AN

INAUGURAL DISSERTATION

ON

The Physiology of Absorption.

SUBMITTED TO THE

PRESIDENT, BOARD OF TRUSTEES,
AND MEDICAL FACULTY

OF THE

UNIVERSITY OF NASHVILLE,

FOR THE DEGREE OF

Doctor of Medicine.

BY

William Myers Welch

OF

Tennessee

1858

W. T. BERRY AND CO.

BOOKSELLERS AND STATIONERS, NASHVILLE.

To

A. H. Buchanan Professor of
Physiology and Surgical Anatomy
in the
Medical department of the
University of Nashville
These lines are Respectfully Inscribed
By the Author.

Physiology of Absorption

It has been thought by some that the hand is the member which distinguishes man from, and makes him superior to the lower animals; others contend that it is the power of speech and superiority of intellect, but as my subject is one which equally concerns all living creatures from the lowest insect to the highest and most perfectly developed animals. I shall not stop to contend about distinguishing characters, but proceed to the investigation of my subject, which, if not one of the most important of physiological actions, is at least one without which all animal and vegetable vitality would shortly have to cease.

Absorption, physiologically considered, has for its object first the introduction of fresh materials from the food, air, and any other liquid or soluble materials that may come in contact with the external or internal surface of the body, into the blood, and secondly the taking away of parts of the organism itself which have served their purpose in the economy or for any other reason need to be renewed.

In both these processes two sets of vessels are, or may be

concerned viz. blood vessels and lacteals or lymphatics, which have been termed absorbent vessels.

It is asserted that lymphatics exist in nearly all parts of the body which contain blood vessels, and contain a peculiar, colorless, and limpid fluid called lymph.

The lacteals are confined to the intestinal canal, and, at certain periods, contain a fluid derived from the intestinal villi, ~~xxxx~~ which gives it a milky appearance. It is by means of this fluid that we distinguish the lacteals from the lymphatics, as they are exactly similar in every other respect.

It has been thought that the lacteals, alone, absorb all the materials which go to the nutrition of the body ~~but~~ it seems very probable that, when parts have served their purpose in the tissues of the body, and are taken up by the lymphatics, there may be matter eliminated from them, which may again serve the purpose of nutrition. It is probable that the excrementitious matter never enters the lymphatics,

but is carried away by means of the blood vessels.
While the chyme is passing along the intestinal canal, its completely digested portion is taken up by the lacteals and blood vessels, distributed in the mucous membrane. The blood vessels absorb only those portions which are completely liquified, and prepared to mix with it directly, and these they take up indiscriminately, but the lacteals take up only certain portions particularly those composed of fatty materials. This process is carried on most actively but not exclusively in the villi of the small intestine, because in this situation the vessels are brought into closer proximity with the chyme than in any other. The large intestine being much more sparingly supplied with lacteals than the small, its lacteal absorption must be much less.
The villi of the small intestine are minute vascular processes of mucous membrane, each containing a delicate network of blood vessels and one or more lacteals

which sometimes seem to ramify and are usually invested by a sheath of cylindrical epithelium. In the interspaces between the villi; as well as, over all the rest of the intestinal canal the lacteals and blood vessels are also densely distributed in close net work.

The manner in which absorption into the lacteals takes place is not well understood. It was once thought that there was a perforation at the extremity of each lacteal, which extended through the covering of each villus, and that the chyle passed into the lacteals through these open mouths, but it has since been ascertained that no such orifices exist. Valentin thought ~~thought~~ ~~that~~ as the blood vessels lay externally to the lacteals, that the chyle must be first absorbed into the blood vessels, and then secreted into the lacteals, but more recent investigations go to prove that absorption into the lacteals, takes place through the medium of cells, and that the blood vessels have no share in the process, except that they contribute to the nutrition of those cells. It seems most probable

that the epithelial cells are first filled with chyle from the intestinal canal, after which it either passes directly into the lacteals, or else enters them through the medium of another set of cells. As some of these cells contain pure chyle, while others contain lymph it would seem that they have the power of eliminating different materials, at the same time. They also seem to be endowed with the property of secernment, as many substances pass into the intestinal canal, and are absorbed ~~no~~ into the blood vessels, no part of which ever enters into the lacteals.

The Lymphatics are the vessels whose office it is to eliminate and convey lymph. It is probable that they exist in all parts of the human body which contain blood vessels, except the bones, brain, spinal marrow, eye, dense tendons, membranes of the ovum, placenta, and umbilical chord. They commence either in closely meshed net-work or in closed and pointed tubes, distributed throughout the various tissues of the animal body.

In man and the mamalia they have no direct communication with the blood vessels, except through the medium of their common trunks, the thoracic duct which terminates at the junction of the subclavian and internal jugular veins on the left side, and a corresponding, but smaller trunk, terminating at the corresponding point on the right. The precise manner in which absorption into the lymphatics takes place is not known. It is highly probable that the purpose which it serves in the economy is similar to that of the matter absorbed into the lacteals; viz, the building up and repair of the various tissues in the animal economy. The lymph is taken either from the waste tissues, the fluid in which they exist, or the liquor sanguinis. It is most probably taken from the latter, as any disease of the lymph is accompanied by a corresponding disease of the liquor sanguinis, and when the blood will not coagulate, neither will the lymph coagulate

The fluid contained in the lacteals during fasting is col-

orless and limpid, and differs in no respect from that contained in the lymphatics, but during absorption from the chyme, it becomes milky and acquires the other properties of chyle. This opacity and whiteness are due to the presence of innumerable particles of oily and fatty matter, of very minute, though nearly uniform size, measuring according to Gulliver (as quoted by Kirkes and Paget) on an average 1–30,000 of an inch in diameter. These are termed by Gulliver the molecular base of the chyle, and their number and consequently the opacity of the chyle are dependent on the quantity of fatty matter in the food. Hence the chyle is whitest and most turbid in carnivorous animals, less so in herbivora, and in birds it is transparent and colorless. The fatty nature of these molecules is made evident by their solubility in ether, and their being deposited in various drops of oil, when the ether is evaporated. But as this oily matter does not run together in large globules, it is probable that it is mixed with albumenous mat-

ter which encircles the drops of oily matter, as it has been proven that oily and albumenous matter will behave towards each other, when combined. And this hypothesis is supported by the fact that when water or dilute acetic acid is added to the chyle, many of the molecules are destroyed and globules of fatty matter are formed, from which it appears, that the albumenous matter is dissolved permitting the fatty matter to run together. The chyle in the villi of the small intestines and lacteals contains no solid or organized matter, except these molecules. The liquid in which they are contained is albumenous and does not spontaneously coagulate, though it may be coagulated by the addition of Ether. But as the chyle passes on towards the thoracic duct and especially, in one or more of the mesenteric glands, it is elaborated so that it will coagulate without the addition of Ether, the quantity of molecules and oily matter gradually diminish; cells are formed, called chyle corpuscles, and by the development of fibrin it acquires the above named

property. The higher up the thoracic duct the chyle passes the more of the properties of blood it assumes until finally, the only material difference between them is that the blood contains red corpuscles, and coagulates more firmly than the chyle. The chyle corpuscles are minute cellular bodies which are pearly white and nebulous in appearance. They exhibit some variety in their aspect, have a distinct cell wall, and are about 1–2500 of an inch in diameter, being tuberculated on their surfaces. The origin of these corpuscles is very obscure. It has been thought by some, that they were formed by the aggregation of some of the particles, composing the molecular base of the chyle, but since no such molecular base exists in the lymph, and there are abundance of corpuscles in it similar to those in the chyle, we cannot see how that could be correct

Lymph, under ordinary circumstances, is colorless and transparent or of a slightly yellowish tint. It is inodorous

and has a slightly alkaline reaction, like chyle, and a saline taste. As it exists in the small trunks it contains no corpuscles or particles of any kind, and it is probably only in the larger trunks, after it has been more highly developed, that it contains corpuscles and fibrin. The manner in which these are formed is, we suppose, essentially similar to that, in which they are formed in chyle, as these constituents are similar to those in the chyle, though less abundant. The fluid in which they float is generally albumenous, and contains no fatty particles or molecular base, but it is subject to variations, according to the state of the blood, and that of the organ in which it exists. It would appear, from what has been said, that the principal difference, between perfect chyle and perfect lymph, consists in the preponderance of fatty matter in the former. According to many chemical tests it has been ascertained that chyle and lymph, each contains water, albumen, fibrin, animal extractive, fatty matter, salts, and iron. The lymph contains the greater, relative, proper-

tion of water, and the chyle the greater relative proportion of each of the other constituents. As the chyle and lymph approach and enter the thoracic duct, their corpuscles and other constituents partake more and more of the characters of blood, till in some instances, they have been so highly developed, as to be tinged with blood. The blood only differs from the chyle and lymph in that it contains a greater amount of solid matter and fibrin, from which, it is evident that chyle and lymph are only blood in a rudimentary state, and that their office in the economy is to replenish the blood, as it is consumed in the building up of the various tissues of the body &c.

From the experiments of Bidder it was ascertained, that the quantity of matter poured into the veins from the lacteal and lymphatic vessels, in the cat, was about equal to the weight of the blood in the animal, in twenty four hours, and in the dog it was ascertained to be about equal to two thirds the weight of the blood, in the animal,

in the same length of time. But it does not follow, that the blood is all renewed in the saime length of time, because Kaase has demonstrated the fact, that the solid constituents of the blood cannot be renewed from less than three or four times its weight of chyle and lymph.

In structure the lacteal and lymphatic vessels are similar to veins. Their external coat is composed of areolo-fibrous tissue, which is very strong, and serves to connect them with the surrounding parts. Interior to this is another membrane, composed of fibro-cellular tissue, with muscular fibres, which are distributed circularly, and are much more abundant in the small than the large vessels. And still within this is an elastic coat, the fibres of which are disposed in a longitudinal direction, and this coat has an internal covering of epithelium, and has attached to its internal surface numerous valves, disposed like those of the veins, with their free surface towards the heart. The lacteal and lymphatic vessels serve, not only to contain, but also

to move the chyle and lymph. Pressure from any cause, made on these vessels, aided by their numerous valves, will cause their contents to pass on towards the termination of the vessels; hence respiration, muscular exertion, the peristaltic motion of the small intestine, &c accelerate the circulation in the lacteal and lymphac vessels. The vis a tergo, caused by absorption, also aids in carrying on the circulation, but it is probable, ~~probably~~ that the principal agency, in carrying on the lymphatic circulation, is the contractility of the vessels themselves.

The glands, placed on the lacteal and lymphatic vessels, are composed essentially of plexuses of vessels, but most of them contain also corpuscles, by the action of which, the chyle and lymph are probably more highly developed. Each gland has an investing membrane of cellular tissue, which dips down into its substance, dividing it into two or more compartments. From two to six vessels, called the afferent vessels, enter each gland. They divide into several smaller vessels, before entering the gland,

and, upon entering it, their walls become much thinner, their external tunic going to form the capsular membrane of the gland. In the substance of the gland they run in a tortuous manner, frequently anastomosing with each other. They leave the gland in a manner similar to, that in which they enters it, receiving an external covering from the capsular membrane of the gland. They then collect into from one to three trunks, called efferent vessels, which are larger than the afferent ones. No lacteal or lymphatic enters the thoracic duct without having traversed one or more of these glands. There is abundance of capillary blood vessels, distributed between or upon the walls of the lymphatic vessels, within the glands, so that the chyle and lymph, within this situation, are brought into close proximity with the blood, and there are in all the more perfect lymphatic glands, grouped in cells, abundant minute corpuscles, nuclei or cyto-blasts. These are very small particles about 1-3000 of an inch in diameter, of simple

structure, but having two or three minute dark particles, like nucleoli, in them. It is probable that these cells secrete a peculiar fluid from the blood, which, when poured out into the lymph, causes the great increase of fibrin and other changes, which the lymph and chyle undergo, in the glands. It is however, thought by some physiologists that this change is produced by matter derived directly from the blood, as the close proximity of the two fluids, in this situation, may probably admit diosmosis to take place freely between them

It has been proven, by the experiments of Magendie and others, that many of the substances which are absorbed into the blood vessels, never have any portion of them taken up by the lacteal and lymphatic vessels, or if any of them be taken up, it is not until they have been somewhat modified, by having first entered into the blood. From this it would appear that the lacteal and lymphatic vessels are so

constructed, that only certain materials can penetrate their walls. or else the chyle and lymph are derived from the blood by an action of the lacteals and lymphatics, similar to that of secreting glands, and according to either hypothesis, we class the action of the lacteals and lymphatics in the category of vital actions, as we cannot explain it on mechanical or chemical principles.

It has been thought, that absorption by the blood vessels is carried on entirely by the veins, but there is nothing in the structure of veins, that proves that absorption may take place into them more rapidly than into arteries of the same size, or so rapidly as it may into capillary vessels. We may therefore, assume that absorption takes place in all the blood vessels, but principally in the capillaries. It is true that substances, absorbed into the circulation of the blood vessels, may be first detected in the veins, but this results from the fact, that they are

carried there by means of the circulating fluid.
In absorption into the blood vessels there is no
discrimination in the kind of matter taken up, as
there is in the lacteals and lymphatics, which
appear to take up nothing except that which is
capable of being converted into blood. On the
contrary the blood vessels absorb all substances
indiscriminately. The conditions, necessary
for the process, are that the substances shall be
in the gaseous or liquid state, or that they shall
be soluble in the liquids, with which they come in
contact, or in a state of very minute me
chanical division. The manner, in which
certain substances enter the circulation of the
blood, is somewhat peculiar. Gases are absorb-

ed into the liquid which moistens the walls of the vessels, and enter the circulation, after being dissolved in the liquid. In the lungs oxygen gas is absorbed into the circulation in this manner, at the same time water and carbonic acid are given out, constituting endosmosis and exosmosis, and it is probable that there is matter given out from the blood in other portions of the body, during absorption, but the blood itself is not given out during life, because it is in rapid motion, and the matter absorbed will not dissolve its particles, but if a portion of the fleshy membrane of a recently killed animal, be put into a vessel of water, it will absorb water and give out blood which will tinge the liquid red. Its bulk will also increase, because the blood, being the more dense liquid, will not pass through the walls of the vessels so fast as the ~~the~~ water will.

When the blood vessels are distended with fluid, absorption goes on very slowly, and, if sufficiently distended it may hinder the process entirely.
Other things being equal the process of absorption will be accelorated by an accelorration of the circulation of the blood, as fresh particles will be brought in contact with the matter to be absorbed more rapidly

When the vessels are distended with fluid, absorption goes on very slowly, and if sufficiently distended, it may hinder the process entirely. Other things being equal, absorption will be accelerated by an acceleration in the circulation of the blood, as fresh particles are brought into contact with the substance to be absorbed more rapidly