuated, and look at it." "Female

stags are captured by the sound of the pipe and by singing. When two

persons go out to capture them, one shows himself, and either plays upon

a pipe or sings, and the other strikes behind, when the first gives him

the signal." "Swans have the power of song, especially when near the end

of their life; for they then fly out to sea, and some persons sailing

near the coast of Libya have met many of them in the sea singing a

mournful song, and have afterwards seen some of them die." "Of all wild

animals, the elephant is the most tame and gentle; for many of them are

capable of instruction and intelligence, and they have been taught \_to

worship the king\_."

In the work "On the Parts of Animals," the author considers not only the

phenomena of life exhibited by each species, but also the cause or

causes to which these phenomena are attributable. After a general

introduction, he proceeds to enumerate the three degrees of composition,

viz.:--

(1) "Composition out of what some call the elements, such as air,

earth, water, and fire," or "out of the elementary forces, hot

and cold, solid and fluid, which form the material of all

compound substances."

(2) Composition out of these primary substances of the homogeneous

parts of animals, e.g. blood, fat, marrow, brain, flesh, and

bone.

(3) Composition into the heterogeneous parts or organs. These parts he

describes in detail, considering those belonging to sanguineous

animals first and most fully.

These divisions correspond roughly to the threefold study of structure

which we nowadays recognize as chemical, histological, and anatomical.

As examples of Aristotle's method of treatment, his descriptions of

blood, the brain, the heart, and the lung may be considered.

Of the \_blood\_ he says, "What are called fibres are found in the blood

of some animals, but not of all. There are none, for instance, in the

blood of deer and of roes, and for this reason the blood of such

animals as these never coagulates.... Too great an excess of water makes

animals timorous.... Such animals, on the other hand, as have thick and

abundant fibres in their blood are of a more choleric temperament, and

liable to bursts of passion.... Bulls and boars are choleric, for their

blood is exceedingly rich in fibres, and the bull's, at any rate,

coagulates more rapidly than that of any other animal.... If these

fibres are taken out of the blood, the fluid that remains will no longer

coagulate."

From these quotations it will be noted that Aristotle attributed the

coagulum to the presence of fibres, and in this he anticipated

Malpighi's discovery made in the seventeenth century. His remarks on the

proportion of coagulum and serum in different animals, which is enlarged

upon in the "History of Animals,"[5] harmonize with modern observations.

In another of his works[6] he remarks that the blood in certain diseased

conditions will not coagulate. This is known to be the case in cholera,

certain fevers, asphyxia, etc.; and the fact was probably obtained from

Hippocrates. Although Aristotle speaks here of entire absence of

coagulation in the blood of the deer and the roe, in the "History of

Animals" he admits an imperfect coagulation, for he says, "so that their

blood does not coagulate like that of other animals." The animals named

are commonly hunted, and it was probably after they had been hunted to

death that he examined them. Now, it is generally admitted that

coagulation under such circumstances is imperfect and even uncommon. The

statement as to the richness in fibres of the blood of bulls and boars

has been confirmed by some modern investigations, which have shown that

the clot bears a proportion to the strength and ferocity of the animal.

The remarks, however, as to the relative rapidity of coagulation would

appear to be contradicted by later observations, for Thackrah came to

the conclusion that coagulation commenced sooner in small and weak

animals than in strong.

Of the \_brain\_ Aristotle makes the following among other assertions: "Of

all parts of the body there is none so cold as the brain.... Of all the

fluids of the body it is the one that has the least blood, for, in fact,

it has no blood at all in its proper substance.... That it has no

continuity with the organs of sense is plain from simple inspection, and

still more closely shown by the fact that when it is touched no

sensation is produced.... The brain tempers the heat and seething of the

heart.... In order that it may not itself be absolutely without heat,

blood-vessels from the aorta end in the membrane which surrounds the

brain.... Of all animals man has the largest brain in proportion to his

size: and it is larger in men than in women. This is because the region

of the heart and of the lung is hotter and richer in blood in man than

in any other animal; and in men than in women. This again explains why

man alone of animals stands erect. For the heat, overcoming any opposite

inclination, makes growth take its own line of direction, which is from

the centre of the body upwards.... Man again has more sutures in his

skull than any other animal, and the male more than the female. The

explanation is to be found in the greater size of the brain, which

demands free ventilation proportionate to its bulk.... There is no brain

in the hinder part of the head.... The brain in all animals that have

one is placed in the front part of the head ... because the heart, from

which sensation proceeds, is in the front part of the body."

Although it would perhaps be difficult to find anywhere as many errors

in as few words, yet it should be observed that Aristotle here shows

himself to have been aware of the existence of the membranes of the

brain--the \_pia mater\_ and the \_dura mater\_; and elsewhere[7] he says

more explicitly, "Two membranes enclose the brain; that about the skull

is the stronger; the inner membrane is slighter than the outer one." And

further, it should be noted that he describes the latter membrane as a

vascular one. The fact of the brain substance being insensible to

mechanical irritation was known to Aristotle, and may have been learnt

from the practice of Hippocrates. Lastly, it should be remembered

that--though this may have been but a lucky guess on Aristotle's

part--the relative weight of brain to the entire body has been shown,

with few exceptions, to be greater in man than in any other animal.

In describing the \_heart\_ Aristotle says: "The heart lies about the

centre of the body, but rather in its upper than in its lower half, and

also more in front than behind.... In man it inclines a little towards

the left, so that it may counterbalance the chilliness of that side. It

is hollow, to serve for the reception of the blood; while its wall is

thick, that it may serve to protect the source of heat. For here, and

here alone, in all the viscera, and in fact in all the body, there is

blood without blood-vessels, the blood elsewhere being always contained

within vessels. The heart is the first of all the parts of the body to

be formed, and no sooner is it formed than it contains blood.... For no

sooner is the embryo formed than its heart is seen in motion like a

living creature, and this before any of the other parts. The heart is

abundantly supplied with sinews.... In no animal does the heart contain

a bone, certainly in none of those that we ourselves have inspected,

with the exception of the horse and a certain kind of ox. In animals of

great size the heart has three cavities; in smaller animals it has two;

and in all it has at least one."

It will be observed that here Aristotle so correctly describes the

position of the human heart as to render it probable that he is speaking

from actual inspection; although man is not the only animal in which the

heart is turned towards the left. In contrasting the heart with the

other viscera he appears to have overlooked the existence of the

coronary vessels, and to have imagined that the nutrition of the heart

was effected directly by the blood in its cavities. Although the heart

is not really the first part to appear, the observation of its very

early appearance in the embryo, which he treats more fully elsewhere,[8]

is alone enough to establish his reputation as an original observer. It

is remarkable that Aristotle should have overlooked the presence of the

valves of the heart, the structure and functions of which were fully

investigated within thirty years of his death by the anatomists of the

Alexandrian school. This is the more remarkable, as he calls attention

here, and in the "History of Animals," to the sinews or tendons (νεῦρα)

with which, he says, the heart is supplied, and by which he probably

meant chiefly the \_chordæ tendineæ\_. The "bone in the heart" of which he

speaks was probably the cruciform ossification which is normally found

in the ox and the stag below the origin of the aorta. It is found in the

horse only in advanced age, or under abnormal conditions. The statement

that the heart contains no more than three chambers has always been

considered as a very gross blunder on the part of Aristotle. Even

Cuvier, who generally lavishes upon the philosopher the most extravagant

praise, sneers at this. Professor Huxley,[9] however, has shown, by a

comparison of several passages from the "History of Animals," that what

we now call the right auricle was regarded by the author as a venous

sinus, as being a part not of the heart, but of the great vein (\_i.e.\_

the superior and the inferior \_venæ cavæ\_).

Aristotle speaks of the \_lung\_ as a single organ, sub-divided, but

having a common outlet--the trachea. Elsewhere[10] he says, "Canals from

the heart pass to the lung and divide in the same fashion as the

windpipe does, closely accompanying those from the windpipe through the

whole lung." His theory of respiration, as explained in his treatise on

the subject, is that it tempers the excessive heat produced in the

heart. The lung is compared to a pair of bellows. When the lung is

expanded, air rushes in; when it is contracted, the air is expelled. The

heat from the heart causes the lung to expand--cold air rushes in, the

heat is reduced, the lung collapses, and the air is expelled. The cold

air drawn into the lung reaches the bronchial tubes, and as the vessels

containing hot blood run alongside these tubes, the air cools it and

carries off its superfluous heat. Some of the air which enters the lung

gets from the bronchial tubes into the blood-vessels by transudation,

for there is no direct communication between them; and this air,

penetrating the body, rapidly cools the blood throughout the vessels.

But Aristotle did not consider the "pneuma," which thus reached the

interior of the blood-vessels, to be exactly the same thing as air--it

was "a subtilized and condensed air."[11] And this we now know to be

oxygen.

The treatise "On the Generation of Animals" is an extraordinary

production. "No ancient and few modern works equal it in

comprehensiveness of detail and profound speculative insight. We here

find some of the obscurest problems of biology treated with a mastery

which, when we consider the condition of science at that day, is truly

astounding. That there are many errors, many deficiencies, and not a

little carelessness in the admission of facts, may be readily imagined;

nevertheless at times the work is frequently on a level with, and

occasionally even rises above, the speculations of many advanced

embryologists."[12]

It commences with the statement that the present work is a sequel to

that "On the Parts of Animals;" and first the masculine and feminine

\_principles\_ are defined. The masculine principle is the origin of all

motion and generation; the feminine principle is the origin of the

material generated. Aristotle's philosophy of nature was teleological,

and the imperfect character of his anatomical knowledge often gives him

occasion to explain particular phenomena by final causes. Thus animals

producing soft-shelled eggs (\_e.g.\_ cartilaginous fish and vipers) are

said to do so because they have so little warmth that the external

surface of the egg cannot be dried.

Among insects, some (\_e.g.\_ grasshopper, cricket, ant, etc.) produce

young in the ordinary way, by the union of the sexes; in other cases

(\_e.g.\_ flies and fleas) this union of the sexes results in the

production of a \_skolex\_; while others have no parents, nor do they have

congress--such are the ephemera, tipula, and the like. Aristotle

discusses and rejects the theory that the male reproductive element is

derived from every part of the body. He concludes that "instead of

saying that it comes \_from\_ all parts of the body, we should say that it

goes \_to\_ them. It is not the nutrient fluid, but that which is \_left

over\_, which is secreted. Hence the larger animals have fewer young than

the smaller, for by them the consumption of nutrient material will be

larger and the secretion less. Another point to be noticed is, that the

nutrient fluid is universally distributed through the body, but each

secretion has its separate organ.... It is thus intelligible why

children resemble their parents, since that which makes all the parts of

the body, resembles that which is left over as secretion: thus the

hand, or the face, or the whole animal pre-exists in the sperm, though

in an undifferentiated state (ἀδιορίστως); and what each of these is in

actuality (ἐνεργείᾳ), such is the sperm in potentiality (δυνάμει)."

In later times the two great rival theories put forward to account for

the development of the embryo have been--

(\_a\_) The theory of Evolution, which makes the embryo pre-existent in

the germ, and only rendered visible by the unfolding and

expansion of its organs.

(\_b\_) The theory of Epigenesis, which makes the embryo arise, by a

series of successive differentiations, from a simple

homogeneous mass into a complex heterogeneous organism.

The above quotation will show how closely Aristotle held to the theory

of Epigenesis; and in another place he says, "Not at once is the animal

a man or a horse, for the end is last attained; and the specific form is

the end of each development."

Spontaneous generation is nowadays rejected by science; but Aristotle

went so far as to believe that insects, molluscs, and even eels, were

spontaneously generated. It is, however, noteworthy, in view of modern

investigations, that he looked upon \_putrefying\_ matter as the source of

such development.

A chapter of this work is devoted to the consideration of the hereditary

transmission of peculiarities from parent to offspring.

The fifth and last book contains inquiries into the cause of variation

in the colour of the eyes and hair, the abundance of hair, the sleep of

the embryo, sight and hearing, voice and the teeth.

Widely different opinions have been held from time to time of the value

of Aristotle's biological labours. This philosopher's reputation has,

perhaps, suffered most from those who have praised him most. The praise

has often been of such an exaggerated character as to have become

unmeaning, and to have carried with it the impression of insincerity on

the part of the writer. Such are the laudations of Cuvier. To say as he

does, "Alone, in fact, without predecessors, without having borrowed

anything from the centuries which had gone before, since they had

produced nothing enduring, the disciple of Plato discovered and

demonstrated more truths and executed more scientific labours in a life

of sixty-two years than twenty centuries after him were able to do," is

of course to talk nonsense, for the method which Aristotle applied was

that which Hippocrates had used so well before him; and it is evident to

any one that both his predecessors and contemporaries are frequently

laid under contribution by Aristotle, although the authority is rarely,

if ever, stated by him unless he is about to refute the view put

forward. Exaggerated praise of any author has a tendency to excite

depreciation correspondingly unjust and untrue. It has been so in the

case of this great man. In the endeavour to depose him from the

impossible position to which his panegyrists had exalted him, his

detractors have gone to any length. The principal charges brought

against his biological work have been inaccuracy and hasty

generalization. In support of the charge of inaccuracy, some of the

extraordinary statements which are met with in his works are adduced.

"These," Professor Huxley says, "are not so much to be called errors as

stupidities." Some, however, of the inaccuracies alleged against

Aristotle are fancied rather than real. Thus he is charged with having

represented that the arteries contained nothing but air; that the aorta

arose from the right ventricle; that the heart did not beat in any other

animal but man; that reptiles had no blood, etc.; although in reality he

made no one of these assertions. There remain, nevertheless, the gross

misstatements referred to above, and which really do occur. Such, for

instance, as that there is but a single bone in the neck of the lion;

that there are more teeth in male than in female animals; that the mouth

of the dolphin is placed on the under surface of the body; that the back

of the skull is empty, etc. Although these absurdities undoubtedly occur

in Aristotle's works, it by no means follows that he is responsible for

them. Bearing in mind the curious history of the manuscripts of his

treatises, we shall find it far more reasonable to conclude that such

errors crept in during the process of correction and restoration, by men

apparently ignorant of biology, than that (to take only one case) an

observer who had distinguished the cetacea from fishes and had detected

their hidden mammæ, discovered their lungs, and recognized the distinct

character of their bones, should have been so blind as to fancy that the

mouth of these animals was on the under surface of the body.

That Aristotle made hasty generalizations is true; but it was

unavoidable. Biology was in so early a stage that a theory had often of

necessity to be founded on a very slight basis of facts. Yet,

notwithstanding this drawback, so great was the sagacity of this

philosopher, that many of his generalizations, which he himself probably

looked upon as temporary, have held their ground for twenty centuries,

or, having been lost sight of, have been discovered and put forward as

original by modern biologists. Thus "the advantage of physiological

division of labour was first set forth," says Milne-Edwards, "by myself

in 1827;" and yet Aristotle had said[13] that "whenever Nature is able

to provide two separate instruments for two separate uses, without the

one hampering the other, she does so, instead of acting like a

coppersmith, who for cheapness makes a spit-and-a-candlestick in

one.[14] It is only when this is impossible that she uses one organ for

several functions."

In conclusion, we may say that the great Stagirite expounded the true

principles of science, and that when he failed his failure was caused by

lack of materials. His desire for completeness, perhaps, tempted him at

times to fill in gaps with such makeshifts as came to his hand; but no

one knew better than he did that "theories must be abandoned unless

their teachings tally with the indisputable results of observation."[15]

FOOTNOTES:

[3] Pliny, "Natural History," viii. c. 16.

[4] "History of Animals," i. 11.

[5] Bk. iii. 19.

[6] "Meteorology," iv. 7-11.

[7] "History of Animals," i. 16.

[8] "History of Animals," vi. 3.

[9] "On some of the errors attributed to Aristotle."

[10] "History of Animals," i. 17.

[11] See Professor Huxley's article already referred to.

[12] "Aristotle," by G. H. Lewes, p. 325.

[13] "De Part. Anim.," iv. 6.

[14] ὀβελισκολύχνιον.

[15] "De Gener.," iii. 10, quoted by Dr. Ogle.

GALEN.

\_GALEN.\_

Under the Ptolemies a powerful stimulus was given to biological studies

at Alexandria. Scientific knowledge was carried a step or two beyond the

limit reached by Aristotle. Thus Erasistratus and Herophilus thoroughly

investigated the structure and functions of the valves of the heart, and

were the first to recognize the nerves as organs of sensation. But,

unfortunately, no complete record of the interesting work carried on by

these men has come down to our times. The first writer after Aristotle

whose works arrest attention is Caius Plinius Secundus, whose so-called

"Natural History," in thirty-seven volumes, remains to the present day

as a monument of industrious compilation. But, as a biologist properly

so called, Pliny is absolutely without rank, for he lacked that

practical acquaintance with the subject which alone could enable him to

speak with authority. Of information he had an almost inexhaustible

store; of actual knowledge, the result of observation and experience, so

far as biological studies were concerned, he had but little. This was

largely due to the encyclopædic character of the work he undertook; his

mental powers were weighed down by an enormous mass of unarranged and

ill-digested materials. But it was due also to the peculiar bent of

Pliny's mind. He was not, like Aristotle, an original thinker; he was

essentially a student of books, an immensely industrious but not always

judicious compiler. Often his selections from other works prove that he

failed to appreciate the relative importance of the different subjects

to which he made reference. His knowledge of the Greek language appears,

too, to have been defective, for he gives at times the wrong Latin names

to objects described by his Greek authorities. To these defects must be

added his marvellous readiness to believe any statement, provided only

that it was uncommon; while, on the other hand, he showed an

indefensible scepticism in regard to what was really deserving of

attention. The chief value of his work consists in the historical and

chronological notes of the progress of some of the subjects of which he

treats--fragments of writings which would otherwise be lost to us. Pliny

was killed in the destruction of Pompeii, A.D. 79.

Claudius Galenus was born at Pergamus, in Asia Minor, in the hundred and

thirty-first year of the Christian era. Few writers ever exercised for

so long a time such an undisputed sway over the opinions of mankind as

did this wonderful man. His authority was estimated at a much higher

rate than that of all the biological writers combined who flourished

during a period of more than twelve centuries, and it was often

considered a sufficient argument against a hypothesis, or even an

alleged matter of fact, that it was contrary to Galen.

Endowed by nature with a penetrating genius and a mind of restless

energy, he was eminently qualified to profit by a comprehensive and

liberal education. And such he received. His father, Nicon, an

architect, was a man of learning and ability--a distinguished

mathematician and an astronomer--and seems to have devoted much time and

care to the education of his son. The youth appears to have studied

philosophy successively in the schools of the Stoics, Academics,

Peripatetics, and Epicureans, without attaching himself exclusively to

any one of these, and to have taken from each what he thought to be the

most essential parts of their system, rejecting, however, altogether the

tenets of the Epicureans. At the age of twenty-one, on the death of his

father, he went to Smyrna to continue the study of medicine, to which he

had now devoted himself. After leaving this place and having travelled

extensively, he took up his residence at Alexandria, which was then the

most favourable spot for the pursuit of medical studies. Here he is said

to have remained until he was twenty-eight years of age, when his

reputation secured his appointment, in his native city of Pergamus, to

the office of physician in charge of the athletes in the gymnasia

situated within the precincts of the temple of Æsculapius. For five or

six years he lived in Pergamus, and then a revolt compelled him to leave

his native town. The advantages offered by Rome led him to remove

thither and take up his residence in the capital of the world. Here his

skill, sagacity, and knowledge soon brought him into notice, and excited

the jealousy of the Roman doctors, which was still further increased by

some wonderful cures the young Greek physician succeeded in effecting.

Possibly it was owing to the ill feeling shown to Galen that, on the

outbreak of an epidemic a year afterwards, he left the imperial city and

proceeded to Brindisi, and embarked for Greece. It was his intention to

devote his time to the study of natural history, and for this purpose he

visited Cyprus, Palestine, and Lemnos. While at the last-named place,

however, he was suddenly summoned to Aquileia to meet the Emperors

Marcus Aurelius and Lucius Verus. He travelled through Thrace and

Macedonia on foot, met the imperial personages, and prepared for them a

medicine, for which he seems to have been famous, and which is spoken of

as the \_theriac\_. It was probably some combination of opium with various

aromatics and stimulants, for antidotes of many different kinds were

habitually taken by the Romans to preserve them from the ill effects of

poison and of the bites of venomous animals.[16]

With the Emperor M. Aurelius he returned to Rome, and became afterwards

doctor to the young Emperor Commodus. He did not, however, remain for a

long period at Rome, and probably passed the greater part of the rest of

his life in his native country.

Although the date of his death is not positively known, yet it appears

from a passage[17] in his writings that he was living in the reign of

Septimius Severus; and Suidas seems to have reason for asserting that he

reached his seventieth year.

Galen's writings represent the common depository of the anatomical

knowledge of the day; what he had learnt from many teachers, rather than

the results of his own personal research. Roughly speaking, they deal

with the following subjects: Anatomy and Physiology, Dietetics and

Hygiene, Pathology, Diagnosis and Semeiology, Pharmacy and Materia

Medica, Therapeutics.

The only works of this voluminous writer at which we can here glance are

those dealing with Anatomy and Physiology. These exhibit numerous

illustrations of Galen's familiarity with practical anatomy, although it

was most likely comparative rather than human anatomy at which he

especially worked. Indeed, he seems to have had but few opportunities of

carrying on human dissections, for he thinks himself happy in having

been able to examine at Alexandria two human skeletons; and he

recommends the dissection of monkeys because of their exact resemblance

to man. To this disadvantage may, perhaps, be attributed the readiness,

which sometimes appears, to assume identity of organization between man

and the brutes. Thus, because in certain animals he found a double

biliary duct, he concluded the same to be the case in man, and in one

instance he proceeded to deduce the cause of disease from this erroneous

assumption.

He supposed that there were three modes of existence in man, namely--

(\_a\_) The nutritive, which was common to all animals and plants, of

which the liver was the source.

(\_b\_) The vital, of which the heart was the source.

(\_c\_) The rational, of which the brain was the source.

Again, he considered that the animal economy possessed four natural

powers--

(1) The attractive.

(2) The alterative or assimilative.

(3) The retentive or digestive.

(4) The expulsive.

Like his predecessors, he asserted that there were four humours, namely,

blood, yellow bile, black bile, and aqueous serum. He held that it was

the office of the liver to complete the process of sanguification

commenced in the stomach, and that during this process the yellow bile

was attracted by the branches of the hepatic duct and gall-bladder; the

black bile being attracted by the spleen, and the aqueous humour by the

two kidneys; while the liver itself retained the pure blood, which was

afterwards attracted by the heart through the vena cava, by whose

ramifications it was distributed to the various parts of the body.

Following Aristotle especially, he regarded hair, nails, arteries,

veins, cartilage, bone, ligament, membranes, glands, fat, and muscle as

the simplest constituents of the body, formed immediately from the

blood, and perfectly homogeneous in character. The organic members,

\_e.g.\_ lungs, liver, etc., he looked upon as formed of several of the

foregoing simple parts.

The osteology contained in Galen's works is nearly as perfect as that of

the present day. He correctly names and describes the bones and sutures

of the cranium; notices the quadrilateral shape of the parietals, the

peculiar situation and shape of the sphenoid, and the form and character

of the ethmoid, malar, maxillary, and nasal bones. He divides the

vertebral columns into cervical, dorsal, and lumbar portions.

With regard to the nervous system, he taught that the nerves of the

senses are distinct from those which impart the power of motion to

muscles--that the former are derived from the anterior parts of the

brain, while the latter arise from the posterior portion, or from the

spinal cord. He maintained that the nerves of the finer senses are

formed of matter too soft to be the vehicles of muscular motion;

whereas, on the other hand, the nerves of motion are too hard to be

susceptible of fine sensibility. His description of the method of

demonstrating the different parts of the brain by dissection is very

interesting, and, like his references to various instruments and

contrivances, proves him to have been a practical and experienced

anatomist.

In his description of the organs and process of nutrition, absorption by

the veins of the stomach is correctly noticed, and the union of the

mesenteric veins into one common \_vena portæ\_ is pointed out. The

communications between the ramifications of the vena portæ and of the

proper veins of the liver are supposed by Galen to be effected by means

of anastomosing pores or channels. Although it is evident that Galen was

ignorant of the true absorbent system, yet he appears to have been aware

of the \_lacteals\_; for he says that in addition to those mesenteric

veins which by their union form the vena portæ, there are visible in

every part of the mesentery other veins, proceeding also from the

intestines, which terminate in glands; and he supposes that these veins

are intended for the nourishment of the intestines themselves. Some of

Galen's contemporaries asserted that upon exposing the mesentery of a

sucking animal several small vessels were seen filled \_first\_ with air,

and \_afterwards\_ with milk. They had, doubtless, mistaken colourless

lymph for air; but Galen ridicules both assertions, and thereby shows

that he had not examined the contents of the lacteals. This is somewhat

remarkable, because as a rule he omitted no opportunity of determining

with certainty, by vivisection and experiments on living animals, the

uses of the various parts of the body. As an illustration of this, we

have his correct statement, established by experiment, that the pylorus

acts as a valve \_only\_ during the process of digestion, and that it is

relaxed when digestion is completed.

He recognizes that the flesh of the heart is somewhat different to that

of the muscles of voluntary motion. Its fibres are described as being

arranged in longitudinal and transverse bundles; the former by their

contractions shortening the organ, the latter compressing and narrowing

it. Such statements show that he regarded the heart as essentially

muscular. He thought, however, that it was entirely destitute of nerves.

Although he admitted that possibly it had one small branch derived from

the \_nervus vagus\_ sent to it, yet he entirely overlooked the great

nervous plexus surrounding the roots of the blood-vessels, from which

branches proceed in company with the branches of the coronary arteries

and veins, and penetrate the muscular substance of the ventricles. He

endeavoured to prove, by experiment, observation, and reasoning, that

the arteries as well as the veins contained blood, and in this

connection he tells an amusing story. A certain teacher of anatomy, who

had declared that the aorta contained no blood, was earnestly desired by

his pupils, who were ardent disciples of Galen, to exhibit the requisite

demonstration, they themselves offering animals for the experiment. He,

however, after various subterfuges, declined, until they promised to

give him a suitable remuneration, which they raised by subscription

among themselves to the amount of a thousand drachmæ (perhaps £30). The

professor, being thus compelled to commence the experiment, totally

failed in his attempt to cut down upon the aorta, to the no small

amusement of his pupils, who, thereupon taking up the experiment

themselves, made an opening into the thorax in the way in which they had

been instructed by Galen, passed one ligature round the aorta at the

part where it attaches itself to the spine, and another at its origin,

and then, by opening the intervening portion of the artery, showed that

blood was contained in it.

The arteries, Galen thought, possessed a pulsative and attractive power

of their own, independently of the heart, the moment of their dilatation

being the moment of their activity. They, in fact, \_drew\_ their charge

from the heart, as the heart by its diastole \_drew\_ its charge from the

vena cava and the pulmonary vein. The pulse of the arteries, he also

thought, was propagated by their coats, not by the wave of blood thrown

into them by the heart. He taught that at every systole of the arteries

a certain portion of their contents was discharged at their extremities,

namely, by the exhalents and secretory vessels. Though he demonstrated

the anastomosis of arteries and veins, he nowhere hints his belief that

the contents of the former pass into the latter, to be conveyed back to

the heart, and from it to be again diffused over the body. He made a

near approach to the Harveian theory of the circulation, as Harvey

himself admits in his "De Motu Cordis;"[18] but the grand point of

difference between Galen and Harvey is the question whether or not, at

every systole of the left ventricle, more blood is thrown out than is

expended on exhalation, secretion, and nutrition. Upon this point Galen

held the negative, and Harvey, as we all know, the affirmative.

The famous Asclepiads held that respiration was for the generation of

the soul itself, breath and life being thus considered to be identical.

Hippocrates thought it was for the nutrition and refrigeration of the

innate heat, Aristotle for its ventilation, Erasistratus for the

filling of the arteries with spirits. All these opinions are discussed

and commented upon by Galen, who determines the purposes of respiration

to be (1) to preserve the animal heat; (2) to evacuate from the blood

the products of combustion.

He conjectured that there was in atmospheric air not only a quality

friendly to the vital spirit, but also a quality inimical to it, which

conjecture he drew from observation of the various phenomena

accompanying the support and the extinction of flame; and he says that

if we could find out why flame is extinguished by absence of the air, we

might then know the nature of that substance which imparts warmth to the

blood during the process of respiration.

On another occasion he says that it is evidently the \_quality\_ and not

the \_quantity\_ of the air which is necessary to life. He further shows

that he recognized the analogy between respiration and combustion, by

comparing the lungs to a lamp, the heart to its wick, the blood to the

oil, and the animal heat to the flame.

From certain observations in various parts of his works, it appears

that, although ignorant of the doctrine of atmospheric pressure, he was

acquainted with some of its practical effects. Thus, he says, if you put

one end of an open tube under water and suck out the air with the other

end, you will draw up water into the mouth, and that it is in this way

that infants extract the milk from the mother's breast.

Again, Erasistratus supposed that the vapour of charcoal and of certain

pits and wells was fatal to life because \_lighter\_ than common air, but

Galen maintained it to be \_heavier\_.

He describes two kinds of respiration, one by the mouths of the arteries

of the lungs, and one by the mouths of the arteries of the skin. In each

case, he says, the surrounding air is drawn into the vessels during

their diastole, for the purpose of cooling the blood, and during their

systole the fuliginous particles derived from the blood and other fluids

of the body are forced out.

He considers the diaphragm to be the principal muscle of respiration,

but he makes a clear distinction between ordinary respiration, which he

calls a natural and involuntary effort, and that deliberate and forced

respiration which is obedient to the will; and he says that there are

different muscles for the two purposes. Elsewhere he particularly points

out the two sets of intercostal muscles and their mode of action, of

which, before his time, he asserts that anatomists were ignorant.

He describes various effects produced on respiration and on the voice by

the division of those nerves which are connected with the thorax; and

shows particularly the effect of dividing the recurrent branch of his

sixth pair of cerebral nerves (the pneumogastric of modern anatomy). He

explains how it happens that after division of the spinal cord, provided

that division be \_beneath\_ the lower termination of the neck, the

diaphragm will still continue to act--in consequence, namely, of the

origin of the phrenic nerve being \_above\_ the lower termination of the

neck.

Before the time of Galen the medical profession was divided into several

sects, \_e.g.\_ Dogmatici, Empirici, Eclectici, Pneumatici, and

Episynthetici, who were always disputing with one another. After his

time all sects seem to have merged in his followers. The subsequent

Greek and Roman biological writers were mere compilers from his works,

and as soon as his writings were translated into Arabic they were at

once adopted throughout the East to the exclusion of all others. He

remained paramount throughout the civilized world until within the last

three hundred years. In the records of the College of Physicians of

England we read that Dr. Geynes was cited before the college in 1559 for

impugning the infallibility of Galen, and was only admitted again into

the privileges of his fellowship on acknowledgment of his error, and

humble recantation signed with his own hand. Kurt Sprengel has well said

that "if the physicians who remained so faithfully attached to Galen's

system had inherited his penetrating mind, his observing glance, and his

depth, the art of healing would have approached the limit of perfection

before all the other sciences; but it was written in the book of

destiny that mind and reason were to bend under the yoke of superstition

and barbarism, and were only to emerge after centuries of lethargic

sleep."

FOOTNOTES:

[16] Hence the name θηρίακαι.

[17] "De Antidotis," i. 13, vol. xiv. p. 65, Kuhn.

[18] "Ex ipsius etiam Galeni verbis hanc veritatem confirmari posse,

scilicet: non solum posse sanguinem e vena arteriosa in arteriam venosam

et inde in sinistrum ventriculum cordis, et postea in arterias

transmitti."--"De Motu Cordis," cap. vii.

VESALIUS.

\_VESALIUS.\_

The authority of Galen, at once a despotism and a religion, was scarcely

ever called in question until the sixteenth century. No attempt worth

recording was made during thirteen hundred years to extend the boundary

of scientific knowledge in anatomy and physiology. It is true that the

scholastic philosopher, Albertus Magnus, who was for a short time

(1260-1262) Bishop of Ratisbon, in the middle of the thirteenth century

wrote a "History of Animals," which was a remarkable production for the

age in which he lived; although Sir Thomas Browne, in his famous

"Enquiries into Common Errors," speaks of these "Tractates" as requiring

to be received with caution, adding as regards Albertus that "he was a

man who much advanced these opinions by the authoritie of his name, and

delivered most conceits, with strickt enquirie into few."

As regards human anatomy, it was considered, during the Middle Ages, to

be impiety to touch with a scalpel "the dead image of God," as man's

body was called. Mundinus, the professor of medicine at Bologna from

1315 to 1318, was the first to attempt any such thing. He exhibited the

public dissection of three bodies, but by this created so great a

scandal that he gave up the practice, and contented himself with

publishing a work, "De Anatome," which formed a sort of commentary on

Galen. This work, with additions, continued to be the text-book of the

schools until the time of Vesalius, who founded the study of anatomy as

nowadays pursued.

Andreas Vesalius was born at Brussels, on the last day of the year 1514,

of a family which for several generations had been eminent for medical

attainments. He was sent as a boy to Louvain, where he spent the greater

part of his leisure in researches into the mechanism of the lower

animals. He was a born dissector, who, after careful examination, in his

early days, of rats, moles, dogs, cats, monkeys, and the like, came, in

after-life, to be dissatisfied with any less knowledge of the anatomy of

man.

He acquired great proficiency in the scholarship of the day. Indeed the

Latin, in which he afterwards wrote his great work, is so singularly

pure that one of his detractors pretended that Vesalius must have got

some good scholar to write the Latin for him. Latin was not the only

language in which he was proficient; he added Greek and Arabic to his

other accomplishments, and this for the purpose of reading the great

biological works in the languages in which they were originally written.

From Louvain the youth went to Paris, where he studied anatomy under a

most distinguished physician, Sylvius. It was the practice of that

illustrious professor to read to his class Galen on the "Use of Parts,"

omitting nearly all the sections where exact knowledge of anatomical

detail was necessary. Sometimes an attempt was made to illustrate the

lecture by the dissection of a dog, but such illustration more often

exposed the professor's ignorance than it added to the student's

knowledge. Indirectly, however, it did good, for whenever Sylvius, after

having tried in vain to demonstrate some muscle, or nerve, or vein, left

the room, his pupil Vesalius slipped down to the table, dissected out

the part with great neatness, and triumphantly called the professor's

attention to it on his return.

Besides studying under Sylvius, Vesalius had for his teacher at Paris

the famous Winter, of Andernach, who was physician to Francis I. This

learned man, in a work published three years after this period, speaks

of Vesalius as a youth of great promise. At the age of nineteen Vesalius

returned to Louvain; and here for the first time he openly demonstrated

from the human subject. In this connection a somewhat ghastly story is

told, which serves to show the intensity of the enthusiasm with which

our anatomist was inspired. On a certain evening it chanced that

Vesalius, in company with a friend, had rambled out of the gates of

Louvain to a spot where the bodies of executed criminals were wont to

be exposed. A noted robber had been executed. His body had been chained

to a stake and slowly roasted; and the birds had so entirely stripped

the bones of every vestige of flesh, that a perfect skeleton, complete

and clean, was suspended before the eyes of the anatomist, who had been

striving hitherto to piece together such a thing out of the bones of

many people, gathered as occasion offered. Mounting upon the shoulder of

his friend, Vesalius ascended the charred stake and forcibly tore away

the limbs, leaving only the trunk, which was securely bound by iron

chains. With these stolen bones under their clothes the two youths

returned to Louvain. In the night, however, and alone, the sturdy

Vesalius found his way again to the place--which to most men, at any

rate in those times, would have been associated with unspeakable

horrors--and there, by sheer force, wrenched away the trunk, and buried

it. Then leisurely and carefully, day after day, he smuggled through the

city gates bone after bone. Afterwards, when he had set up the perfect

skeleton in his own house, he did not hesitate to demonstrate from it.

But such an act of daring plunder could not escape detection, and he was

banished from Louvain for the offence. This story is here quoted only to

show the extraordinary physical and moral courage which the anatomist

possessed; which upheld him through toils, dangers, and disgusts; and by

which he was strengthened to carry on, even in a cruel and

superstitious age, and placed, as he was, on the very threshold of the

Inquisition, a work at all times repulsive to flesh and blood.

After serving for a short time as a surgeon in the army of the Emperor

Charles V., Vesalius went to Italy, where he at once attracted the

attention of the most learned men, and became, at the age of twenty-two,

Professor of Anatomy at the University of Padua. This was the first

purely anatomical professorship that had been established out of the

funds of any university. For seven years he held the office, and he was

at the same time professor at Bologna and at Pisa. During these years

his lectures were always well attended, for they were a striking

innovation on the tameness of conventional routine. In each university

the services of the professor were confined to a short course of

demonstrations, so that his duties were complete when he had spent,

during the winter, a few weeks at each of the three towns in succession.

He then returned to Venice, which he appears to have made his

head-quarters. At this city, as well as at Pisa, special facilities were

offered to the professor for obtaining bodies either of condemned

criminals or others. At Padua and Bologna the enthusiasm of the

students, who became resurrectionists on their teacher's behalf, kept

the lecture-table supplied with specimens. They were in the habit of

watching all the symptoms in men dying of a fatal malady, and noting

where, after death, such men were buried. The seclusion of the graveyard

was then invaded, and the corpse secretly conveyed by Andreas to his

chamber, and concealed sometimes in his own bed. A diligent search was

at once made to determine accurately the cause of death. This pitiless

zeal for correct details in anatomy, associated as it was with

indefatigable practice in physic, appeared to Vesalius, as it does to

his successors of to-day, to be the only satisfactory method of

acquiring that knowledge which is essential to a doctor. Thus it was

that he, who at the age of twenty-two was able to name, with his eyes

blindfolded, any human bone put into his hand, who was deeply versed in

comparative anatomy, and had more accurate knowledge of the human frame

than any graybeard of the time, enjoyed afterwards a reputation as a

physician which was unbounded. One illustration of his sagacity in

diagnosis will suffice. A patient of two famous court physicians at

Madrid had a big and wonderful tumour on the loins. It would have been

easily recognized in these days as an aneurismal tumour, but it greatly

puzzled the two doctors. Vesalius was therefore consulted, and said,

"There is a blood-vessel dilated; that tumour is full of blood." They

were surprised at such a strange opinion; but the man died, the tumour

was opened; blood was actually found in it, and we are told \_in

admirationem rapti fuère omnes\_.

It was not until after Vesalius had been three years professor that he

began to distrust the infallibility of Galen's anatomical teaching.

Constant practical experience in dissection, both human and comparative,

slowly convinced him that--great anatomist as the "divus homo" had

undoubtedly been--his statements were not only incomplete, but often

wrong; further, that Galen very rarely wrote from actual inspection of

the human subject, but based his teaching on a belief that the structure

of a monkey was exactly similar to that of a man. With this conviction

established, Vesalius proceeded to note with great care all the

discrepancies between the text of Galen and the actual parts which it

endeavoured to describe, and in this way a volume of considerable

thickness was soon formed, consisting entirely of annotations upon

Galen. The generally received authorities being thus found to be

unreliable, it became necessary in the next place to collect and arrange

the fundamental facts of anatomy upon a new and sounder basis. To this

task Vesalius, at the age of twenty-five, devoted himself, and began his

famous work on the "Fabric of the Human Body." Owing possibly to the

good fortune of his family, and to the income which he derived from his

professorships, Andreas was able to secure for his work the aid of some

of the best artists of the day. To Jean Calcar, one of the ablest of the

pupils of Titian, are due the splendid anatomical plates which

illustrate the "Corporis Humani Fabrica," and which are incomparably

better than those of any work which preceded it. To him most likely is

due also the woodcut which adorns the first page, and which represents

the young Vesalius, wearing professor's robes, standing at a

lecture-table and pointing out, from a robust subject that lies before

him, the inner secrets of the human body; while the tiers of benches

that surround the professor are completely crowded with grave doctors

struggling to see, even climbing upon the railings to do so.

But throughout the work the plates are used simply to illustrate and

elucidate the text, and the information furnished in the latter is

minute and accurate, and stated in well-polished Latin. As the author

proceeds, he finds it necessary to disagree with Galen, and the reasons

for this disagreement are given. The inevitable result follows that

Vesalius is placed at issue not only with "the divine man," but also

with all those who for thirteen centuries had unquestioningly followed

him. Such a result Vesalius must have foreseen. It was not, therefore, a

great surprise to him, perhaps, to receive, soon after the publication

of his work, a violent onslaught from his old master Sylvius. He simply

replied to it by a letter full of respect and friendly feeling,

inquiring wherein he had been guilty of error. The answer he got was

that he must show proper respect for Galen, if he wished to be regarded

as a friend of Sylvius.

In 1546, three years after the publication of his great work, Andreas

was summoned to Ratisbon to exercise his skill upon the emperor, and

from that date he was ranked among the court physicians. In the same

year, 1546, in a long letter, entitled "De usu Radicis Chinæ," he not

only treats of the medicine by which the emperor's health had been

restored, but he vindicates his teaching against his assailants, and

again gives cumulative proof of the fact that Galen had dissected only

brutes.

It was the practice of Vesalius, while he was professor in Italy, to

issue a public notice the day before each demonstration, stating the

time at which it would take place, and inviting all who decried his

errors to attend and make their own dissections from his subject, and

confound him openly. It does not appear that any one was rash enough

ever to accept the challenge; yet, although the majority of the young

men were on the side of Vesalius, the older teachers continued to regard

him as a heretic, and in 1551 Sylvius published a bitterly personal

attack. It was nothing to him that the results of actual dissection were

against him--he even went so far as to assert that the men of his time

were constructed somewhat differently to those of the time of Galen!

Thus, to the proof that Vesalius gave that the carpal bones were not

absolutely without marrow, as Galen had asserted, Sylvius replied that

the bones were harder and more solid among the ancients, and were, in

consequence, destitute of medullary substance. Again, when Vesalius

showed that Galen was wrong in describing the human femur and humerus as

greatly curved, Sylvius explained the discrepancy by saying that the

wearing of narrow garments by the moderns had straightened the limbs.

Through these attacks, however, the writings of Vesalius fell into

somewhat bad odour in the court; for in that very superstitious age

there was a kind of vague dread felt of reading the works of a man

against whom such serious charges of arrogance and impiety were brought.

And so it came about that when he received the summons to take up his

residence permanently at Madrid, and the orthodoxy of the day seemed for

the moment to triumph, in a fit of proud indignation, he burned all his

manuscripts; destroying a huge volume of annotations upon Galen; a whole

book of medical formulæ; many original notes on drugs; the copy of Galen

from which he lectured, and which was covered with marginal notes of new

observations that had occurred to him while demonstrating; and the

paraphrases of the books of Rhases, in which the knowledge of the

Arabian was collated with that of the Greeks and others. The produce of

the labour of many years was thus reduced to ashes in a short fit of

passion, and from this time Vesalius lived no more for controversy or

study. He gave himself up to pleasure and the pursuit of wealth, resting

on his reputation and degenerating into a mere courtier. As a

practitioner he was held in high esteem. When the life of Don Carlos,

Philip's son, was despaired of, it was Vesalius who was called in, and

who, seeing that the surgeons had bound up the wound in the head so

tightly that an abscess had formed, promptly brought relief to the

patient by cutting into the pericranium. The cure of the prince,

however, was attributed by the court to the intercession of St. Diego,

and it is possible that on the subject of this alleged miraculous

recovery Vesalius may have expressed his opinion rather more strongly

than it was safe for a Netherlander to do. At any rate, the priests

always looked upon him with dislike and suspicion, and at length they

and the other enemies of the great anatomist had their revenge.

A young Spanish nobleman had died, and Vesalius, who had attended him,

obtained permission to ascertain, if possible, by a post-mortem

examination, the cause of death. On opening the body, the heart was

said--by the bystanders--to beat; and a charge, not merely of murder,

but of impiety also, was brought against Vesalius. It was hoped by his

persecutors that the latter charge would be brought before the

Inquisition, and result in more rigorous punishment than any that would

be inflicted by the judges of the common law. The King of Spain,

however, interfered and saved him, on condition that he should make a

pilgrimage to the Holy Land. Accordingly he set out from Madrid for

Venice, and thence to Cyprus, from which place he went on to Jerusalem,

and was returning, not to Madrid, but to Padua, where the professorship

of physic had been offered him, when he suffered shipwreck on the island

of Zante, and there perished miserably of hunger and grief, on October

15, 1564, before he had reached the age of fifty. His body was found by

a travelling goldsmith, who recognized, notwithstanding their starved

outlines, the features of the renowned anatomist, and respectfully

buried his remains and raised a statue to his memory.

Two of the works of this great man have been already referred to,

namely: "De Corporis Humani Fabrica;" "De usu Radicis Chinæ." Besides

these the following have appeared: "Examen Observationum Gabrielis

Fallopii;" "Gabrielis Cunei Examen, Apologiæ Francisci Putei pro Galeno

in Anatome;" a great work on Surgery in seven books.

With respect to the last of these, it may be sufficient to remark that

there is every reason to believe that the name of the famous anatomist

was stolen after his death to give value to the production, which was

compiled and published by a Venetian named Bogarucci; and that Vesalius

is not responsible for the contents.

The other works are undoubtedly genuine. In 1562 Andreas seems to have

been roused for a short time from the lethargy into which he had sunk,

by an attack from Franciscus Puteus; for to this attack a reply

appeared--from a writer calling himself Gabriel Cuneus--which has always

been attributed by the most competent authorities to Vesalius himself.

In this rather long work, covering as it does more than fifty pages in

the folio edition, the views of Vesalius, which are at variance with

Galen, are gone through \_seriatim\_ and defended.

In 1561 Fallopius, who had studied under Vesalius, published his

"Anatomical Observations," containing several points in which he had

extended the knowledge of anatomy beyond the limits reached by his

master. He had taught publicly for thirteen years at Ferrara, and had

presided for eight years over an anatomical school, so that he was no

novice in the field of biology. Yet so completely had Vesalius lost the

philosophic temperament that he regarded this publication as an

infringement of his rights, and in this spirit wrote an "Examen

Observationum Fallopii," in which he decried the friend who had made

improvements on himself, as he had been decried for his improvements on

Galen. The manuscript of this work, finished at the end of December,

1561, was committed by the author to the care of Paulus Teupulus of

Venice, orator to the King of Spain, who was to give it to Fallopius.

The orator, however, did not reach Padua until after the death of

Fallopius, and he consequently retained the document until Vesalius, on

his way to Jerusalem, took possession of it, and caused it to be

published without delay. It appeared at Venice in 1564.[19]

The letter on the China root--a plant we know nowadays as

sarsaparilla--by the use of which the emperor's recovery was effected,

has been already referred to. It was addressed to the anatomist's

friend, Joachim Roelants. Very little space, however, is taken up with a

description of the medicine which gives title to the letter. Something

certainly is said of the history and nature of the plant, the

preparation of the decoction and its effects; but the writer soon

introduces the subject which was at that time of very vital importance

to him, namely, his position with regard to the statements of Galen and

his followers. He collects together various assertions of the Greek

anatomist, on the bones, the muscles and ligaments, the relations of

veins and arteries, the nerves, the character of the peritoneum, the

organs of the thorax, the skull and its contents, etc., and shows from

each and all of these that reference had not been made to the human

subject, and that therefore the statements were unreliable.

To the work on the "Fabric of the Human Body" we have already alluded,

as well as to the causes which led to its being written. More than half

of this great treatise is occupied with a minute description of the

build of the human body--its bones, cartilages, ligaments, and muscles.

It may have been owing to the thorough acquaintance which Vesalius

showed with these parts that his detractors pretended afterwards that he

only understood superficial injuries. But other branches of anatomy are

fully dealt with. The veins and arteries are described in the third

book, and the nerves in the fourth; the organs of nutrition and

reproduction are treated of in the next; while the remaining two books

are devoted to descriptions of the heart and brain.

Vesalius gives a good account of the sphenoid bone, with its large and

small wings and its pterygoid processes; and he accurately describes the

vestibule in the interior of the temporal bone. He shows the sternum to

consist, in the adult, of three parts and the sacrum of five or six. He

discovered the valve which guards the \_foramen ovale\_ in the fœtus; and

he not only verified the observation of Etienne as to the valve-like

fold guarding the entrance of each hepatic vein into the inferior vena

cava, but he also fully described the \_vena azygos\_. He observed, too,

the canal which passes in the fœtus between the umbilical vein and vena

cava, and which has since been known as the \_ductus venosus\_. He was the

first to study and describe the mediastinum, correcting the error of the

ancients, who believed that this duplicature of the pleura contained a

portion of the lungs. He described the omentum and its connections with

the stomach, the spleen, and the colon; and he enunciated the first

correct views of the structure of the pylorus, noticing at the same time

the small size of the cæcal appendix in man. His account of the anatomy

of the brain is fuller than that of any of his predecessors, but he does

not appear to have well understood the inferior recesses, and his

description of the nerves is confused by regarding the optic as the

first pair, the third as the fifth, and the fifth as the seventh. The

ancients believed the optic nerve to be hollow for the conveyance of the

visual spirit, but Vesalius showed that no such tube existed. He

observed the elevation and depression of the brain during respiration,

but being ignorant of the circulation of the blood, he wrongly explained

the phenomenon.

Exclusively an anatomist, he makes but brief references in his great

work to the functions of the organs which he describes. Where he differs

from Galen on these matters he does so apologetically. He follows him in

regarding the heart as the seat of the emotions and passions--the

hottest of all the viscera and source of heat of the whole body;

although he does not, as Aristotle did, look upon the heart as giving

rise to the nerves. He considers the heart to be in ceaseless motion,

alternately dilating and contracting, but the diastole is in his opinion

the influential act of the organ. He knows that eminences or projections

are present in the veins, and indeed speaks of them as being analogous

to the valves of the heart, but he denies to them the office of valves.

To him the motion of the blood was of a to-and-fro kind, and valves in

the veins acting as such would have interfered with anything of the

sort. He expresses clearly the idea, that was entertained in the old

physiology, of the attractions exerted by the various parts of the body

for the blood; and especially that of the veins and heart for the blood

itself. "The right sinus of the heart," he says, "attracts blood from

the vena cava, and the left attracts air from the lungs through the

\_arteria venalis\_ (pulmonary vein), the blood itself being attracted by

the veins in general, the vital spirit by the arteries." Again, he

speaks of the blood filtering through the septum between the ventricles

as if through a sieve, although he knows perfectly well from his

dissection that the septum is quite impervious.

It will thus be seen that the physiological teaching of Galen was left

undisturbed by Vesalius.

FOOTNOTES:

[19] See Professor Morley's article on "Anatomy in Long Clothes," in

\_Fraser's Magazine\_, 1853, from which most of the facts in this sketch

have been taken.

HARVEY.

\_HARVEY.\_

The importance of Harvey's discovery of the circulation of the blood can

only be properly estimated by bearing in mind what was done by his

predecessors in the same field of inquiry. Aristotle had taught that in

man and in the higher brutes the blood was elaborated from the food in

the liver, conveyed to the heart, and thence distributed by it through

the veins to the whole body. Erasistratus and Herophilus held that,

while the veins carried blood from the heart to the members, the

arteries carried a subtle kind of air or spirit. Galen discovered that

the arteries were not merely air-pipes, but that they contained blood as

well as vital air or spirit. Sylvius, the teacher of Vesalius, was aware

of the presence of valves in the veins; and Fabricius, Harvey's teacher

at Padua, described them much more accurately than Sylvius had done; but

neither of these men had a true idea of the significance of the

structures of which they wrote. Servetus, the friend and contemporary of

Vesalius, writing in 1533, correctly described the course of the lesser

circulation in the following words: "This communication (\_i.e.\_ between

the right and left sides of the heart) does not take place through the

partition of the heart, as is generally believed; but by another

admirable contrivance, whereby from the right ventricle the subtle blood

is agitated in a lengthened course through the lungs, wherein prepared,

it becomes of a crimson colour, and from the vena arterialis (pulmonary

artery) is transferred into the arteria venalis (pulmonary vein).

Mingled with the inspired air in the arteria venalis, freed by

respiration from fuliginous matter, and become a suitable home of the

vital spirit, it is attracted at length into the left ventricle of the

heart by the diastole of the organ." But when Servetus comes to speak of

the systemic circulation, what he has to say is as old as Galen.

The opinions, therefore, on the subject of the blood and its

distribution which were prevalent at the end of the sixteenth century

prove--

(1) That although the blood was not regarded as stagnant, yet its

circulation, such as is nowadays recognized, was unknown;

(2) That one kind of blood was thought to flow from the liver to the

right ventricle, and thence to the lungs and general system by

the veins, while another kind flowed from the left ventricle to

the lungs and general system by the arteries;

(3) That the septum of the heart was regarded as admitting of the

passage of blood directly from the right to the left side;

(4) That there was no conception of the functions of the heart as the

motor power of the movement of the blood, for biologists of that

day doubted whether the substance of the heart were really

muscular; they supposed the pulsations to be due to expansion of

the spirits it contained; they believed the only dynamic effect

which it had on the blood to be that of sucking it in during its

active diastole, and they supposed the chief use of its constant

movements to be the due mixture of blood and spirits.

This was the state of knowledge before Harvey's time. By his great work

he established--

(1) That the blood flows continuously in a circuit through the whole

body, the force propelling it in this unwearied round being the

rhythmical contractions of the muscular walls of the heart;

(2) That a portion only of the blood is expended in nutrition each time

that it circulates;

(3) That the blood conveyed in the systemic arteries communicates heat

as well as nourishment throughout the body, instead of exerting a

cooling influence, as was vulgarly supposed; and

(4) That the pulse is not produced by the arteries enlarging and so

filling, but by the arteries being filled with blood and so

enlarging.

We can now consider the method by which Harvey arrived at these results.

The work, "De Motu Cordis et Sanguinis," after giving an account of the

views of preceding physiologists, ancient and modern, commences with a

description of the heart as seen in a living animal when the chest has

been laid open and the pericardium removed. Three circumstances are

noted--

(\_a\_) The heart becomes erect, strikes the chest, and gives a beat;

(\_b\_) It is constricted in every direction;

(\_c\_) Grasped by the hand, it is felt to become harder during the

contraction.

From these circumstances it is inferred--

(1) That the action of the heart is essentially of the same nature as

that of voluntary muscles, which become hard and condensed when

they act;

(2) That, as the effect of this, the capacity of the cavities is

diminished, and the blood is expelled;

(3) That the intrinsic motion of the heart is the systole, and not the

diastole, as previously imagined.

The motions of the arteries are next shown to be dependent upon the

action of the heart, because the arteries are distended by the wave of

blood that is thrown into them, being filled like sacs or bladders, and

not expanding like bellows. These conclusions are confirmed by the

jerking way in which blood flows from a cut artery.

In the heart itself two distinct motions are observed--first of the

auricles, and then of the ventricles. These alternate contractions and

dilatations can have but one result, namely, to force the blood from the

auricle to the ventricle, and from the ventricle, on the right side, by

the pulmonary artery to the lungs, and on the left side by the aorta to

the system.

These considerations suggest to the mind of Harvey the idea of the

circulation. "I began to think," he says, "whether there might not be a

motion, as it were, in a circle." This is next established by proving

the three following propositions:--

(1) The blood is incessantly transmitted by the action of the heart

from the vena cava to the arteries in such quantity that it

cannot be supplied from the ingesta, and in such wise that the

whole mass must very quickly pass through the organ;

(2) The blood, under the influence of the arterial pulse, enters, and

is impelled in a continuous, equable, and incessant stream

through every part and member of the body, in much larger

quantity than were sufficient for nutrition, or than the whole

mass of fluids could supply;

(3) The veins in like manner return this blood incessantly to the heart

from all parts and members of the body.

As to the first proposition Harvey says, "Did the heart eject but two

drachms of blood on each contraction, and the beats in half an hour were

a thousand, the quantity expelled in that time would amount to twenty

pounds and ten ounces; and were the quantity an ounce, it would be as

much as eighty pounds and four ounces. Such quantities, it is certain,

could not be supplied by any possible amount of meat and drink consumed

within the time specified. It is the same blood, consequently, that is

now flowing out by the arteries, now returning by the veins; and it is

simply matter of necessity that the blood should perform a circuit, or

return to the place from whence it went forth."

Demonstration of the second proposition--that the blood enters a limb by

the arteries and returns from it by the veins--is afforded by the

effects of a ligature. For if the upper part of the arm be \_tightly\_

bound, the arteries below will not pulsate, while those above will throb

violently. The hand under such circumstances will retain its natural

colour and appearance, although, if the bandage be kept on for a minute

or two, it will begin to look livid and to fall in temperature. But if

the bandage be now slackened a little, the hand and the arm will

immediately become suffused, and the superficial veins show themselves

tumid and knotted, the pulse at the wrist in the same instant beginning

to beat as it did before the application of the bandage. The tight

bandage not only compresses the veins, but the arteries also, so that

blood cannot flow through either. The slacker ligature obstructs the

veins only, for the arteries lie deeper and have firmer coats. "Seeing,

then," says Harvey, "that the moderately tight ligature renders the

veins turgid, and the whole hand full of blood, I ask, Whence is this?

Does the blood accumulate below the ligature coming through the veins,

or through the arteries, or passing by certain secret pores? Through the

veins it cannot come; still less can it come by any system of invisible

pores; it must needs, then, arrive by the arteries."

The third position to be proved is that the veins return the blood to

the heart from all parts of the body. That such is the case might be

inferred from the presence and disposition of the valves in the veins;

for the office of the valves is by no means explained by the theory that

they are to hinder the blood from flowing into inferior parts by

gravitation, since the valves do not always look upwards, but always

towards the trunks of the veins, invariably towards the seat of the

heart. The action of the valves is then demonstrated experimentally on

the arm bound as for blood-letting. The point of a finger being kept on

a vein, the blood from the space above may be streaked upwards till it

passes the valve, when that portion of the vein between the valve and

the point of pressure will not only be emptied of its contents, but will

remain empty as long as the pressure is continued. If the pressure be

now removed, the empty part of the vein will fill instantly and look as

turgid as before.

Other confirmatory evidence is then added, e.g. the absorption of animal

poisons and of medicines applied externally, the muscular structure of

the heart and the necessary working of its valves.

William Harvey, the illustrious physiologist, anatomist, and physician,

to whom this discovery is due, was the eldest son of a Kentish yeoman,

and was born in April, 1578. At the age of ten he entered the Canterbury

Grammar School, where he appears to have remained for some years. At

sixteen he passed to Caius-Gonvil College, Cambridge, and three years

afterwards took his B.A. degree and quitted the university. Like most

students of medicine of that day, he found it necessary to seek the

principal part of his professional education abroad. He travelled to

Italy, selected Padua as his place of study, and there continued to

reside for four years, having as one of his teachers the famous

Fabricius of Aquapendente. On his return to England, in 1602, he took

his doctor's degree at Cambridge, and entered on the practice of his

profession.

In 1604 he joined the College of Physicians, and three years later was

elected a Fellow of that learned body. Two years afterwards he applied

for the post of physician to St. Bartholomew's Hospital; and his

application being supported by letters of recommendation to the

governor, from the king and from the president of the College of

Physicians, he was duly elected to the office in the same year, as soon

as a vacancy occurred.

In 1615, when thirty-seven years of age, Harvey was chosen to deliver

the lectures on surgery and anatomy to the College of Physicians, and it

is possible that at this time he gave an exposition of his views on the

circulation. He continued to lecture on the same subject for many years

afterwards, although he did not publish his views until 1628, when they

appeared in the work "De Motu Cordis."

Some few years after his appointment as lecturer to the college, he was

chosen one of the physicians extraordinary to King James I., and about

five or six years after the accession of Charles I. he became physician

in ordinary to that unfortunate monarch. The physiologist's

investigations seem to have interested King Charles, for he had several

exhibitions made of the \_punctum saliens\_ in the embryo chick, and also

witnessed dissections from time to time.

When, in 1630, the young Duke of Lennox made a journey on the Continent,

Harvey was chosen to travel with him, and probably remained abroad

about two years. During this time Harvey most likely visited Venice. Of

this tour the doctor speaks in the following terms in a letter written

at the time: "I can only complayne that by the waye we could scarce see

a dogg, crow, kite, raven, or any bird or any thing to anatomise; only

sum few miserable poeple the reliques of the war and the plauge, where

famine had made anatomies before I came."

Six years after this, in April, 1636, he accompanied the Earl of Arundel

in his embassy to the emperor. Having to visit the principal cities of

Germany, he was thus afforded an opportunity of meeting the leading

biologists of the time, and at Nuremberg he probably met Caspar

Hoffmann, and made that public demonstration of the circulation of the

blood which he had promised in his letter dated from that city, and

which convinced every one present except Hoffmann himself. Hollar, the

artist, informs us that Harvey's enthusiasm in his search for specimens

often led him into danger, and caused grave anxiety to the Earl of

Arundel. "For he would still be making of excursions into the woods,

making observations of strange trees, plants, earths, etc., and

sometimes like to be lost; so that my lord ambassador would be really

angry with him, for there was not only danger of wild beasts, but of

thieves."

Soon after his return to England, as court physician, his movements

became seriously restricted by the fortunes of the king. Aubrey says,

"When King Charles I., by reason of the tumults, left London, Harvey

attended him, and was at the fight of Edgehill with him; and during the

fight the Prince and the Duke of York were committed to his care. He

told me that he withdrew with them under a hedge, and tooke out of his

pockett a booke and read; but he had not read very long before a bullet

of a great gun grazed on the ground neare him, which made him remove his

station.... I first sawe him at Oxford, 1642, after Edgehill fight, but

was then too young to be acquainted with so great a doctor. I remember

he came severall times to our Coll. (Trin.) to George Bathurst, B.D.,

who had a hen to hatch egges in his chamber, which they dayly opened to

see the progress and way of generation."

In 1645, Charles, after the execution of Archbishop Laud, took upon

himself the functions of visitor of Merton College, and having removed

Sir Nathaniel Brent from the office of warden for having joined "the

Rebells now in armes against" him, he directed the Fellows to take the

necessary steps for the election of a successor. This course consisted

in giving in three names to the visitor, in order that one of the three

(the one named first, probably) should be appointed. Harvey was so named

by five out of the seven Fellows voting, and was accordingly duly

elected. A couple of days after his admission he summoned the Fellows

into the hall and made a speech to them, in which he pointed out that

it was likely enough that some of his predecessors had sought the office

in order to enrich themselves, but that his intentions were quite of

another kind, wishing as he did to increase the wealth and prosperity of

the college; and he finished by exhorting them to cherish mutual concord

and amity. After the surrender of Oxford, July, 1646, Harvey retired

from the court. He was in his sixty-ninth year, and doubtless found the

hardships and inconveniences which the miserable war entailed far from

conducive to health. The rest and seclusion to be had at the residence

of one or other of his brothers offered him the much-needed opportunity

of renewing his inquiries into the subject of generation, and it is of

this time that Dr. Ent speaks in the preface to the published work on

that subject which appeared in 1651. "Harassed with anxious and in the

end not much availing cares, about Christmas last, I sought to rid my

spirit of the cloud that oppressed it, by a visit to that great man, the

chief honour and ornament of our college, Dr. William Harvey, then

dwelling not far from the city. I found him, Democritus-like, busy with

the study of natural things, his countenance cheerful, his mind serene,

embracing all within its sphere. I forthwith saluted him, and asked if

all were well with him. 'How can it,' said he, 'whilst the Commonwealth

is full of distractions, and I myself am still in the open sea? And

truly,' he continued, 'did I not find solace in my studies, and a balm

for my spirit in the memory of my observations of former years, I should

feel little desire for longer life. But so it has been, that this life

of obscurity, this vacation from public business, which causes tedium

and disgust to so many, has proved a sovereign remedy to me.'"

Harvey died in June, 1657. Aubrey, his contemporary, says, "On the

morning of his death, about ten o'clock, he went to speake, and found he

had the dead palsey in his tongue; then he sawe what was to become of

him, he knew there was then no hopes of his recovery, so presently sends

for his young nephews to come up to him, to whom he gives one his watch,

to another another remembrance, etc.; made sign to Sambroke his

Apothecary to lett him blood in the tongue, which did little or no good,

and so he ended his dayes.... The palsey did give him an easie

passeport.... He lies buried in a vault at Hempsted in Essex, which his

brother Eliab Harvey built; he is lapt in lead, and on his brest, in

great letters, 'Dr. William Harvey.' I was at his Funerall, and helpt to

carry him into the vault."

The publication of Harvey's views on the movement of the blood excited

great surprise and opposition. The theory of a complete circulation was

at any rate novel, but novelty was far from being a recommendation in

those days. According to Aubrey, the author was thought to be

crackbrained, and lost much of his practice in consequence. He himself

complains that contumelious epithets were levelled at the doctrine and

its author. It was not until after many years had elapsed, and the facts

had become familiar, that men were struck with the simplicity of the

theory, and tried to prove that the idea was not new after all, and that

it was to be found in Hippocrates, or in Galen, or in Servetus, or in

Cæsalpinus--anywhere, in fact, except where alone it existed, namely, in

the work, "De Motu Cordis et Sanguinis." No one seems to have denied,

while Harvey lived, that he was the discoverer of the circulation of the

blood; indeed, Hobbes of Malmesbury, his contemporary, said of him, "He

is the only man, perhaps, that ever lived to see his own doctrine

established in his lifetime."

In one important respect Harvey's account of the circulation was

incomplete. He knew nothing of the vessels which we now speak of as

capillaries. Writing to Paul Marquard Slegel, of Hamburg, in 1651, he

says, "When I perceived that the blood is transferred from the veins

into the arteries through the medium of the heart, by a grand mechanism

and exquisite apparatus of valves, I judged that in like manner,

wherever transudation does not take place through the pores of the

flesh, the blood is returned from the arteries to the veins, not

without some other admirable artifice" (\_non sine artificio quodam

admirabili\_). It was this \_artificium admirabile\_ of which Harvey was

unable to give a description. On account of the minuteness of their

structure, the capillaries were beyond his sight, aided as it was by a

magnifying glass merely. He indeed demonstrated physiologically the

existence of some such passages; but it remained for a later observer,

with improved appliances, to verify the fact. This was done by Malpighi

in 1661, who saw in the lung of a frog, which was so mounted in a frame

as to be viewed by transmitted light, the network of capillaries which

connect the last ramifications of the arteries with the radicles of the

veins.

Harvey rightly denied that the arteries possessed any pulsific power of

their own, and maintained that their pulse is owing solely to the sudden

distension of their walls by the blood thrown into them at each

contraction of the ventricles. But the remission which succeeds the

pulse was regarded by him as caused simply by collapse of the walls of

the arteries due to elastic reaction. Knowing nothing of the muscular

coat of the arteries, he was unaware of the fact that the elastic

reaction of the arteries, after their distension, is aided by the tonic

contractility of their walls; the two forces, physical and vital, acting

in concert with each other--the former converting the intermittent flow

from the heart into an even stream in the capillaries and veins; the

latter, through the vaso-motor system, regulating the flow of blood to

particular parts in order to meet changing requirements.

It is somewhat surprising to find that such an accurate observer as

Harvey should have failed to recognize the significance and importance

of the system of lacteal vessels. But such was the case. Eustachius, in

the sixteenth century, had discovered the thoracic duct in the horse,

although he seems to have thought that it was peculiar to that animal.

Aselli, while dissecting the body of a dog in 1622, accidentally

discovered the lacteals, and thought at first that they were nerves; but

upon puncturing one of them, and seeing the milky fluid which escaped,

found them to be vessels. He, however, failed to trace them to the

thoracic duct, and believed them to terminate in the liver. Pecquet of

Dieppe followed them from the intestines to the mesenteric glands, and

from these into a common sac or reservoir, which he designated

\_receptaculum chyli\_, and thence to their entry by a single slender

conduit into the venous system at the junction of the jugular and

subclavian veins. The existence of the lacteals had not entirely escaped

Harvey, however. He had himself noticed them in the course of his

dissections before Aselli's book was published, but "for various

reasons" could not bring himself to believe that they contained chyle.

The smallness of the thoracic duct seemed to him a difficulty, and as

it was a demonstrated fact that the gastric veins were largely

absorptive, the lacteals appeared to him superfluous. He is not

"obstinately wedded to his own opinion," and does not doubt "but that

many things, now hidden in the well of Democritus, will by-and-by be

drawn up into day by the ceaseless industry of a coming age."

Late in the author's life, as we have seen, the work on the "Generation

of Animals" appeared; but neither physiological nor microscopical

science was sufficiently advanced to admit of the production of an

enduring work on a subject necessarily so abstruse as that of

generation. It was impossible, however, for so shrewd and able an

investigator as Harvey to work at a subject even as difficult as this

without leaving the impress of his original genius. He first announced

the general truth, "Omne animal ex ovo," and clearly proved that the

essential part of the egg, that in which the reproductive processes

begin, was not the \_chalazæ\_, but the \_cicatricula\_. This Fabricius had

looked upon as a blemish, a scar left by a broken peduncle. Harvey

described this little cicatricula as expanding under the influence of

incubation into a wider structure, which he called the eye of the egg,

and at the same time separating into a clear and transparent part, in

which later on, according to him, there appeared, as the first rudiment

of the embryo, the heart, or \_punctum saliens\_, together with the

blood-vessels. He was clearly of opinion that the embryo arose by

successive formation of parts out of the homogeneous and nearly liquid

mass. This was the doctrine of epigenesis, which, notwithstanding its

temporary overthrow by the erroneous theory of evolution,[20] is, with

modifications, the doctrine now held.

Of Harvey's scholarship and culture we are not left in ignorance. Bishop

Pearson, writing about seven years after the doctor's death, and

Aubrey[21] have told us of his appreciation of the works of Aristotle,

and in his own writings he refers more frequently to the Stagirite than

to any other individual. Sir William Temple[22] has also put it on

record that the famous Dr. Harvey was a great admirer of Virgil, whose

works were frequently in his hands. His store of individual knowledge

must have been great; and he seems never to have flagged in his anxiety

to learn more. He made himself master of Oughtred's "Clavis Mathematica"

in his old age, according to Aubrey, who found him "perusing it and

working problems not long before he dyed."

Nor should it be forgotten that this illustrious physiologist and

scholar was also the first English comparative anatomist. Of his

knowledge of the lower animals he makes frequent use, and he says (in

his work on the heart), "Had anatomists only been as conversant with the

dissection of the lower animals as they are with that of the human body,

many matters that have hitherto kept them in a perplexity of doubt,

would, in my opinion, have met them freed from every kind of

difficulty." Aubrey says that Harvey often told him "that of all the

losses he sustained, no grief was so crucifying to him as the loss of

his papers (containing notes of his dissections of the frog, toad, and

other animals), which, together with his goods in his lodgings at

Whitehall, were plundered at the beginning of the rebellion."

FOOTNOTES:

[20] According to the theory of evolution, the egg contained from the

first an excessively minute, but complete animal, and the changes which

took place during incubation consisted not in a formation of parts, but

in a growth, \_i.e.\_ in an expansion of the already existing embryo (see

p. 40).

[21] See p. lxxxii. of "Life," by Dr. Willis.

[22] "Miscellanies:" Part II. on Poetry, p. 314.

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