

Researches on the action and sounds of the heart / by George Paton.

Contributors

Francis A. Countway Library of Medicine

Publication/Creation

London : Churchill, 1873.

Persistent URL

<https://wellcomecollection.org/works/bphga43u>

License and attribution

This material has been provided by This material has been provided by the Francis A. Countway Library of Medicine, through the Medical Heritage Library. The original may be consulted at the Francis A. Countway Library of Medicine, Harvard Medical School. where the originals may be consulted. This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

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



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

ON THE
ACTION AND SOUNDS
OF
THE HEART

GEORGE PATON, M.D.

73.4

15.6.16.

Deposited by the BOSTON ATHENÆUM

IN THE LIBRARY OF THE

Boston Medical Library Association,

BY AUTHORITY OF THE TRUSTEES.

Wm. C. Lane

Librarian.

Date *Oct. 1896*

Boston Athenæum.

From the

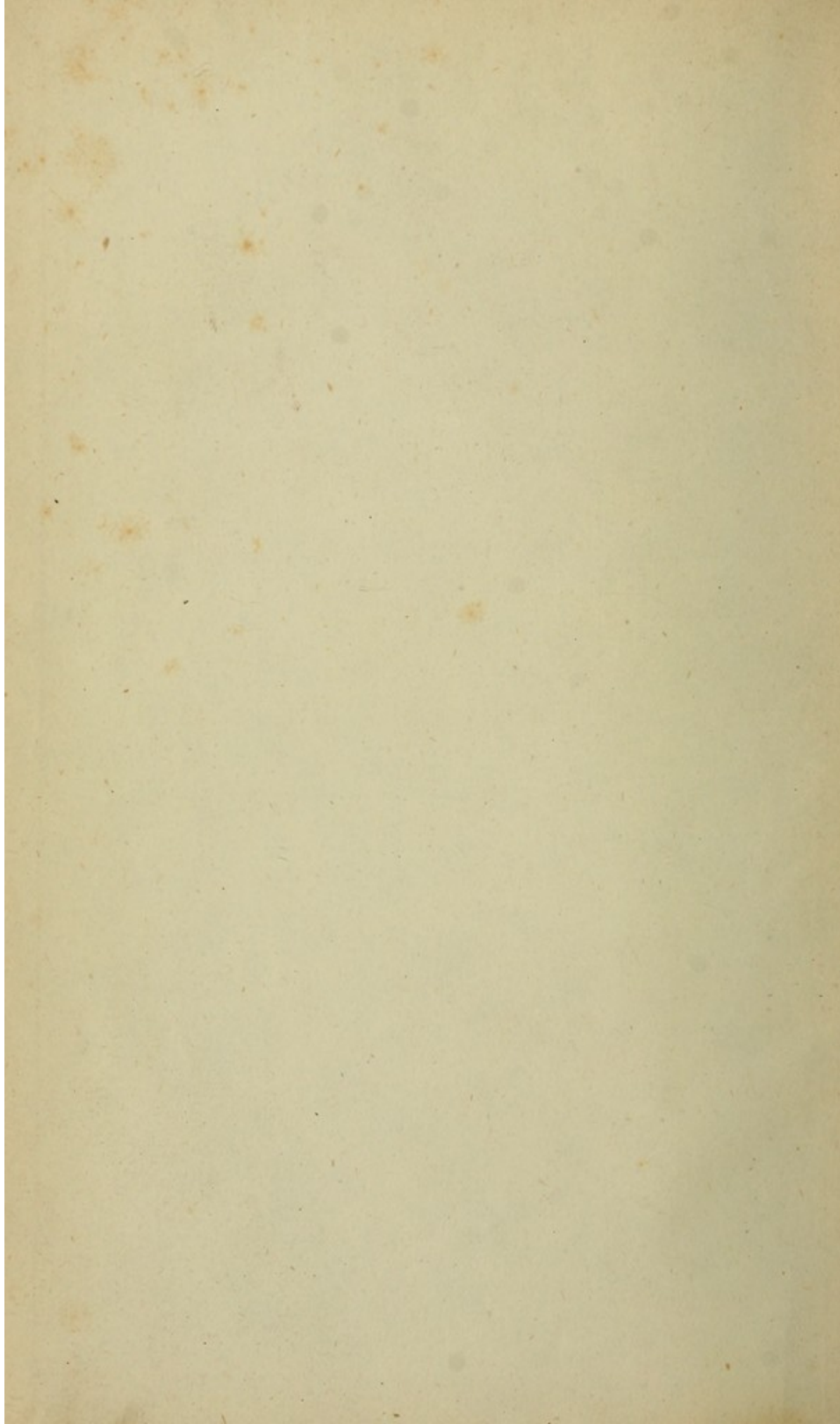
Appleton Fund.

Received April 17, 1873.

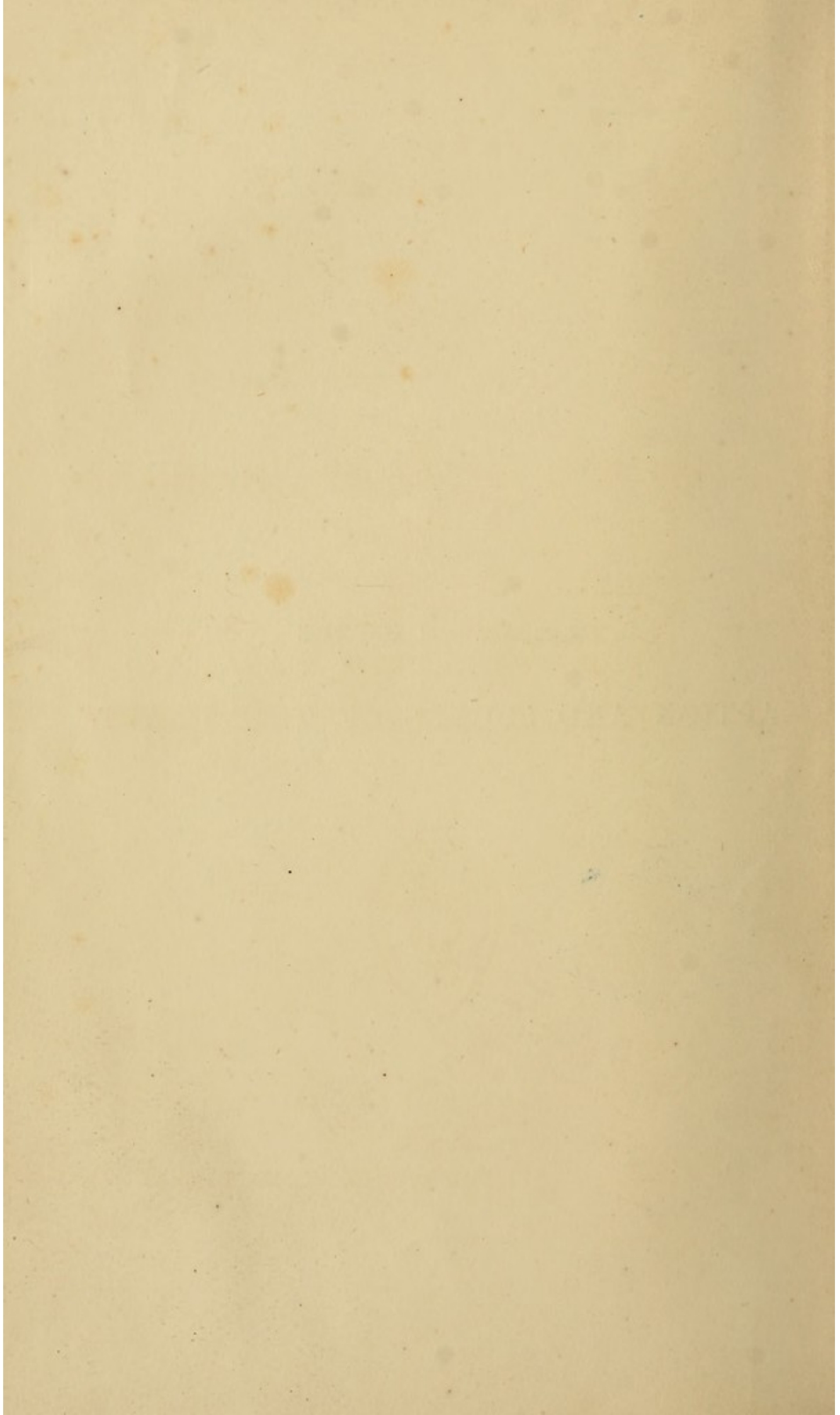
EXTRACT FROM THE FOURTH BY-LAW RELATIVE TO TAKING
BOOKS FROM THE ATHENÆUM LIBRARY.

“If any book shall be lost or injured, — the writing
of notes, comments,¹ or other matter in a book shall be
deemed an injury, — the person to whom it stands
charged shall replace it by a new volume or set.”





RESEARCHES ON THE
ACTION AND SOUNDS OF THE HEART



RESEARCHES
ON THE
ACTION AND SOUNDS OF THE HEART

By GEORGE PATON, M.D.

AUTHOR OF NUMEROUS PAPERS ON MEDICAL SUBJECTS PUBLISHED IN THE BRITISH AND
AMERICAN MEDICAL JOURNALS.



LONDON:
J. & A. CHURCHILL, NEW BURLINGTON STREET.

1873.

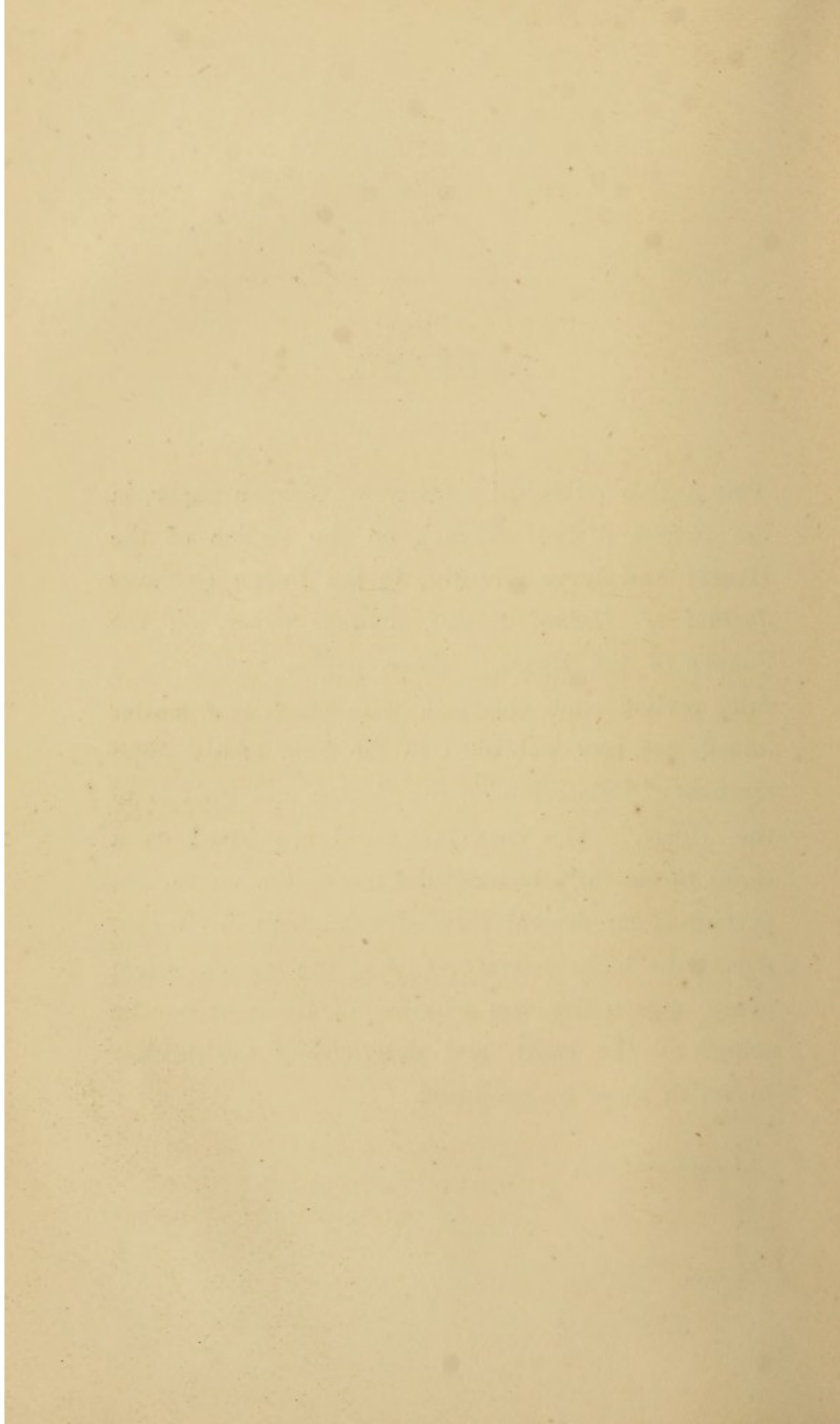
1576

38736

PREFACE.

THE Author published a few years since a paper, in the *British Medical Journal*, on the Action of the Heart; and more recently, in the *Dublin Quarterly Journal of Medical Science*, another paper, on the Sounds of the Heart. These papers having been fully revised and enlarged, with much new matter added, are now published in the form of a distinct treatise—"Researches on the Action and Sounds of the Heart." The views advanced are based on a series of carefully conducted experiments on turtles, performed for several successive summers in Canada, during the highest temperature of the season, where every opportunity was afforded of listening to the sounds of the heart, and determining the manner in which they are produced.

London, Oct., 1872.



RESEARCHES
ON THE
ACTION AND SOUNDS OF THE HEART.

THE opinion generally entertained by physiologists respecting the action of the heart is that the diastole of the ventricle is the result of its previous contraction; the fibres relaxing and assuming a state of rest. And the act is described as an instantaneous expansive movement, by which the ventricle returns to the same state with regard to form, size, and position, as during the previous period of repose; the blood flowing from the auricles by a suction-power, to fill up a vacuum produced in the interior of the ventricle.

If we examine the action of the heart when it is slow, pulsating at the rate of twelve or fourteen times a minute—in a turtle, for instance—we perceive that when the auricles contract and expel a portion of blood into the ventricle, it is immediately brought to the point of distention, and contracts, projecting a wave of blood along the aorta; or rather the contraction of the auricles extends by a sort of vermicular or continuous movement to the ventricle, causing it also to contract. After contraction the ventricle

immediately dilates, its parietes becoming lax and flaccid, and blood passes rapidly from the dilated auricles, without contraction, into the cavity of the ventricle, filling it out to a certain extent.

Properly to understand the manner in which the diastole of the ventricle is effected during the action of the heart, we must remember that at this moment the veins in connection with the auricles, and the auricles themselves, are filled and almost distended with blood; and a *vis à tergo*, or power by which the blood is impelled towards the heart, is exerted against the internal parietes of the auricles, which, the instant the fibres of the ventricle and of the auriculo-ventricular valve begin to relax, causes the blood to enter the foramen of the ventricle, and quickly fill out or dilate its cavity to the previous extent during the pause. But when the action is more vigorous, the blood passes so quickly from the dilated auricles into the cavity of the ventricle, that the movements seem almost simultaneous, the blood appearing to open up, as it were, the relaxing parietes of the ventricle, or dilate them to their previous extent during the pause.

This constitutes the first stage of dilatation, the pause ensuing, during which the fibres of the auricles and of the ventricle remain relaxed. And as the auriculo-ventricular foramen continues open the *vis à tergo* exerted on the blood in the two cavities—the auricle and the ventricle—may be said to be nearly equalized. But if the force exerted by the blood as it passed from the auricle into the ventricle had been greater, it would have dilated the parietes till they reached the

point of distention, and contraction would have ensued. But this power during the natural action of the heart is only produced by contraction of the auricles; for, as the blood on its return from the extremities passes along the *venæ cavæ* to the heart, it readily dilates and distends the parietes of the auricles, which being thinner, are more easily dilated than those of the ventricle; and then the auricle contracts, and projects a portion of blood into the ventricle, completing the second stage of the diastole, and causing the ventricles, as we have stated, to contract.

We have distinctly seen, during this state of the circulation, the blood as it reached the heart fill out and distend the auricles, causing them to contract and produce contraction in the ventricle, while no contractions were observed in the *venæ cavæ*, or extremities of the venous trunks. Showing that, when the action of the heart is slow, the impetus imparted by the blood as it reaches the auricles is sufficient to dilate the parietes, and produce contraction, independently of any action in the *venæ cavæ*, or extremities of the veins; and that one reason why the auricles are destitute of valves is, that the blood may readily reach and distend their parietes in maintaining the action of the heart.

There can be no doubt, however, that when the action of the heart is more vigorous the contraction of the extremities of the venous trunks exerts an influence over the distention of the auricles, whilst the valves with which the veins are furnished prevent the reflux of the blood during the auricular systole.

With regard to the amount of blood that enters the

ventricle during each stage of the diastole, we may remark, that when the action of the heart is slow the ventricle is chiefly dilated during the first stage of the diastole, as the auricles do not contract with vigour, and in warm-blooded animals principally in the appendices; the act being apparently or chiefly designed to produce contraction in the ventricle, and consisting of a sort of vermicular movement, extending to the ventricle. When the action becomes more rapid, we have, during the second stage of the diastole, seen the ventricle enlarged by one-third of its previous size, the parietes being distinctly stretched out, and the fibres elongated, till distention was produced. From which it appears that in this condition of the circulation—that is, when the diastole consists of two stages—the greater proportion of blood enters the ventricle during the first stage of the diastole, and that the auricles only feebly and partially contract.

But when the action of the heart begins to increase, the auricles contract sooner in point of time and of rhythm. On being dilated they appear filled with blood, and a portion passes quickly from the auricles into the cavity of the ventricle, as its fibres relax after contraction. But, before the first stage of dilatation is completed the auricles contract, which annihilates the pause, and renders the diastole one continuous act. In this case we have distinctly seen and felt, in warm-blooded animals, the fibres of the ventricle, during the contraction of the auricles, continue to be extended and elongated till distention ensued, and contraction commenced.

When the action of the heart is still more vigorous,

respiration being fully maintained, the contraction of the auricles is synchronous with the diastole of the ventricles. The auricles on being dilated, do not remain distended with blood, but immediately contract, and the whole of the blood that enters the ventricle is projected by contraction of the auricles. The *vis à tergo* in the veins has now no influence in assisting the dilatation of the ventricle, and the ventricle dilates whilst the auricles contract, and they contract with considerable energy, the diastole of the ventricle being completed by a continuous and uninterrupted movement, without the slightest appearance of a pause.

It is surprising to observe the different opinions that are entertained by physiologists on the action of the heart, according to the phenomena presented to their view. Dr. Hope states:* “On examining the posterior surface of the heart of a frog, when its action was reduced to 15 or 20 per minute, the whole of the auricle, which had previously been concealed by the ventricle, being now exposed, it was found that for a short space of time, the ventricle being at rest partially distended with blood, the auricle then contracted with a smart brief motion, but only partially contracted; for the sinus venosus was constantly full of blood, both in this experiment and those of the rabbit, and whether the circulation was quick or slow. When the auricle had relaxed again, and not till then, the ventricle, stimulated, I conjecture, by the motion, for it certainly was not by distention, was seen suddenly to rise up on its basis, to shorten its fibres, and to expel

* Hope on the “Heart,” p. 11.

its contents, which latter action was slowly performed. After the completion of the systole, which was indicated by the pale colour, the diastole took place, and allowed a partial influx of blood, denoted by the return of the red colour; and in this state the ventricle remained quiescent for a short space, until again stimulated by the auricular contraction. It may be objected to this account, that as the action of the heart was preternaturally slow, the motions were abnormal. We thought, however, that we could discern the same series of actions, when the pulsations were 40 per minute." Professor Müller, as the result of his experiments on the action of the heart, states: "In the frog the contractions of the venous trunk, of the auricle, the ventricle and the bulbous aorta appeared to me to follow the order in which I have named the parts, the intervals between the four contractions being nearly equal; so that the same interval of time elapsed from the contraction of the auricles to the contraction of the ventricle, as between the contraction of the ventricle and that of the bulb of the aorta."

The discrepancy of opinion that exists between these two authors respecting the action of the heart, undoubtedly arose from the circumstance that Dr. Hope viewed the heart when its action was slow and languid; and Professor Müller when it was quick and vigorous, beating at the rate of 60 or 70 times per minute. And it will be observed that in the latter case the auricles contracted and expelled their blood into the ventricle whilst it dilated. And the movements being alternate, dilated whilst the ventricle contracted; so that nothing like a pause or period of

repose occurred during the diastole of the ventricle. And this fact we have repeatedly witnessed in the course of our experiments in the frog, the fish, and the turtle, when the action of the heart was vigorous and respiration well maintained.

As the principle that obtains in the action of the heart, is the same in warm as in cold-blooded animals, Dr. Hope maintained that a pause always exists between the diastole of the ventricles and the contraction of the auricles, and that this contraction immediately precedes the contraction of the ventricles, or rather that it passes into it by a sort of vermicular movement. But other physiologists who have examined the action of the heart when it was vigorous in living animals, pulsating at the rate or 60 per minute and upwards, respiration being well maintained, are decidedly of opinion, that the contraction of the auricles takes place simultaneously with the commencement of the diastole of the ventricle; that no pause or period of repose occurs during the ventricular diastole, but that it consists of one distinct and continuous movement, immediately succeeded by the systole.

More fully to explain our views, we may observe that having denuded the heart of a living turtle, we carefully observed the phenomena. Respiration remained unaffected. When the heart beat at 10 or 12 pulsations per minute, the ventricle, after contraction, dilated, and became partially filled with blood passing into it from the distended auricles, a pause ensued; and then the auricles contracted and completed the diastole of the ventricle, causing it to contract. When the action increased to 16 or 18 pulsations per minute,

the ventricle after contraction dilated, and a portion of blood passed from the distended auricles into the ventricle, filling out its parietes, but before this was completed, the auricles contracted, and projecting their blood into the ventricle brought it into a state of distention at once, which annihilated the pause, and rendered the diastole one continuous act. But on the pulsations increasing to 26, 28, and 30 per minute, the auricles contracted synchronously with the diastole of the ventricle, which consisted of one continuous and uninterrupted movement. The blood projected by the auricles filled out or dilated the ventricle, as its walls expanded, till distention ensued and contraction took place. Here we observed that, as the diastole proceeded, a sort of undulation passed along the cavity of the ventricle, as if the blood, by the force which it exerted, opened up and distended its walls. The animal remaining in a calm and quiescent state, and the action of the heart proceeding with much uniformity, suddenly as if impelled by an impulse, the auricles began to contract with great energy, and projected the blood into the ventricle with increased velocity; and its parietes expanded at a proportionate ratio, and contracted in a similar manner. The vigorous contraction of the auricles appeared to open up the relaxing parietes of the ventricle, and caused them to dilate with great velocity. These movements would continue for a time, and then the slower action of the heart would return.

In another turtle, the action of whose heart we examined during the highest temperature of the season (July 8th), it appeared that the contraction of the

auricles exerted an influence on the dilatation of the ventricle; for, when the action of the heart had attained its greatest degree of speed—36 pulsations per minute—the contracting power of the ventricle was sometimes apparently prolonged as if from the vigour with which it acted; and whilst the ventricle continued in this contracted state, the auricles contracted, and the moment the blood entered the foramen of the ventricle, its parietes opened up, and continued to expand till they contracted. This fact was also apparent when the action of the heart was 30 pulsations per minute. We placed our fingers against the parietes of the ventricle, and we distinctly recognised that they did not become smooth and soft till the auricles began to contract; and the moment that took place, the blood appeared to open up the contracted walls of the ventricle, or caused them to expand till contraction commenced.

There was now a great difference in the character of the movements, both of the auricles and the ventricle. When the action of the heart was slow, as at 10 or 12 pulsations per minute, the auricles, on being dilated, continued distended with blood during the first stage of the diastole and the pause. But, when the action of the heart was vigorous, the auricles were dilating whilst the ventricle was contracting; and as the auricles immediately contracted on being dilated, the blood entered the foramen of the ventricle at the moment its fibres were beginning to relax, and rapidly dilated its walls, or filled out the cavity of the ventricle, till distention was produced, and contraction commenced.

We denuded the heart of a living frog, and carefully observed its action. The pulsations were 64 per minute. Respiration remained perfect. The auricles, on being dilated, immediately contracted, and they contracted synchronously with the diastole of the ventricle; the parietes of the ventricle continuing to expand as the blood was projected by the auricles, till distention was produced, and the ventricle contracted. During dilatation the ventricle assumed a deep red colour, and the blood could be distinctly seen to enter its cavity as the parietes expanded and dilated. During contraction the ventricle became small and pale, all the blood appearing to be expelled from its cavity. But, after contraction, there was no expansion of the parietes of the ventricle, and no blood entered its cavity till the auricles contracted. The animal continued to respire with vigour, and the action of the heart increased to 72 and 74 per minute. The movements were maintained in a similar manner, but the auricles contracted with greater rapidity; and as they projected the blood into the ventricle, its parietes expanded at a proportionate rate, and also more quickly contracted, projecting the blood with greater velocity along the aorta. After a few hours, the action of the heart fell to 30 per minute, and precisely the same movements were observed, the wave of auricular contraction passing as it were into the foramen of the ventricle; and the blood could be distinctly seen to enter its cavity, whilst the walls of the ventricle expanded and dilated. But there was not the slightest approach to anything like the dilatation of the ventricle before the contraction of the auricles.

On denuding the heart in warm-blooded animals we have carefully observed its action, both by touching the ventricles with the fingers and steadily watching their movements with the eye, the pulsations being in some cases, as in large animals, 64 per minute; in other cases, as in small animals, 80, 90, or 100 per minute. But at this rate of speed we have never been able to detect anything like a pause during the diastole of the ventricles. In all these cases the contraction of the auricles was synchronous with the diastole of the ventricles, which consisted of one rapid and continuous act, the blood being projected by the auricles into the cavities of the ventricles, till distention was produced and the systole took place, propelling the blood along the aorta and pulmonary artery.

We have now reached that degree of velocity in the action of the heart, when the auricles contract as the ventricles dilate; there being no interval between the diastole of the ventricles and the contraction of the auricles, but the acts occur simultaneously. And if we analyse these movements of the heart,—that is, when its action is quick,—we perceive that the ventricles do not relax before the auricles begin to contract, which can easily be ascertained by placing the point of the finger against the side of the ventricles, and observing the movements of the auricles. The contractile energy of the ventricles may even afford somewhat the appearance of a pause, the ventricle appearing to remain for an instant contracted, after it has propelled the wave of blood into the aorta, and we have even repeatedly seen, as already stated, the auricles contract, whilst the ventricle was still in a con-

tracted state, but that moment the fibres relaxed, and as the blood from the auricles entered the ventricle, the parietes swelled out, and the diastole was completed in its usual manner by a continuous and uninterrupted movement.

When the action of the heart has attained such a degree of celerity that the contraction of the auricles is synchronous with the diastole of the ventricles, the parietes of the ventricles do not instantaneously expand, and the blood then enters the cavities. The movements are simultaneous. The diastole of the ventricles proceeds at a ratio proportionate to the energy with which the auricles contract. If the auricles contract with greater vigour, the ventricles dilate with greater rapidity. If the auricles contract with less vigour, the ventricles dilate with less. And if we carefully examine the parietes of the ventricles, we can distinctly see and feel the fibres gradually dilate as the blood from the auricles shoots to the apex and distends the cavity. No doubt the parietes of the ventricles relax after contraction in virtue of the power which they possess, as muscular tissue, of assuming their previous condition. But the fibres may not always relax with a degree of rapidity sufficient to sustain the vigorous action of the heart. Muscular fibres have been observed continuing in contraction.* And we have repeatedly seen when the animal became much agitated the ventricle remain contracted till excited to dilatation by the blood projected by the auricles. And Müller remarks that "the degree to which the heart dilates, independent of being dilated

* Müller's "Physiology," vol. ii. p. 888.

by a fluid, can be but slight." * We have also observed the auricles contract whilst the ventricle remained in a contracted state, the animal continuing calm and quiescent. And Laennec, in his observations on the action of the heart, states, "that in some cases the systole of the ventricles seems scarcely over before it begins again to swell out afresh."† The contraction of the auricles then, being synchronous with the diastole of the ventricles, subserves a most important purpose in maintaining the vigorous action of the heart. Then a force is exerted which converts the movement of relaxation into one of active dilatation, because the power with which the auricles contract may not only excite the dilatation, but impart a stimulus to the relaxing parietes of the ventricles, which renders the diastole the first and most prominent movement, and the systole its sequence. If we examine the action of the heart under these circumstances, we easily perceive that the movements of the ventricles partake of this character, that the ventricles first dilate and then contract. For the moment the auricles contract the ventricles swell out, as if by an active power; opening up or dilating their walls till fully distended, they contract, propelling the blood along the aorta and pulmonary artery. Fully to understand this movement, let us suppose a cavity into which a fluid flows as its walls relax or dilate, and when filled the cavity contracts and expels the fluid along another tube. The fluid enters the cavity as the walls expand, and is expelled as they contract,

* Müller's "Physiology," vol. i. p. 233.

† Laennec on "Diseases of the Chest," p. 508.

which is the case when the action of the heart is slow. But suppose that a force is exerted when the fluid enters, opening up the dilating walls of the cavity, and when filled or distended the cavity contracts, expelling the fluid along another tube. It is evident that the whole character of the movement is changed. There is an active force exerted, both in dilating the cavity and contracting it to expel the fluid, and this is undoubtedly what obtains during the vigorous action of the heart.

That this is the principle on which the action of the heart depends, will more distinctly appear if we attend to the following points:—1st. The diastole of the ventricle consists of one continuous movement, by which the fibres are stretched out not merely to their normal extent, but till distention ensues and contraction commences. 2nd. The ventricle dilates with various degrees of rapidity, according to the velocity with which the circulation is maintained. It dilates with twice as great velocity at 60 per minute as at 30, and with three times as great velocity at 90 per minute, and so on in relative proportion to the action of the heart. And what is it that confers this power upon the ventricle—first of attaining during the act of dilatation to the point of distention and contraction; and secondly, of increasing the rapidity with which the fibres dilate, according to the increased vigour of the circulation? It cannot depend on mere muscular relaxation, for that would not carry it to the point of contraction; and the increased velocity of the dilatation of the ventricle cannot be accounted for on the principle of the fibres of the ventricle relaxing with greater rapidity according to the previous con-

traction, because increased action in the dilatation commences before the ventricle contracts. If the action of the heart be proceeding at a moderate rate of speed, and the auricles commence to contract with greater vigour, the ventricle at this moment dilates with greater velocity, and contracts with similar energy. Every successive movement, as the action of the heart increases, proceeds in the same manner, the first impulse of increased activity of the ventricle commencing with and depending on the rapidity of the diastole.

From these statements, then, it appears that the auricles during the vigorous action of the heart contract with energy, and exert an influence over the whole of the diastole of the ventricle. Many physiologists also concur in the opinion that the auricles contract with vigour. Dr. John Reid states "that the systole of the auricles is performed with great regularity when the action of the heart is still vigorous, and appears to be effected by the simultaneous contraction of all its fibres. According to the observations of Harvey, Lower, Senac, Haller, and others, the contraction of the auricles is performed with considerable force."* "In the experiments of Dr. Hope, Mr. Carlisle, Mr. Bouilland, and the Dublin Committee for Investigating the Cause of the Sounds of the Heart, the contraction of the auricles appeared to be comparatively trifling, and was most apparent in the appendices. From my own experiments," says he, "upon rabbits and dogs, I am convinced that the

* Article "Heart," by Dr. John Reid, in "Cyclopædia of Anatomy and Physiology." London.

auricles contract considerably more when the movements of the heart are proceeding in a natural manner than some of these last experimenters would lead us to believe, and that this contraction is not confined to the appendix, but extends over the whole auricle; but that none of the muscular fibres of the auricles are passive, but exert a force proportionate to their strength, we have evidence both from experiment and the effect of disease. In some of those cases where an impediment to the passage of the blood from the auricle to the ventricle exists, all the muscular fibres of the auricles become much increased in thickness and in strength."

There can be no doubt that during the moderate and regular action of the heart the auricles contract with energy. And we have the most satisfactory evidence for concluding that they exert a direct influence over the ventricle, both during its diastole and its systole, which enables us to see how the action of the heart is really increased and maintained. The physiologists who adopt the views supported by Dr. Hope, admit that the auricles are the *primum mobile*, or cause of the movements of the ventricle. But they confine their action to bringing the ventricle, already partially filled with blood, to the point of distention and producing the contraction; the first stage of dilatation and the pause according to that view always existing. So that as only an instant is occupied in bringing the ventricle to its full distention, it is chiefly in the rapidity of the contraction that the increased action of the heart is produced; which is a circuitous mode of increasing the circulation of the blood, and

incompatible with the great velocity that is frequently attained. But in the preceding experiments we have shown that when the action of the heart is vigorous, the contraction of the auricles is synchronous with the diastole of the ventricle, which annihilates the first stage of dilatation and the pause. And as the force which the auricles exert extends through the whole period of the ventricular diastole, it increases the rapidity with which the parietes dilate, whilst it imparts to them a greater stimulus to contraction.

In this state of the circulation the ventricle is not only filled and distended solely by the contraction of the auricles, but it is brought to the point of distention by a smaller quantity of blood entering it than when the action of the heart is slow and languid. We have always observed that when the action of the heart is vigorous and the blood highly arterialized, the ventricle is more quickly distended and by a smaller amount of fluid; the vigorous condition of the ventricle rendering it susceptible of the finer stimulus. Thus we see how the action of the heart is increased and maintained when the systole of the auricle is synchronous with the diastole of the ventricle, the two movements proceeding in a regular and uninterrupted manner and in quick and rapid succession, and not only is this the case, but, when the auricles contract with still greater rapidity, the diastole of the ventricle is performed with greater energy, and the systole with similar velocity. Hence when the circulation is quick and vigorous the whole diastole of the ventricles, as well as the systole, is regulated by the auricles or directly under their influence, causing the ventricles to manifest an actively

dilating power by the rapidity with which the movement is executed.

We perceive then that the principle on which the action of the heart is established, renders it adapted either to a slow, or a rapid circulation of the blood. When the action is slow a pause occurs in the diastole of the ventricle, which disappears as the circulation increases; and the auricular systole becomes synchronous with the ventricular diastole. If the ventricle pulsate at the rate of 14 or 16 times a minute, the pause occurs and is long, the blood being imperfectly arterialized; a due stimulus is not imparted to the heart, and all the functions of the body are languid. When the action of the heart increases to 30, 34, or 40 pulsations per minute in cold-blooded animals, as the turtle, and to 50 and 60 pulsations per minute in the warm-blooded, respiration being well maintained, the pause entirely disappears, and the diastole of the ventricle is synchronous with the contraction of the auricle, and occurs in half a second or thereabouts, and the systole in half a second. When the action increases to 90 pulsations per minute the diastole occupies one-third of a second or thereabouts, and the systole one-third, and the movements proceed in this manner, the diastole being quickly performed and succeeded by the systole; and when the action of the heart increases to 180 pulsations per minute, as in the *menoculus pulex* and some others, whose blood is highly arterialized, three pulsations occur in one second of time, allowing one-sixth for the diastole, and one-sixth for the systole.

But the ventricle is considered to dilate with a force

which, in warm-blooded animals, is sufficient to open up the closed hand seizing it, a phenomenon that physiologists have had great difficulty in accounting for, and to which we shall particularly refer in another section.

We shall now shortly inquire how the diastole of the auricles is produced. The auricles, it is well known, are never empty of blood, a portion remaining after contraction, dilating their walls. The parietes of the auricles are thin, and during relaxation very distensible or easily dilated. The auricles possess no valves behind them, but a free communication exists between them and the extremities of the veins which are possessed of the power of contracting and dilating with the fibres of the heart. In cold-blooded animals, when the action of the heart is vigorous, the venous trunks or extremities of the veins contract first, then the auricles, after that the ventricle, and the bulb of the aorta, which is synchronous with the ventricular systole; the ventricle being still contracted when the aorta pulsates. In this case the contraction of the venous trunks distend the auricles with blood, and produce their contraction. But when the circulation was slower, we have observed the blood in the veins on its return from the body continue to distend the auricles and cause them to contract, independent of contraction in the venous trunks; showing that the blood returns along the veins with a power sufficient to distend the auricles and sustain the action of the heart, and this appeared to take place without a *vis-à-fronte*; for, in cases where respiration had ceased, and the ventricles were dilated and filled with blood, the

blood on its return from the extremities continued to dilate the auricles and over-distend their parietes.

During these experiments the action of the heart was always increased by the animals continuing to respire for a time. The blood becoming more highly arterialized, appeared to impart a greater stimulus to the internal parietes of the auricles and ventricles. And it is a well-known fact that exercise or increased exertion quickens the circulation in the veins, and causes the blood to return with greater vigour to the heart.

But it appears that independently of this principle, the auricles are capable of being excited by a stimulus conveyed through the cerebral or sympathetic nerves to the heart. We have frequently seen in the turtle and also in other animals whose heart had been denuded, when the animal was remaining calm and quiescent, the action of the heart proceeding with great regularity, that suddenly, as if by a strong impulse, the auricles commenced to contract with great energy, and transmit the blood rapidly into the ventricle, increasing its action; and these movements would continue for a time, and then subside, the calm and uniform action of the heart being restored.

During our experiments on large warm-blooded animals, we have found the heart, immediately after being denuded, beat at 60 pulsations per minute and upwards. And on carefully examining its action, both by placing our fingers against its parietes, and observing its movements with the eye, we perceived that the blood passed rapidly along the veins to the auricles; and that the auricle on its parietes becoming tense

communicated a strong impulse to the fingers that pressed it at the moment. Cruveilhier believes that it is during the dilatation of the auricles, that an expanding force is exerted by the parietes, but it is when distention has been attained, and the systole has commenced; for the fibres being shortened, the parietes are rendered tense; and by the force of the contraction expand, and are thrown outwards, communicating an impulse to the fingers.

We therefore conclude that the diastole of the auricles depends on the same principle, and is produced in a similar manner as the diastole of the ventricles; but that independent of this the auricles are susceptible of being excited by a stimulus conveyed through the nervous system, causing them to contract with greater vigour, and impart a stimulus to the ventricle, increasing the action of the heart.

CONTRACTION OF THE VENTRICLE.

When the ventricle commences to contract, its parietes are rapidly brought into the same plane with those of the aorta, so that the blood passes as it were along the same tube; and the contraction takes place with an impulse, the walls of the ventricle becoming tense and firm, and expanding with a force that communicates a shock to the fingers; and in large warm-blooded animals opens up the hand that seizes the ventricle, whilst the blood is being expelled from the cavity. During the diastole, the fibres of the ventricle are soft, smooth, and compressible: during the systole, tense, firm, and resisting. And if we examine this

phenomenon in cold-blooded animals, where it can be most distinctly discerned, we perceive that the ventricle is first brought to the point of distention by the force of the blood from the auricles, and that when distended its parietes are still smooth and soft—beginning to grow tense. And as the contraction commences an impulse proceeds from the apex to the base, the fibres becoming rapidly firm and tense over all the ventricle, and the lateral parietes expanding with considerable force; the pressure of the fingers being always more resisted there than at the apex. And in large warm-blooded animals, when the action of the denuded heart was slow, we have observed, that as the auricles contracted, and sent their wave of blood into the ventricle, an undulation passed along the parietes, which still felt soft and compressible; but the moment the systole commenced, the parietes became suddenly tense and firm, opening up the hand that grasped them. And the force exerted by contraction of the auricles was not so strong as that of the lateral expansion of the ventricular parietes.

Physiologists, however, have connected this phenomenon with the diastole, rather than with the systole of the ventricles; believing that as the fingers are forced open, the ventricle must be dilating, and that it is inconsistent to suppose that the parietes could expand when the ventricle had commenced to contract and expel the blood from its cavity.

Hence Pechlin, Perrault, Bichat, Cruveilhier, and several other physiologists who have observed the action of the heart when it was exposed in living

animals, considered that it is during the diastole of the ventricle, when it is receiving an accession of blood into the cavity, that the hand is opened up.

Dr. J. B. Williams in his observations on the action of the heart, states, that the diastole of the ventricle in large warm-blooded animals, in whatever manner it may be accounted for, takes place with a force sufficient to open up the closed hand. And Dr. Hope observes, "that at each systole, the sudden tension of the ventricle was such as to produce an abrupt shock to the fingers placed on any part of it, with which shock the first sound exactly coincided; and the impulse from lateral expansion was greatest at the margins of the auricular orifices, there throwing out the fingers with a sudden jerk." And the Dublin committee in the course of their investigations into the action of the heart, remark, "The ventricles with a rapid motion assumed a somewhat globular form in their middle part, and during their continuance in this state, they were hard to the touch, and if grasped by the hand at the commencement of the movement they communicated a shock or impulse, and separated the fingers."

In these observations, Pechlin, Perrault, Bichat, Cruveilhier, and Dr. Williams, speak of the ventricle as opening up the hand during the diastole. Whilst Dr. Hope, in describing the same act, speaks of it as occurring during the systole of the ventricle. The shock imparted to the hand coincided exactly with the first sound, and we know that it occurs during the contraction of the ventricle. And the Dublin committee state that the ventricle was hard

to the touch, that is, in a state of tension, and consequently contracting when the shock or impulse was imparted to the hand.

These statements show the great difficulty that physiologists have had in classifying this movement, whether to refer it to the diastole or the systole of the ventricle, which undoubtedly arises from the manner in which the action takes place—the ventricle feeling to the touch as if it were dilating, whilst it is contracting with an impulse.

In explanation of this fact we may observe, that the longitudinal axis of the ventricle is shortened during contraction, and the parietes of the ventricle, though strongly muscular, partake much during life of the character of fibrous elastic tissue, expanding by the force of the contractile energy exerted. And when the ventricle is brought to the point of distention by the blood from the auricles, another force is immediately gained as the contractile energy commences. Just as an artery always reacts with greater force than that by which it is excited, so the ventricle, whilst a constant ratio exists between its power and that of the auricles, contracts with greater energy than it receives from them; and the left ventricle, being more muscular, contracts with greater force than the right. Hence, when the ventricle gives the impulse that communicates the shock to the hand, the parietes being then rendered tense, are thrown outwards and expand, from the force of the contractile energy exerted; the strong contractile action that shortens the ventricle, producing the lateral expansion, whilst the blood is propelled into the aorta.

We denuded the heart of a turtle, June 3rd, and on the action amounting to 32 pulsations per minute, the auricles contracting synchronously with the commencement of the diastole of the ventricle, we observed, that as the auricle projected the blood into the ventricle, it swelled out and dilated till it attained the point of distention; it then immediately contracted, its parietes expanding with considerable force, resisting the pressure of the fingers applied to them. This was more particularly the case at the base of the ventricle and with the transverse diameter than the longitudinal axis of the ventricle. The longitudinal axis was distinctly shortened as the transverse diameter was increased. But at this moment every portion of the parietes felt tense; and this condition increased as the blood was expelled, the ventricle being contracted towards the orifice of the aorta. In another turtle where the circulation had ceased, but the auricles and ventricle continued for a time to contract and dilate with considerable energy, on applying a stimulus to the ventricle whilst it was soft and relaxed, and exciting the systole, the parietes quickly became tense, and expanded with a force that separated the fingers and thumb, as the ventricle contracted. And then the parietes suddenly relaxed, and felt soft and flaccid. On being again excited by the stimulus or by the irritation produced by contraction of the auricles, the movements were repeated, the parietes of the ventricle becoming tense and firm, and expanding in a similar manner: which phenomenon could not be produced by the impetus of the blood against the internal parietes of the ventricle, for only a small portion was now con-

tained in the ventricle. But the parietes were here distinctly contracting as they expanded and threw out the fingers. And in our experiments on large warm-blooded animals, when the action of the denuded heart was maintained with great vigour, beating at the rate of 64 and 66 pulsations per minute, on grasping the ventricle with the hand, we perceived that on the auricles contracting, and sending the blood with an impetus into the ventricle, the parietes were rapidly brought to the point of distention, and as the contractile action commenced the parietes expanded with a force that opened up the hand, the walls being rendered more apart, whilst the ventricle was slightly curved in the centre, and the apex tilted up. And when the ventricle has been exposed in large warm-blooded animals, as the horse, and the circulation is brought to a stand, it is found that the ventricle continues susceptible of a stimulus for a short time, and on being irritated starts up at intervals, and its walls expand with a force that opens up the hand grasping them; which act is viewed by physiologists as the dilatation of the ventricle, but great difficulty has been experienced in accounting for the force with which it is performed. It cannot depend on the relaxation of the muscular fibres, for it is a general law that the parietes are then soft and compressible. And it cannot be produced by the impetus of the blood from the auricles, for the circulation has now ceased through both cavities. Besides, this phenomenon takes place totally independent of the auricles, on the stimulus or irritation being applied to the parietes of the ventricle itself. Hence many physiologists have thought that the

ventricle is possessed of an actively dilating power inherent in the parietes by which this force is exerted. Whilst others have supposed that there are two sets of fibres connected with the ventricle—one for contraction, and another for dilatation. But the phenomenon admits of an easy explanation—the ventricle is now contracting and not dilating.

When the ventricle remains at rest, it is in a dilated state, its fibres soft, lax, and compressible. But when it starts up on being irritated, it is in a contracting state, its parietes becoming firm and tense, opening up the hand as its transverse diameter expands on its longitudinal axis being shortened. If the circulation had been maintained the blood would have passed into the ventricle from the auricle, when its walls are lax and flaccid, and on being brought to the point of distention, contraction would have commenced and been accomplished in the manner in which it is now performed. But when we see the ventricle empty of blood on being irritated suddenly become tense and expand with force, resisting the pressure of the fingers, we imagine it is dilating, but it is actually contracting at the moment.

There are two things then that particularly demand our attention. 1. The ventricle at this moment passes from a dilated or relaxed state into one that is firm and tense; and it is not the impetus of the blood from the auricles against the internal parietes of the ventricle that gives the shock or impetus to the hand, but it is on the parietes becoming tense, that is, by the fibres contracting, that the shock is communicated and the fingers thrown out. 2. The ventricle is a

hollow muscle distensible, and in some measure possessed of the power of elastic tissue, and does not bring its sides and parietes into close apposition in expelling the blood from the cavity, but contracts from its apical extremity to its base, and as its longitudinal fibres are shortened, its lateral parietes, becoming tense, are thrown outward and expand from the force exerted, and as this takes place with an impulse, the blood is rapidly propelled into the aorta, and the aorta instantly pulsates. It is, then, in the shortening of the ventricle whilst the parietes are simultaneously rendered tense, that the phenomenon of lateral expansion is produced, by which the shock is communicated to the hand. And the rapid shortening of the fibres depends on the strong contractile impulse exerted, in the propulsion of the blood-wave from the ventricle into the aorta.

SOUNDS OF THE HEART.

In every class of animals in which we have examined the action of the heart, we have found that the ventricle contracts towards the orifice of the aorta or vessel that conveys the blood from the ventricle into the system; the mode of contraction being evidently designed to facilitate the passage of the blood from the respective ventricle into the aorta or pulmonary artery.

In contracting, the ventricle does not continue its action till the whole of the blood is expelled. It only contracts to an extent proportionate with the impetus received from the auricles, expelling a certain amount of blood termed the blood-wave.

June 29.—Took a large turtle, and removed a portion of the sternum or bone that covers the thorax, leaving the thoracic parietes uninjured; and observed the action and listened to the sounds of the heart.

When the ventricle contracts and propels the blood into the aorta, it raises up slightly the parietes of the thorax, and we can distinctly follow the course of the blood from the ventricle into the arch of the aorta, by the heaving up or elevation of the muscular parietes. There appears to be two impulses or movements, first, that of the contraction of the ventricle; second, that of the distention and reaction of the aorta, which take place simultaneously, and are synchronous with the first sound of the heart.

The heart having been fully denuded, the animal continued strong and vigorous, moving about with great energy, and survived several days. Pulsations, 32 per minute.

We applied the stethoscope and listened to the sounds of the heart. Both sounds are distinctly heard; the first—a dull and prolonged sound terminating by a sort of knock, or as if a piece of cloth or leather were fully stretched out, or extended to its ultimum—is heard most distinctly over the semilunar valves, at the origin of the aorta or a little above it, and synchronous with the contraction of the ventricle and pulsation of the aorta. The second sound immediately follows the first; is a short, sharp sound, like that produced by the tongue striking the roof of the mouth, and occurs during the contraction of the auricles, as they pour their blood with force into the ventricles during the diastole of the latter.

When the ventricle contracts, the blood passes rapidly into the aorta, which becomes more curved and tense, the contraction proceeding from the apex to the base, and as it reaches the muscular fibres around the origin of the aorta they contract with energy, passing below the semilunar valves, constricting the part, and sending the last portion of the blood-wave into the aorta with force; the aorta starts up, and the rapid reaction of the distended parietes causes the blood to recoil against the semilunar valves and shut them, as it imparts an impulse to the wave, the fibres of the ventricle being contracted behind the aorta, as if supporting the valves, whilst the blood recoils against them—synchronous with which the first sound of the heart attains intensity and terminates.

The sound commences as the blood passes with force through the aortic foramen, and terminates in the aorta, as the blood is thrown back against the valves and shuts them, whilst the aorta pulsates. Sometimes a little roughness or bruit attends this sound, which disappears as the ventricle contracts with greater vigour. The sound is distinctly heard through the medium of the stethoscope, or by the naked ear applied over the heart, and as many as 30 pulsations can be counted at a time without interruption.

Immediately after the contraction of the ventricle and impulse of the aorta terminate, the auricles contract; and as they propel their blood into the ventricle, the second sound of the heart is heard. It is a short, sharp sound, distinctly recognised through the medium of the stethoscope. It appears to be deeper-seated, and not so near the ear as the first sound, and is heard

at the side of the aorta, in the position of the auricles pouring their blood into the ventricle. The whole of the auricles now contract, and not a part of them, and as they pour their blood with force into the ventricle, the second sound of the heart is produced.

July 3rd.—Denuded the heart of a large turtle; observed the action, and listened to the sounds.

When the ventricle contracts, it sends with an impulse the wave of blood into the aorta, distending its walls, and the aorta simultaneously contracts from its origin, shutting the valves and rendering the arch more curved as the blood is impelled along it, the ventricle being contracted when the aorta pulsates. Synchronous with the contraction of the ventricle and pulsation of the aorta, the first sound is heard, and is produced by the blood being propelled with force through the aortic foramen and the wave that has entered the aorta recoiling against the valves as it is impelled onwards. Hence the sound is dull and prolonged, and heard most distinctly over the semilunar valves as they shut. Immediately after the aorta pulsates, the auricles contract with an impulse, and as they propel the blood into the ventricle through the ventricular foramen, the second sound is heard. It is a short, sharp sound, and appears at a greater distance than the first sound, as the auricles are here deeper seated than the arch of the distended aorta.

The first sound ascends in the course of the blood from the ventricle along the aorta. But the second sound descends in the path of the blood from the auricles into the ventricle; so that it is heard in a lower position than the first sound.

The second sound is recognised at the commencement of the contraction of the auricles, immediately following the first sound, and is most distinct over the auriculo-ventricular foramen, as the blood is sent with force into the ventricle distending its *walls*. And a longer interval of silence occurs between the second, and the commencement of the first sound; because the ventricle on being distended, commences to contract with an impulse towards the aorta, and the first sound is produced as the blood is propelled with force through the aortic foramen and the aorta pulsates at its origin, shutting the valves.

On the vigorous action of the heart, the auricles which have been refilling during contraction of the ventricle commence to contract immediately after the aorta pulsates and the first sound terminates. But when the action of the heart grows slower the auricles are later in commencing to contract, so that they appear rather to precede immediately the succeeding contraction of the ventricle than succeed the preceding ventricular contraction. And it is this circumstance of viewing the action of the heart when it is becoming slower, that has led experimentalists to believe that the contraction of the auricles could not account for the second sound of the heart, which so immediately follows the first sound.

We tested this question of the sounds of the heart with the greatest care and attention, when the pericardium had just been slit open, and the action of the heart strong and vigorous. Pulsations 40 per minute. Temperature of day 92° Fahrenheit, in the shade. On applying the stethoscope and carefully avoiding

pressure, we counted 1, 2, 3, 4, 5, 6, &c., as we heard the first sound of the heart, and several gentlemen who observed the action, distinctly perceived that the ventricle contracted and the origin of the aorta pulsated as we mentioned the numbers. And on listening to the second sound, it was also clearly found that the auricles contracted as we counted 1, 2, 3, 4, 5, 6, &c., thus putting it beyond all doubt that the first sound of the heart is produced during contraction of the ventricle and pulsation of the origin of the aorta; and the second sound is produced during contraction of the auricles, as the blood is propelled into the ventricle.

The ventricle then contracts, propelling the blood-wave with force into the aorta, distending its walls, and the aorta simultaneously reacts from its origin, shutting the valves as it gives the impulse to the wave. And the first sound of the heart is distinctly heard over the semilunar valves, whilst the ventricle is still contracted and the arch of the aorta more curved and tense. And the second sound is heard immediately after the first as the auricles contract and send the blood with an impulse into the ventricle.

We performed similar experiments on several other turtles during the highest temperature of the season, and with precisely the same results. In some cases the action of the heart amounted to 36 pulsations per minute, in others to 40 and even 50 per minute; but in general 36 to 40 pulsations per minute were the highest attained.

The ventricle in contracting propelled its wave of blood with force into the aorta, distending its walls, and the aorta, reacting with a power superior to that

by which it was distended,* caused the blood to recoil against the semilunar valves and shut them, as it imparted its impetus to the wave, the ventricle being contracted behind the valves, when the impulse of the aorta is exerted, synchronous with which the first sound of the heart is distinctly recognised over the semilunar valves, or a little above that; the impulse of the aorta preceding the pulse at the extremity of the arteries by a very short interval.

The fibres of the ventricle relax as the auricles contract, and the parietes of the aorta at the same time become straighter, and attain an interval of rest, till the ventricle contracts and again distends the aorta, there being the closest connection between the condition of the ventricle and that of the aorta.

Dr. Hope, as the result of his experiments on the sounds of the heart, concluded that the first sound depends on three causes: First, a degree of valvular sound, produced by the blood recoiling against the auriculo-ventricular valves; second, a sudden jerking extension of the muscular walls of the ventricle, as a sound is produced by the extension of the leather of a pair of bellows, which he termed the sound of extension; third, a prolongation or increase of this sound by the sonorous vibrations peculiar to muscular fibre. Dr. Williams maintains that the first sound of the heart is produced chiefly by the muscular contraction itself, and that as a general law a sound accompanies every rapid muscular contraction; but he considers that the tightening of the auriculo-ventricular valves also contributes to the production of the first sound.

* Pousseuille.

The Dublin Committee, as the result of their experiments on the sounds of the heart, concluded that the first sound is produced either by the rapid passage of the blood along the internal surface of the ventricles on its way to the mouths of the arteries, or by the *bruit musculaire* itself, or probably by both these causes combined; whilst the London Committee attributed the first sound to muscular contraction, but considered that the impulse of the heart against the thorax may occasionally act as an auxiliary cause in increasing the intensity of the sound. M. Cruveilhier, as the result of his observations, states that the first sound is heard most distinctly at the origin of the large arteries, and diminishes as we approach the apex of the heart. And Carpenter concludes that the principal cause of the first sound exists at the entrances to the arterial trunks. And it does not seem, he states, that any other reason can be assigned for it than the prolonged rush of blood through their orifices, and the throwing back of the semilunar valves; which, in suddenly flapping down again, produce the second sound.*

From these statements it appears that physiologists have, in general, confined the first sound of the heart to the action of the ventricle; but that M. Cruveilhier and Carpenter believe that it is connected with the entrance of the blood into the aorta and pulmonary artery—a view which we consider the nearest approach to the real cause of the first sound of the heart.

We must further observe, it is considered an established fact in physiology, that the first sound of the

* Carpenter's "Physiology," p. 419.

heart is synchronous with the contraction of the ventricle, and also with the pulsation of the aorta, or as it is termed, with the pulse of the arteries near the heart. Carpenter says * that "the first sound is evidently synchronous with the impulse of the heart against the parietes of the chest, and also with the pulse as felt near the heart." Dr. Wood states, † "The first sound is heard during the contraction or systole of the ventricle, and is synchronous with the beating of the ventricle, and with the pulsation in the large arteries near the centre of circulation, but anticipates by a very minute, but still appreciable interval, the pulse of the wrist." Müller observes, ‡ "The pulsation of the arteries near the heart is synchronous with the systole of the ventricle." And Dr. Hope maintains § that, "synchronous with the systole of the ventricle are, the first sound, the impulse of the apex against the ribs, and in vessels near the heart, the pulse; but in vessels at some distance as the radial, the pulse follows at a barely appreciable interval." From this united testimony of physiologists, it must be admitted that the first sound of the heart is synchronous with the contraction of the ventricle and pulsation of the aorta.

But the aorta cannot pulsate without the blood recoiling against the semilunar valves, and shutting them as it is impelled onwards. If the blood had been sent along the aorta in a constant stream, there would have been no shutting of the valves in its onward course. But the blood is propelled by the ventricle,

* Carpenter's "Physiology," p. 418.

† Wood's "Medicine." Philadelphia.

‡ Müller's "Physiology," p. 699.

§ Hope on "The Heart," p. 56.

par saccadés, in successive waves, and as each wave is sent with force into the aorta, it distends its walls, and the aorta instantly reacts, shutting the valves by the rebounding of the wave as it is impelled onwards. And the ventricle is fully contracted at the origin of the aorta, as if supporting the valves, whilst this impulsive movement takes place. The distending force of the ventricle ceases as the last portion of the wave enters the aorta, but it is now within the valves, and the parietes return on their contents with an energy superior to that by which they were distended, throwing the blood against the valves and shutting them, as an impulse is exerted on the wave; the impulse of the aorta being succeeded by the pulse at the wrist by only an appreciable interval of about one-thirtieth of a second.* Hence, it is during the onward course of the blood that it recoils against the aortic valves, just as the fluid in the forcing pump reacts against the valves, during the lateral pressure that propels it forward.

We have seen in the course of our experiments that the first sound of the heart is heard^{*} most distinctly over the semilunar valves, at the origin of the aorta, and occurs as the aorta pulsates and the valves shut. During the ventricular systole the blood is sent rapidly into the aorta, rendering it more curved and tense; and as the contraction reaches the muscular fibres at the origin of the aorta they contract with energy, passing behind the semilunar valves, constricting the part, whilst the aorta becomes fully distended and reacts, throwing the blood against the valves, and

* Müller's "Physiology," p. 176.

shutting them, by the impetus given to the wave.* Immediately after this, the ventricle commences to dilate as the auricles contract, and the parietes of the aorta grow straighter, and recover their former situation, till the ventricle again contracts, and the movements are repeated.

These facts seem to establish the proposition that the blood recoils against the aortic valves and shuts them during the ventricular systole, and not during its diastole; and that the sound which is then produced is the first sound of the heart. It commences as the blood is propelled with force through the aortic foramen, and attains its intensity in the aorta, as it reacts on the advancing wave. It is a dull and prolonged sound, fully brought out at its termination; synchronous with the contraction of the ventricle and impulse of the aorta, and precedes the pulse at the

* The fact that during the ventricular systole, the blood recoils against the aortic valves and shuts them, on pulsation of the aorta can easily be verified, by denuding the heart of a living fish, or other cold-blooded animal, in summer, and observing the phenomena.

May 16th.—Denuded the heart of a perch fish, and carefully observed its action.

When the ventricle contracted, it started up and assumed a curved form, propelling the blood-wave into the bulbous aorta or vessel that conveys the blood from the ventricle to the gills—distending its walls: the ventricle falling a little backward, as the bulbous aorta swelled out and pulsated, the blood-wave being then distinctly seen to pass along the arch. The impulse of this aorta took place as quick as the eye could follow it from contraction of the ventricle, the ventricle being still contracted, whilst the aorta pulsated, and in shutting the valves the aorta raised itself from its base, becoming smaller and narrower as it propelled the blood onward. Immediately after this, the parietes of the ventricle relaxed as the auricle contracted, and the walls of the aorta became soft, till again distended by the blood-wave from the ventricle. But there was no shutting of the valves, and no recoiling of the blood against them, except when the bulbous aorta pulsated, and that was synchronous with the contraction of the ventricle.

extremities of the arteries by only an appreciable instant.

And we can perceive the necessity of the semilunar valves being shut, and sustained by the ventricle contracted behind them, as the full impetus of the distended aorta is imparted to the blood-wave,—the impulse recoiling against the valves, and passing along the tube with such rapidity that the amount of blood which enters the aorta almost simultaneously displaces a similar amount at the extremities of the arteries,—communicated to the veins.

In contraction, the force which the ventricle exerts is spent on the impetus or momentum given to the wave and the distention of the aortic parietes; but as an artery always reacts with increased vigour, the latter force is more than regained and exerted during the arterial systole.

No portion of the first sound could be connected during these experiments with the auriculo-ventricular valves, because a membranous expansion, very small, of the internal parietes, or lining membrane of the ventricle is extended over the orifices, and covers the parts completely during the contraction and expansion of the walls of the ventricle; and it is so small, and so situated, that no sound can be produced at the part during the ventricular contraction.

The beat of the facial artery, says Müller, which is known to depend on the contraction of the ventricle, is nearly synchronous with the heart's impulse, being only one-thirtieth of a second later than it, while the second sound is not heard until one-fifth of a second after the impulse; consequently the second sound can

in no respect be connected with the pulsation of the aorta, where, as we have shown, a sound is produced. "The second sound," according to Dr. Hope, "results from the sudden expansion of the semilunar valves, occasioned by the reflux on them of the columns of blood in the aorta and pulmonary artery during the ventricular diastole." And Dr. Williams says: "The second sound being caused solely by the sudden reaction of the arterial columns of blood on the semilunar valves, its loudness will depend on the mobile and perfect state of these valves, and the extent and abruptness with which they are stretched by the recoil of the blood, at the moment of the ventricular diastole. It will therefore be most perfect when the heart acts regularly and slowly, giving time for the full gush of blood to carry the valves loose into their slight recesses in the walls of the artery, and for the as perfect reaction of the contents of the distended artery on their concave surfaces."* But if the second sound be produced by the columns of blood reacting against the semilunar valves, when the artery is distended, that must occur during the ventricular systole, for there are no columns of blood in the aorta and pulmonary artery during the ventricular diastole. The blood has already been propelled forward by the pulse in the aorta and pulmonary artery during the contraction of the ventricle; it is then only the blood that remains in the contracted arteries—that is in the arteries after the systole has taken place—that can fall back and recoil against the valves during the diastole. Dr. John Reid, whose statements are more explicit on this

* Williams on "The Heart," p. 213.

subject, says: "Synchronous with the first sound of the heart, we have the impulse of the heart against the chest, and the propulsion of the blood along the large arteries." "And during the second sound, which is synchronous with the diastole of the ventricle, we have the regurgitation of part of the blood in the large arteries upon the semilunar valves, throwing them inwards to the axes of the vessels." "And as the second sound appears to be produced by the shock of the blood upon the semilunar valves, its intensity must, in a great measure, depend upon the diastole of the ventricle drawing part of the blood back upon them; but perhaps more particularly upon the elasticity of the large arteries returning suddenly on their contents during the diastole of the ventricle, when the distending force of the ventricle has been withdrawn."*

This observation shows that Dr. Reid, who performed numerous experiments on the action of the heart, considered that the reason usually assigned by physiologists for the cause of the second sound was insufficient to account for it, and therefore, he says, perhaps more particularly upon the elasticity of the large arteries returning suddenly on their contents. But we must observe, the ventricle during its diastole, cannot, by a sort of suction power, draw the blood back upon the semilunar valves with a force sufficient to produce an acute and sharp sound like the second sound of the heart. Besides, the dilatation of the ventricle always commences at the auriculo-ventricular foramen, and when the action of the heart is vigorous,

* "Cyclopædia of Anatomy and Physiology," London. Art. "Heart," by Dr. John Reid.

the contraction of the auricles is synchronous with the diastole of the ventricle, and nothing like a suction power then exists in the ventricle to produce a reflux of the blood in the aorta against the semilunar valves. And as regards the elasticity of the arteries returning suddenly on their contents, that occurs during the systole of the ventricle when the blood is impelled forwards. During the ventricular diastole the arteries straighten themselves, and the aorta feels soft and compressible, and is in a state of rest, till its parietes are distended by the next ventricular contraction. And in the course of our experiments, no sound was produced in the aorta during the ventricular diastole.

Physiologists seem to think that the contraction of the ventricle propels the blood along the arterial tube to its extremity, independently of the action of the semilunar valves; and that the blood in the distended arteries recoils against the valves during the diastole of the ventricle, and produces the second sound of the heart. But this is not the manner in which the heart acts. If the ventricle propelled the blood along the arteries, independent of the action of the aortic valves, it could not relax till the impulse which it imparted had reached the farthest extremities of the arteries, communicating the amount of the blood-wave to the veins, in which case the arteries would no longer be distended with blood; for if the ventricle relaxed before this was accomplished, then the blood would fall back, and recoil against the semilunar valves, and shut them, whilst it was in the act of being impelled along the arteries to their extremities, that is, during the arterial systole. But in transmitting the blood from

the heart to and through the arterial system, the ventricle acts in concert with the aorta and its valves.*

And the aorta is not a rigid and unyielding tube, in which the fluid falls back against the valves when the propelling force has been withdrawn. But the aorta is distensible and elastic; and being distended by the blood-wave on contraction of the ventricle, instantly reacts or pulsates, forcing the blood against the valves as it is impelled onwards. And this occurs whilst the ventricle is contracted, and before the diastole has commenced. If there were no semilunar valves, the aorta being distensible and pulsative, would send the blood partially back into the ventricle at each pulsation; but the valves placed there prevent its return, and the impulse of the aorta which completes each successive systole of the ventricle exerts an influence in the movement of the blood throughout the arteries, the pulse, as we have stated, being felt at their

* For the sake of illustration we may be permitted to allude to the action of the single forcing pump, which it somewhat resembles. The piston, which is contained in the working barrel at the base, has a range of two feet or upwards, and on being raised immediately descends to that extent, the valve opening, and the fluid passing readily into the upper compartment of the tube. But the instant the upward stroke is given the valve shuts by the fluid recoiling against it, and a distinct sound is produced; and as the piston is elevated to the limit of its range, viz., two feet, it exerts a force upon the whole of the fluid contained in the tube, expelling at the upper extremity an amount of fluid equal to what had entered at the base. And when the ventricle contracts it sends with an impulse the wave of blood into the aorta, distending its walls, and the aorta, reacting on the blood that has entered it, forces it against the valves, shutting them, and produces the termination of the first sound of the heart as the impetus is exerted on the wave, the impulse of the aorta being synchronous with the contraction of the ventricle, and preceding at a very short interval the pulse at the extremity of the arteries.

extremities in an appreciable short interval after the aorta pulsates.

The fact, then, that the aorta is distensible and elastic secures its reaction on the blood, and shutting of the valves in connection with the ventricular systole.

When disease exists at the orifice of the aorta, interfering with the passage of the blood into the foramen, a bellows sound is produced, masking the commencement of the first sound of the heart; and if the aortic valves be incompetent a murmur is also produced as the aorta pulsates, affecting the termination of the first sound, the blood recoiling against the valves and partially regurgitating into the ventricle, so that the aortic regurgitant murmur occurs in connection with the ventricular systole, and not with its diastole, as is generally supposed. In proof of this we may observe, if the blood had been propelled by the ventricle along the arteries, independently of the action of the aortic valves, their incompetency could not affect the character of the pulse. But in all these cases the pulse is described as a "jerking pulse, the pulse of unfilled arteries, shooting like a ball beneath the finger," because the blood, instead of being sent along the arteries in a full stream, partly regurgitates through the aortic valves; just as the fluid in a pump is only partially expelled, when the valve in the working barrel is rendered incompetent. Physiologists are apt to think that this murmur, being regurgitant, must be of a diastolic character, and that it supplants the second sound of the heart; but it is quite the reverse. The blood only recoils against the

valves from the impulse of the aorta that sends it onward, and the murmur is produced at the aortic incompetent valves as the wave advances. And in anæmia we have the bellows murmur well defined at the orifice of the aorta, and often more audible a little higher up as the aorta pulsates, but in all these cases the blood is passing along the aorta during the ventricular systole.

When disease commences in the aortic valves, and the individual is subjected to much physical exertion, causing the ventricle to contract and distend the aorta with energy, the reaction of the aorta on the blood-wave may be performed with an impetus which the valves cannot fully sustain, and regurgitation takes place partially into the ventricle. We perceive, then, how the first sound of the heart, produced in a state of health by the blood being propelled through the aortic foramen, and recoiling against the valves on the pulsation or reaction of the aorta, is converted in a state of disease into the aortic obstructive, and regurgitant murmur, which take place during the ventricular systole, as the blood is impelled along the arteries. We have even on several occasions, in the course of our experiments, when the action of the heart was weak, heard the first sound with a slight interval, as if it consisted of two parts. But this disappeared on the action of the heart increasing, and the ventricle contracting with greater vigour, the sound becoming continuous and distinct—the normal first sound of the heart. On one occasion when the action of the heart was not strong, the first sound was heard for a considerable time to consist of two parts, produced

during the systole of the ventricle and pulsation of the aorta. Here there could be no reduplicate sound of the ventricle, and as regards the latter part of the sound, we could observe the blood recoil against the aortic valves when it was produced. The second sound was also occasionally heard, on contraction of the auricles, the three sounds constituting the triple sound of the heart. But when the ventricle contracted with more vigour the first became one continuous and distinct sound, and the second sound more audible, constituting the normal and healthy sounds of the heart.

When the ventricle contracts, the aorta pulsates, shutting the valves as the arterial systole takes place, immediately after which the ventricle relaxes as the auricles contract, the aorta becoming soft and compressible. But if during the diastole the arteries were distended with columns of blood that recoiled against the valves, it would act as an obstacle to the blood entering the aorta, and require an additional force to be exerted by the ventricle during its contraction to overcome it; and it would allow no period of rest to the parietes of the aorta, as they would be kept distended, both during the ventricular systole and diastole, which would speedily destroy their action.

There are three propositions, then, which we consider established by these experiments:—

1st. The first sound of the heart, viz., the dull and prolonged sound, must be associated with the contraction of the ventricle and pulsation of the aorta.

2nd. During the ventricular systole the semilunar

valves are tightened and shut, by the blood recoiling against them on the impulse of the aorta.

3rd. The sound which is heard in the denuded heart over the semilunar valves or a little above them, is not the second sound of the heart, but the first sound attaining its intensity and termination.

The second sound has no connection with the aorta, but depends on the contraction of the auricles, and the force with which they pour their blood into the ventricles, and occurs quickly after the first sound terminates.

We have seen that closely following the first sound of the heart, a second sound is heard of a short, sharp, and acute character, and occurs during the contraction of the auricles and diastole of the ventricle, as was clearly ascertained by counting 1, 2, 3, 4, 5, 6, &c., whilst we listened to the second sound through the medium of the stethoscope; and several gentlemen carefully observed the contraction of the auricles, and each contraction of the auricles exactly coincided with the second sound as heard by us. Pressure on the aorta above the semilunar valves, at the moment of the occurrence of the second sound, did not in the least diminish its loudness and intensity, but it was affected by whatever impaired the action of the auricles. When they became weak, the second sound was scarcely audible, but when they contracted with energy, the second sound was clearly and distinctly recognised. It appeared to be produced at the auriculo-ventricular foramen, by the force with which the blood is propelled from the auricles into the ventricle. Sometimes it partook of a slight bruit, as if the

blood passed over something rough on entering the ventricle. But when the auricles contracted with vigour, the second sound was sharp and acute, like the sound produced by the tongue striking the roof of the mouth. It appeared deeper seated, and at a greater distance than the first sound, because the auricles are here deeper seated than the arch of the aorta, and it did not follow the course and direction of the first sound. The first sound ascended along the aorta, but the second descended by the side of the base of the aorta, in the situation of the blood passing from the auricles into the ventricle. We tested this question with the greatest possible care, and distinctly ascertained that the second sound of the heart is produced by contraction of the auricles, as they pour their blood with force into the ventricles. After its occurrence a momentary silence ensued, and then the first sound recommenced.

We have also on several occasions, when the animal became weaker and the action of the heart less vigorous, heard the second sound double, as if the auricles did not contract exactly synchronous. July 21st.—Both sounds of the heart distinctly recognised, but the first is accompanied with a bruit that ascends along the aorta, and the second sound sometimes appears double, the contraction of the auricles being not exactly synchronous. July 23rd.—Both sounds distinctly heard, but the first is accompanied with a bruit, and the second sound more frequently double than formerly. August 3rd.—Action of the heart weaker, but both sounds can be fully recognised. Pulsation 28 per minute. The first sound attended with a

louder bruit, and the second appears double, the auricles not contracting synchronously, and are slightly later in commencing. Three sounds are now heard—the first sound of the heart produced during contraction of the ventricle and pulsation of the aorta, and two short sharp sounds during contraction of the auricles; putting it beyond all doubt that in the normal and healthy action of the heart, the second sound depends on contraction of the auricles.

Dr. Hope concluded, as the result of his experiments on the sounds of the heart, that no sound is produced by contraction of the auricles. But this depended on the manner in which the action of the heart was maintained. We are informed that during these experiments, in which artificial respiration was employed, the auricles contracted only partially, or chiefly in their appendices. But to produce a distinct sound, the auricles require not merely to contract, but to contract with energy, in expelling the blood from their cavity. There are two circumstances which seem to affect the character and loudness of the second sound. When the action of the heart is weak, the auricles do not contract with a vigour sufficient to render the sound clear and distinct. And when the ventricle is already partially filled with blood passing into it from the distended auricles or regurgitating through the aortic valves, the auricle only partially contracts, and the second sound becomes obscure and indistinct. In these cases it is not heard constant and continuous. But when the action of the heart is vigorous, a sharp sound is produced by contraction of the auricles, distinctly recognised and closely following the first sound.

The principle which chiefly contributes to the production of sound in the contraction of the auricles is what obtains as a general law in the passage of fluids through narrow or contracted orifices. If the force by which the blood is propelled be weak, little or no sound is heard, but if the blood be propelled with energy, a clear and distinct sound is produced.

And Dr. Williams informs us, "that in some recent experiments with Mr. Clendinning, he found the auricles of an ass produce a very distinct sound when they contracted vigorously, and independently of the ventricles; this was afterwards heard by all who were present. The same phenomenon has also been observed in some experiments recently performed in America."* Drs. Pinnock and Moore heard a sound produced by contraction of the auricles.† And we have had ample evidence of this fact in the course of our experiments, during these three last summers, on the action and sounds of the heart in the American turtle.

Much has been said by physiologists respecting the second sound not being produced by contraction of the auricles, from the time at which the auricles are believed to contract. Harvey, Lancisi, Senac, and Haller considered that the auricles contract immediately before the contraction of the ventricles, and not immediately after the termination of the preceding contraction. Drs. Hope and Williams also maintained this doctrine as the result of their experiments; and Professor Turner,‡ arguing on these data, showed that as the second sound closely follows the first, it could not depend on

* Williams on "The Chest." † Wood's "Medicine." Philadelphia.

‡ Turner--"Med.-Chirurg. Trans." Edinburgh, 1829.

contraction of the auricles, as their contraction immediately precedes that of the ventricles. Now, it is a fact, that when the action of the heart is slow and weak, as in cold-blooded animals, when it beats at the rate of 20 and 22 pulsations per minute, the ventricle after contraction immediately dilates, and blood enters it from the distended auricles, filling it out to a certain extent; and then the auricles contract and produce contraction of the ventricle, the one movement immediately preceding the other. The same thing occurs in warm-blooded animals after the thorax has been opened, when the action of the heart becomes slow and irregular, or its movements are interfered with, as by preventing the action of any of its valves. In these cases we have observed that after contraction, the ventricle immediately dilates to a certain extent, and blood passes into it from the distended auricles, and then the auricles contract and produce contraction of the ventricle. But we are by no means, from these data, to conclude that this is the manner in which the action of the heart is maintained, when it is quick and regular, beating, as in warm-blooded animals, at 60, 70, and 80 pulsations per minute. We have already shown* that as the action of the heart increases, the auricles contract sooner in point of time and of rhythm; then their contraction becomes synchronous with the diastole of the ventricle; so that they commence to contract immediately after the termination of the preceding ventricular contraction. And let a physiologist examine the action of the heart when it has been quickly denuded in a

* *British Medical Journal*, February, 1868.

warm-blooded animal, and he will see that the auricles contract immediately after the termination of the preceding ventricular contraction, and that the action is maintained with surprising power, the one movement following the other in quick and regular succession. And this is exactly what we have seen in the course of our experiments on turtles during the highest temperature of the season.

In observing the action in a denuded heart, we distinctly perceive that the contraction of the auricles commence the cycle or beat, and the contraction of the ventricle and impulse of the aorta terminate the beat; the one beat succeeding the other in such quick and rapid succession that, when the action is vigorous, the contraction of the auricles is synchronous with the diastole of the ventricle. But in listening to the sounds of the heart through the medium of the stethoscope, or by the naked ear applied to the chest, we associate the dull and prolonged sound with the short and acute sound, considering the former the first sound of the heart and the latter the second sound, and that they belong to the same cycle or beat of the heart; but the reverse is the case. The short and acute sound is in reality the first sound of the heart, being produced by contraction of the auricles, which commence the cycle or beat of the heart, and the dull and prolonged sound is in reality the second sound of the heart, being produced by contraction of the ventricle and impulse of the aorta which terminate the beat; so that the short and acute sound does not belong to the same beat of the heart as the dull and prolonged sound which precedes it but is the commencement of a new beat,

and must be associated with the ventricular contraction and impulse of the aorta that immediately succeed it; which enables us to see that the short and acute sound may appear to succeed the dull and prolonged sound, but is in reality the first sound of the heart.

We wish it to be distinctly understood that the statements we make respecting the sounds and rhythm of the heart refer exclusively to the action of the heart when it is quick and regular, and the contraction of the auricle immediately succeeds the contraction of the ventricle.

The first period of silence occurs between what is called the first and second sounds of the heart, and depends on the time at which the auricles commence to contract after the contraction of the ventricle and impulse of the aorta terminate. According to Müller it is one-fifth of a second; but Laennec thinks that the second sound begins immediately after the first ends. From careful and repeated observations, we are of opinion that an appreciable interval occurs between the first and second sound, that is, between the termination of the contraction of the ventricle and impulse of the aorta, and the commencement of the contraction of the auricles. But this interval is reduced to a minimum when the action becomes very rapid, the heart beating 100 and 120 times per minute.

The second period of silence occurs between what is termed the second and the first sound of the heart, that is, between the termination of the contraction of the auricles and contraction of the ventricles. It is

longer than the first interval, because it extends through the period of the ventricular action, till the blood is sent with force into the aortic-foramen, and the semilunar valves shut.

From what has been stated we arrive at the following conclusions respecting the sounds of the heart:—

The first sound is produced by contraction of the ventricle and impulse of the aorta. It commences as the blood is propelled with force through the aortic foramen and attains its intensity in the aorta, as the blood is thrown back against the aortic valves and shuts them on the impulse being imparted to the wave.

This sound is heard most distinctly in the denuded heart over the semilunar valves—at the origin of the aorta or a little above it.

The second sound depends on the contraction of the auricles, and is produced as they propel their blood with force through the auriculo-ventricular foramen into the ventricle during its dilatation.

It appears to follow the first sound as an immediate sequence, as it takes place so quickly after its completion, but it is the commencement of a new beat, and synchronous with the dilatation of the ventricle, and of course precedes the ventricular systole.

And as the same principle obtains in warm-blooded animals, the first sound of the heart is produced during the ventricular systole, as the blood is propelled with force into the aorta and pulmonary artery, and attains its intensity, as the blood has entered their orifices and is thrown back against the semilunar valves and

shuts them, by the reaction of the distended parietes imparting an impulse to the wave, the impulse of the aorta preceding the pulse at the wrist by an appreciable instant.

The second sound of the heart is produced by the force with which the blood is propelled by contraction of the auricle through each auriculo-ventricular foramen, into the ventricles during their diastole.

From what we have stated it will be seen that a bruit sometimes attends one or both sounds, when the action of the heart is weak, and disappears when the action is strong; so that one cause of inorganic murmurs is the want of energy in the contraction of the auricles or ventricles, and whatever restores this, removes the murmur.

From the manner in which the first sound is produced, we can perceive how a murmur connected with the contraction of the left or right ventricle is propagated along the aorta or pulmonary artery; a circumstance on which Dr. Hope laid great stress in determining to which side of the heart the murmur belonged.

We have thus given an account of the action and sounds of the heart, based on a series of carefully conducted experiments, where we had numerous and ample opportunities of investigating the subject, and we feel persuaded that what we have stated will ultimately be admitted to be the manner in which the sounds are produced. Dr. Hope, in the course of his experiments, limited the first sound to the action of the ventricle, and naturally thought that the sound which he heard in the aorta over the semilunar

valves must be the second sound of the heart. But on this hypothesis it has been found impossible satisfactorily to account for the sounds of the heart; because, whatever view may be taken of the cause of the first sound, it occurs, as is admitted, when the ventricle contracts and the aorta pulsates, which makes the first sound of the heart synchronous with the pulsation of the aorta. But the aorta, when it pulsates, shuts the valves, and the sound which is then produced enters into the formation of the first sound, and constitutes its termination. Dr. Hope endeavoured to separate two things which are identical—the formation of the first sound, and the shutting of the aortic valves, which occur at one and the same moment, as the blood is impelled along the large arteries, and slightly precede the pulse at the wrist. So that what Dr. Hope considered the first and second sounds of the heart are simultaneous, and constitute one prolonged sound well brought out at its termination, recognised by physiologists as the first sound of the heart.

Whilst engaged in investigating the action of the denuded heart to ascertain the manner in which the diastole of the ventricle is produced, we perceived that when the ventricle contracted the aorta pulsated in connection with it, shutting the valves as the impulse of the blood-wave proceeded along the arch; and we concluded that the sound caused by the shutting of the sigmoid valves must occur sooner than is believed, and be synchronous with the ventricular systole. And on listening to the sounds through the medium of the stethoscope, we discovered that when

the ventricle contracted it was one prolonged sound that was heard proceeding through the foramen into the aorta, where it terminates, being loudest at the aortic valves, or a little higher up. This, by repeated experiments, we distinctly ascertained to be what is termed the first sound of the heart.

Dr. Hope did not realize the true cause of the second sound of the heart, perhaps from the irregular manner in which the action was maintained. But we distinctly recognised the second sound, closely following the first, produced, as stated, when the auricles contracted and sent the blood with energy into the ventricle.

Much has been done by pathological research to establish the commonly-received views respecting the sounds of the heart; and yet pathologists still recur to the experiments that were first instituted to determine the cause of the sounds. And we may observe, if the first sound of the heart depended chiefly on the tightening of the muscular fibres of the ventricle, it ought to remain unaltered, under every circumstance, so long as the fibres are healthy and contract firmly. But the character of the sound is changed or modified in disease of the orifice of the aorta or affecting the valves.* And not only is this the case, but the reverse, the sound remains unaltered or little affected, even although the muscular fibres of the ventricle have, in places, entirely disappeared, being substituted by fatty globules; as fully ascertained by the microscope—the change, on the whole, “consisting more of fatty substi-

* Watson's "Practice of Physic," vol. ii. p. 234.

tution rather than of fatty conversion.”* And the first sound cannot properly be connected with the shutting of the auriculo-ventricular valves, as that takes place at the very commencement of the systole, whereas the first sound is admitted to be synchronous with the pulsation of the aorta, that occurs in connection with the blood-wave being propelled with force through the aortic foramen. And it is heard most distinctly in the denuded heart over the aortic valves; and seems to diminish as we approach the apex of the ventricle.†

In diseased action of the aorta and its valves, a double murmur is produced, because a portion of blood regurgitates through the valves when the aorta pulsates. But in the healthy action, the first sound terminates when the sigmoid valves shut.

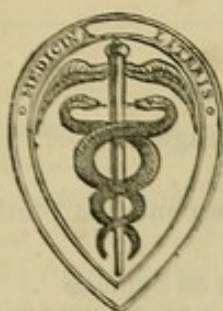
When the action of the heart is vigorous, the auricles contract with energy in propelling the blood into the ventricle. And if an obstacle exists to the free passage of the blood from the auricle into the respective ventricle, the auricles become dilated or hypertrophied.‡ And when the constriction of the mitral orifice has become extreme, the left auricle has been found enormously dilated and hypertrophied, and the second sound of the heart reduplicated §—a conclusive proof that the second sound depends on contraction of the auricles.

* *British Medical Journal*, No. 570, p. 654.

† Carpenter's "Physiology," p. 419.

‡ *British Medical Journal*, No. 526, p. 92.

§ *Ibid.*, No. 573, p. 742.



*London, New Burlington Street,
Oct., 1872*

SELECTION

FROM

MESSRS J. & A. CHURCHILL'S

General Catalogue

COMPRISING

ALL RECENT WORKS PUBLISHED BY THEM

ON THE

ART AND SCIENCE

OF

M E D I C I N E

INDEX

	PAGE		PAGE
Acton on the Reproductive Organs	10	Clark's Surgical Diagnosis	14
— on Prostitution	10	Cobbold on Worms	7
Allingham on Rectum	4	Cotton on Phthisis and the Stetho- scope	15
Anatomical Remembrancer	6	Coulson's Treatise on Syphilis	16
Anderson on Parasitic Affections of Skin	19	— on Stone in the Bladder	16
— on Eczema	19	Curling on Diseases of the Rectum	23
— on Psoriasis and Lepra	19	— on Diseases of the Testis	23
Anderson's Photographs of Leprosy	6	Dale's Practical Medicine	20
Arnott on Cancer	5	De Morgan on the Origin of Cancer	6
Ashton on Prolapsus, Fistula in Ano, &c.	11	Dixon on Diseases of the Eye	23
Barclay's Manual of Medical Dia- gnosis	22	Dobell's Lectures on Winter Cough	6
— on Gout and Rheumatism	22	— first stage of Consumption	6
Barnes' Obstetric Operations	10	Domville's Manual for Hospital Nurses	5
Basham on Renal Diseases	13	Druitt's Surgeon's Vade-Mecum	17
— on Dropsy	13	Elam on Cerebria	5
— on Diseases of the Kidneys	13	Ellis's Manual of the Diseases of Children	16
Bateman on Aphasia	13	Fayrer's Clinical Surgery in India	23
Beale on Kidney Diseases	17	Fenwick on the Stomach and Duo- denum	20
— on Disease Germs	17	— Student's Guide to Medical Diagnosis	20
— on Digitalis	17	Fergusson's Practical Surgery	12
Bennet's Winter and Spring on the Shores of the Mediterranean	8	— on Progress of Anatomy and Surgery	12
— on the Treatment of Pulmo- nary Consumption	8	Flower's Nerves of the Human Body	4
Bennett on Cancerous and other Intra- thoracic Growths	7	Foster on Method and Medicine	11
Birch on Oxygen	19	Fuller on the Lungs and Air Passages	21
— on Constipated Bowels	19	Gamgee on Fractures of the Limbs	7
Black's Functional Diseases of Repro- ductive Organs	5	Gant on the Science and Practice of Surgery	8
Brodhurst on Deformities of the Human Body	11	— on the Irritable Bladder	8
Browne's Handbook of Law and Lunacy	5	Garrett on Irritative Dyspepsia	18
— Medical Jurisprudence of Insanity	8	Glenn and Carpenter on the Laws Affecting Medical Men	8
Bryant's Practice of Surgery	4	Godfrey on Diseases of Hair	7
Carpenter's Human Physiology	16	Grabham on Madeira	15
— Manual of Physiology	16	Habershon on Diseases of the Liver	5
Chambers's Lectures, chiefly Clinical	21	Harley on the Urine	7
— on the Indigestions	21	Headland on the Action of Medicines	22
Chavasse's Advice to a Mother	7	Heath's Practical Anatomy	15
— Counsel to a Mother	7	— Minor Surgery and Bandag- ing	15
— Advice to a Wife	7	— on the Jaws	15
Clark's Outlines of Surgery	4	Hill on Stricture of the Urethra	9
		Holden's Human Osteology	16
		— Dissections	16

	PAGE		PAGE
Holt on Stricture of the Urethra	19	Ross's Graft Theory of Disease	5
Holthouse on Hernial and other Tumours	13	Royle and Headland's Manual of Materia Medica	20
Hood on Gout, Rheumatism, &c.	10	Sabben's Handbook of Law and Lunacy	5
Hooper's Physician's Vade-Mecum by Guy and Harley	17	Sankey's Lectures on Mental Diseases	23
Hutchinson's Medical Remembrancer	21	Sansom on Chloroform	23
Jones (Bence) on the Applications of Chemistry and Mechanics	17	Savage on the Female Pelvic Organs	13
— Croonian Lectures on Matter and Force	17	Savory's Domestic Medicine	11
— (Handfield) on Functional Nervous Disorders	14	Sibson's Medical Anatomy	18
— (Wharton) Ophthalmic Medi- cine and Surgery	23	Smith (H.) on the Surgery of the Rectum	9
Jordan on Treatment of Surgical In- flammations	11	— (J.) Handbook of Dental Ana- tomy	9
Leared on Imperfect Digestion	14	Spender on Ulcers of Lower Limbs	19
Lee's Practical Pathology	13	Squire's Temperature Observations	18
Liebreich's Atlas of Ophthalmoscopy	11	Swain on the Knee-Joint	16
MacCormac's Notes and Recollec- tions of an Ambulance Surgeon	10	Swayne's Obstetric Aphorisms	8
Mackenzie on Growths in the Larynx	9	Tanner's Practical Midwifery	10
— on Hoarseness	9	Taylor's Medical Jurisprudence	22
— Throat Hospital Pharma- copœia	9	Thompson on Stricture of the Ure- thra	14
Macnamara on Diseases of the Eye	15	— on Practical Lithotomy and Lithotripsy	14
— on Asiatic Cholera	15	— on Diseases of the Urinary Organs	14
Mayne's Medical Vocabulary	18	Tilt's Uterine Therapeutics	6
Meryon's Rational Therapeutics	4	— on the Change of Life	6
Morris on Germinal Matter	20	Take on the Influence of the Mind upon the Body	4
— on Irritability	20	Van der Kolk's Mental Diseases, by Rudall	15
Nayler on the Diseases of the Skin	22	Veitch's Handbook for Nurses	14
Nicol's Translation of Dr. Dilln- berger's Handy-book	10	Wahlteuch's Dictionary of Materia Medica and Therapeutics	18
Oppert on Hospitals	20	Ward on Affections of the Liver	5
Parker on Syphilitic Diseases	11	Waring's Practical Therapeutics	9
Parkes's Manual of Practical Hygiene	17	Waters on Diseases of the Chest	20
Pavy on Diabetes	18	Wells (Soelberg) on Diseases of the Eye	12
— on Digestion	18	— on Long, Short, and Weak Sight	12
Peacock on Malformations of Heart	22	— (Spencer) on Diseases of the Ovaries	4
— on Valvular Disease of the Heart	22	Wilson on Diseases of the Skin	12
Pirrie on Hay Asthma	21	— Lectures on Ekzema	12
Power on Diseases of the Eye	21	— Lectures on Dermatology	12
Ramsbotham's Obstetric Medicine and Surgery	21	Winslow's Diseases of the Brain and Mind	19
Reynolds' Uses of Electricity	8	Wise's History of Medicine	21
Richardson's Practical Physic	9	Wolff on Zymotic Diseases	6
Roger's Present State of Therapeutics	14	Wright on Uterine Disorders	22

THE PRACTICE OF SURGERY:

A Manual by THOMAS BRYANT, F.R.C.S., Surgeon to Guy's Hospital. Crown 8vo, with numerous Engravings on wood.

DIAGRAMS OF THE NERVES OF THE HUMAN BODY,

Exhibiting their Origin, Divisions, and Connexions, with their Distribution, by WILLIAM HENRY FLOWER, F.R.S., Conservator of the Museum of the Royal College of Surgeons. Second Edition, roy. 4to, 12s.

OUTLINES OF SURGERY

and Surgical Pathology, including the Diagnosis and Treatment of Obscure and Urgent Cases, and the Surgical Anatomy of some Important Structures and Regions, by F. LE GROS CLARK, F.R.S., Senior Surgeon to St. Thomas's Hospital. Second Edition, Revised and Expanded by the Author, assisted by W. W. WAGSTAFFE, F.R.C.S., Resident Assistant-Surgeon to, and Joint-Lecturer on Anatomy at, St. Thomas's Hospital. 8vo, 10s. 6d.

DISEASES OF THE OVARIES;

their Diagnosis and Treatment. By T. SPENCER WELLS, F.R.C.S., Surgeon to the Queen's Household and to the Samaritan Hospital. 8vo, with about 150 Engravings, 21s.

THE INFLUENCE OF THE MIND UPON THE BODY

in Health and Disease (Illustrations of), designed to elucidate the Action of the Imagination, by DANIEL HACK TUKE, M.D., M.R.C.P. 8vo, 14s.

FISTULA, HÆMORRHOIDS, PAINFUL ULCER,

Stricture, Prolapsus, and other Diseases of the Rectum: their Diagnosis and Treatment. By WM. ALLINGHAM, F.R.C.S., Surgeon to St. Mark's Hospital for Fistula, &c., late Surgeon to the Great Northern Hospital. Second Edition, enlarged, 8vo.

SYMPATHETIC SYSTEM OF NERVES

as a Physiological basis for a rational System of Therapeutics (On the Functions of the), by EDWARD MERYON, M.D., F.R.C.P. 8vo, 3s. 6d.

THE GRAFT THEORY OF DISEASE,

being an Application of Mr. DARWIN's Hypothesis of Pangenesis to the Explanation of the Phenomena of the Zymotic Diseases by JAMES ROSS, M.D., Waterfoot, near Manchester. 8vo, 10s.

FUNCTIONAL DISEASES

of the Renal, Urinary, and Reproductive Organs (On the), by D. CAMPBELL BLACK, M.D., L.R.C.S. Edin., Member of the General Council of the University of Glasgow. 8vo, 10s. 6d.

A MANUAL FOR HOSPITAL NURSES

and others engaged in Attending on the Sick by EDWARD J. DOMVILLE, L.R.C.P., M.R.C.S. Crown 8vo, 2s. 6d.

CANCER:

its varieties, their Histology and Diagnosis. By HENRY ARNOTT, F.R.C.S., Assistant-Surgeon to, and Lecturer on Pathology at, St. Thomas's Hospital. 8vo, with 5 Lithographic Plates and 22 Wood Engravings, 5s. 6d.

ON DISEASES OF THE LIVER:

Lettsomian Lectures for 1872 by S. O. HABERSHON, M.D., F.R.C.P., Physician to Guy's Hospital. Post 8vo, 3s. 6d.

ON SOME AFFECTIONS OF THE LIVER

and Intestinal Canal; with Remarks on Ague and its Sequelæ, Scurvy, Purpura, &c., by STEPHEN H. WARD, M.D. Lond., F.R.C.P., Physician to the Seamen's Hospital, Greenwich. 8vo, 7s.

ON CEREBRIA

and other Diseases of the Brain by CHARLES ELAM, M.D., F.R.C.P., Assistant-Physician to the National Hospital for Paralysis and Epilepsy. 8vo, 6s.

HANDBOOK OF LAW AND LUNACY;

or, the Medical Practitioner's Complete Guide in all Matters relating to Lunacy Practice, by J. T. SABBEN, M.D., and J. H. BALFOUR BROWNE. 8vo, 5s.

FOURTEEN COLOURED PHOTOGRAPHS OF LEPROSY

as met with in the Straits Settlements, with Explanatory Notes by
A. F. ANDERSON, M.D., Acting Colonial Surgeon, Singapore. 4to,
£1 11s. 6d.

LECTURES ON WINTER COUGH

(Catarrh, Bronchitis, Emphysema, Asthma); with an Appendix on
some Principles of Diet in Disease, by HORACE DOBELL, M.D.,
Senior Physician to the Royal Hospital for Diseases of the Chest.
Second Edition, with Coloured Plates, 8vo, 8s. 6d.

BY THE SAME AUTHOR,

TRUE FIRST STAGE OF CONSUMPTION

(Lectures on the). Crown 8vo, 3s. 6d.

A HANDBOOK OF UTERINE THERAPEUTICS

and of Diseases of Women by E. J. TILT, M.D., M.R.C.P. Third
Edition, post 8vo, 10s.

BY THE SAME AUTHOR,

THE CHANGE OF LIFE

in Health and Disease: a Practical Treatise on the Nervous and
other Affections incidental to Women at the Decline of Life. Third
Edition, 8vo, 10s. 6d.

THE ORIGIN OF CANCER

considered with Reference to the Treatment of the Disease by
CAMPBELL DE MORGAN, F.R.S., F.R.C.S., Surgeon to the Middlesex
Hospital. Crown 8vo, 3s. 6d.

THE ANATOMICAL REMEMBRANCER;

or, Complete Pocket Anatomist. Seventh Edition, carefully Re-
vised, 32mo, 3s. 6d.

ZYMOTIC DISEASES:

their Correlation and Causation. By A. WOLFF, F.R.C.S. Post
8vo, 5s.

THE URINE AND ITS DERANGEMENTS

(Lectures on), with the Application of Physiological Chemistry to the Diagnosis and Treatment of Constitutional as well as Local Diseases by GEORGE HARLEY, M.D., F.R.S., F.R.C.P., formerly Professor in University College. Post 8vo, 9s.

ADVICE TO A MOTHER

on the Management of her Children, by PYE H. CHAVASSE, F.R.C.S. Tenth Edition, fcap 8vo, 2s. 6d.

BY THE SAME AUTHOR,

COUNSEL TO A MOTHER:

being a Continuation and the Completion of 'Advice to a Mother.' Second Edition, fcap 8vo, 2s. 6d.

ALSO,

ADVICE TO A WIFE

on the Management of her own Health. With an Introductory Chapter, especially addressed to a Young Wife. Ninth Edition, fcap 8vo, 2s. 6d.

WORMS:

a Series of Lectures delivered at the Middlesex Hospital on Practical Helminthology by T. SPENCER COBBOLD, M.D., F.R.S. Post 8vo, 5s.

DISEASES OF HAIR:

a popular Treatise upon the Affections of the Hair System by BENJAMIN GODFREY, M.D., F.R.A.S. Fcap 8vo, 3s. 6d.

CANCEROUS AND OTHER INTRA-THORACIC

Growths, their Natural History and Diagnosis. By J. RISDON BENNETT, M.D., F.R.C.P., Member of the General Medical Council. Post 8vo, with Plates, 8s.

FRACTURES OF THE LIMBS

(On the Treatment of) by J. SAMPSON GAMGEE, Surgeon to the Queen's Hospital, Birmingham. 8vo, with Plates, 10s. 6d.

WINTER AND SPRING

on the Shores of the Mediterranean; or, the Riviera, Mentone, Italy, Corsica, Sicily, Algeria, Spain, and Biarritz, as Winter Climates. By HENRY BENNET, M.D. Fourth Edition, post 8vo, with numerous Plates, Maps, and Wood Engravings, 12s.

BY THE SAME AUTHOR,

TREATMENT OF PULMONARY CONSUMPTION

(On the) by Hygiene, Climate, and Medicine. Second Edition, enlarged, 8vo, 5s.

CLINICAL USES OF ELECTRICITY

(Lectures on the) delivered at University College Hospital by J. RUSSELL REYNOLDS, M.D. Lond., F.R.C.P., F.R.S., Professor of Medicine in University College. Post 8vo, 3s. 6d.

THE SCIENCE AND PRACTICE OF SURGERY:

a complete System and Textbook by F. J. GANT, F.R.C.S., Surgeon to the Royal Free Hospital. 8vo, with 470 Engravings, £1 4s.

BY THE SAME AUTHOR,

THE IRRITABLE BLADDER:

its Causes and Treatment. Third Edition, crown 8vo, with Engravings, 6s.

THE LAWS AFFECTING MEDICAL MEN

(A Manual of) by ROBERT G. GLENN, LL.B., Barrister-at-Law; with a Chapter on Medical Etiquette by Dr. A. CARPENTER. 8vo, 14s.

THE MEDICAL JURISPRUDENCE OF INSANITY.

By J. H. BALFOUR BROWNE, Barrister-at-Law. 8vo, 10s. 6d.

OBSTETRIC APHORISMS

for the Use of Students commencing Midwifery Practice by J. G. SWAYNE, M.D., Physician-Accoucheur to the Bristol General Hospital. Fifth Edition, fcap 8vo, with Engravings on Wood, 3s. 6d.

GROWTHS IN THE LARYNX,

with Reports and an Analysis of 100 consecutive Cases treated since the Invention of the Laryngoscope by MORELL MACKENZIE, M.D. Lond., M.R.C.P., Physician to the Hospital for Diseases of the Throat. 8vo, with Coloured Plates, 12s. 6d.

BY THE SAME AUTHOR,

HOARSENESS, LOSS OF VOICE,

and Stridulous Breathing in relation to Nervo-Muscular Affections of the Larynx. Second Edition, 8vo, fully Illustrated, 3s. 6d.

ALSO

THROAT HOSPITAL PHARMACOPŒIA,

containing upwards of 150 Formulæ. Fcap 8vo, 2s. 6d.

A MANUAL OF PRACTICAL THERAPEUTICS

by E. J. WARING, M.D., F.R.C.P. Lond. Third Edition, fcap 8vo, 12s. 6d.

DISCOURSES ON PRACTICAL PHYSIC

by B. W. RICHARDSON, M.D., F.R.C.P., F.R.S. 8vo, 5s.

THE SURGERY OF THE RECTUM:

Lettsomian Lectures by HENRY SMITH, F.R.C.S., Surgeon to King's College Hospital. Third Edition, fcap 8vo, 3s. 6d.

HANDBOOK OF DENTAL ANATOMY

and Surgery for the Use of Students and Practitioners by JOHN SMITH, M.D., F.R.S. Edin., Surgeon-Dentist to the Queen in Scotland. Second Edition, fcap 8vo, 4s. 6d.

ORGANIC STRICTURE OF THE URETHRA

(An Analysis of 140 Cases of), of which 120 were submitted to Holt's Operation, and 20 to Perineal Section, by JOHN D. HILL, F.R.C.S., Surgeon to the Royal Free Hospital. 8vo, 3s.

THE REPRODUCTIVE ORGANS

in Childhood, Youth, Adult Age, and Advanced Life (The Functions and Disorders of), considered in their Physiological, Social, and Moral Relations, by WILLIAM ACTON, M.R.C.S. Fifth Edition, 8vo, 12s.

BY THE SAME AUTHOR,

PROSTITUTION:

Considered in its Moral, Social, and Sanitary Aspects. Second Edition, enlarged, 8vo, 12s.

NOTES AND RECOLLECTIONS

of an Ambulance Surgeon, being an Account of Work done under the Red Cross during the Campaign of 1870, by WILLIAM MACCORMAC, F.R.C.S., M.R.I.A., Assistant-Surgeon to St. Thomas's Hospital. 8vo, with 8 Plates, 7s. 6d.

A TREATISE ON GOUT, RHEUMATISM

and the Allied Affections by P. HOOD, M.D. Crown 8vo, 10s. 6d.

LECTURES ON OBSTETRIC OPERATIONS,

including the Treatment of Hæmorrhage, and forming a Guide to the Management of Difficult Labour, by ROBERT BARNES, M.D., F.R.C.P., Obstetric Physician to, and Lecturer on Midwifery at, St. Thomas's Hospital. Second Edition, 8vo, with 113 Engravings, 15s.

PRACTICAL MIDWIFERY AND OBSTETRICS,

including Anæsthetics. By JOHN TANNER, M.D., M.R.C.P. Edin. Fcap 8vo, with numerous Engravings, 6s. 6d.

A TRANSLATION OF DR. DILLNBERGER'S

Handy-Book of the Treatment of Women's and Children's Diseases according to the Vienna Medical School, with Prescriptions, by PATRICK NICOL, M.B. Fcap 8vo, 5s.

PROLAPSUS, FISTULA IN ANO

and other Diseases of the Rectum ; their Pathology and Treatment.
By T. J. ASHTON, M.R.C.S. Third Edition, post 8vo, 3s. 6d.

ON DEFORMITIES OF THE HUMAN BODY:

a System of Orthopædic Surgery, by BERNARD E. BRODHURST,
F.R.C.S., Orthopædic Surgeon to St. George's Hospital. 8vo, with
Engravings, 10s. 6d.

A COMPENDIUM OF DOMESTIC MEDICINE

and Companion to the Medicine Chest ; intended as a Source of
Easy Reference for Clergymen, and for Families residing at a
Distance from Professional Assistance by JOHN SAVORY, M.S.A.
Eighth Edition, 12mo, 5s.

SYPHILITIC DISEASES

(The Modern Treatment of), both Primary and Secondary ; com-
prising the Treatment of Constitutional and Confirmed Syphilis, by
a safe and successful Method, by LANGSTON PARKER, F.R.C.S.
Fifth Edition, 8vo, 10s. 6d.

METHOD AND MEDICINE:

an Essay on the Past, Present, and Future of Medicine by BALTHAZAR
W. FOSTER, M.D., Professor of Physic in Queen's College, Bir-
mingham. 8vo, 2s. 6d.

THE TREATMENT OF SURGICAL INFLAMMATIONS

by a New Method, which greatly shortens their Duration, by
FURNEAUX JORDAN, F.R.C.S., Professor of Surgery in Queen's
College, Birmingham. 8vo, with Plates, 7s. 6d.

ATLAS OF OPHTHALMOSCOPY:

representing the Normal and Pathological Conditions of the Fundus
Oculi as seen with the Ophthalmoscope : composed of 12 Chromo-
lithographic Plates (containing 59 Figures), accompanied by an
Explanatory Text by R. LIEBREICH, Ophthalmic Surgeon to St.
Thomas's Hospital. Translated into English by H. ROSBOROUGH
SWANZY, M.B. Dub. Second Edition, Enlarged and Revised, 4to,
£1 10s.

A SYSTEM OF PRACTICAL SURGERY

by Sir WILLIAM FERGUSSON, Bart., F.R.C.S., F.R.S., Serjeant-Surgeon to the Queen. Fifth Edition, 8vo, with 463 Illustrations on Wood, 21s.

BY THE SAME AUTHOR,

THE PROGRESS OF ANATOMY AND SURGERY

during the Present Century (Lectures on). With numerous Engravings, 8vo, 10s. 6d.

DISEASES OF THE EYE

(A Treatise on the) by J. SOELBERG WELLS, F.R.C.S., Ophthalmic Surgeon to King's College Hospital. Second Edition, 8vo, with Coloured Plates and Wood Engravings, 24s.

BY THE SAME AUTHOR,

ON LONG, SHORT, AND WEAK SIGHT,

and their Treatment by the Scientific Use of Spectacles. Third Edition, 8vo, with Plates, 6s.

ON DISEASES OF THE SKIN:

a System of Cutaneous Medicine by ERASMUS WILSON, F.R.C.S., F.R.S. Sixth Edition, 8vo, 18s.

THE SAME WORK; illustrated with finely executed Engravings on Steel, accurately coloured. 8vo, 36s.

BY THE SAME AUTHOR,

LECTURES ON EKZEMA

and Ekzematous Affections; with an Introduction on the General Pathology of the Skin, and an Appendix of Essays and Cases. 8vo, 10s. 6d.

ALSO,

LECTURES ON DERMATOLOGY

delivered at the Royal College of Surgeons, January, 1870: Synopsis of Diseases of the Skin. 8vo, 6s.

APHASIA OR LOSS OF SPEECH

and the Localisation of the Faculty of Articulate Language. By FREDERIC BATEMAN, M.D., M.R.C.P., Physician to the Norfolk and Norwich Hospital. 8vo, 7s.

THE SURGERY, SURGICAL PATHOLOGY,

and Surgical Anatomy of the Female Pelvic Organs, in a Series of Coloured Plates taken from Nature: with Commentaries, Notes, and Cases by HENRY SAVAGE, M.D. Lond., F.R.C.S., Consulting Physician to the Samaritan Free Hospital. Second Edition, greatly Enlarged, 4to, £1 11s. 6d.

ON HERNIAL AND OTHER TUMOURS

of the Groin and its Neighbourhood with some Practical Remarks on the Radical Cure of Ruptures by C. HOLTHOUSE, F.R.C.S., Surgeon to the Westminster Hospital. 8vo, 6s. 6d.

PRACTICAL PATHOLOGY:

third Edition, in 2 Vols., containing Lectures on Suppurative Fever, Diseases of the Veins, Hæmorrhoidal Tumours, Diseases of the Rectum, Syphilis, Gonorrhœal Ophthalmia, &c., by HENRY LEE, F.R.C.S., Surgeon to St. George's Hospital. 8vo, 10s. each vol.

RENAL DISEASES;

a Clinical Guide to their Diagnosis and Treatment by W. R. BASHAM, M.D., F.R.C.P., Senior Physician to the Westminster Hospital. Post 8vo, 7s.

BY THE SAME AUTHOR,

ON DROPSY,

and its Connection with Diseases of the Kidneys, Heart, Lungs, and Liver. Third Edition, 8vo, with 16 Plates, 12s. 6d.

ALSO,

THE DIAGNOSIS OF DISEASES OF THE KIDNEYS

(Aids to). 8vo, with 10 Plates, 5s.

ON THE PRESENT STATE OF THERAPEUTICS;

with some Suggestions for placing it on a more scientific basis by
JAMES ROGERS, M.D. 8vo, 6s. 6d.

HANDBOOK FOR NURSES FOR THE SICK

by Miss VEITCH. Crown 8vo, 2s. 6d.

STUDIES ON FUNCTIONAL NERVOUS DISORDERS

by C. HANDFIELD JONES, M.B., F.R.C.P., F.R.S., Physician to
St. Mary's Hospital. Second Edition, much enlarged, 8vo, 18s.

PRINCIPLES OF SURGICAL DIAGNOSIS

(Lectures on the) especially in Relation to Shock and Visceral
Lesions, delivered at the Royal College of Surgeons by F. LE GROS
CLARK, F.R.C.S., Senior Surgeon to, and Lecturer on Surgery at,
St. Thomas's Hospital. 8vo, 10s. 6d.

IMPERFECT DIGESTION:

its Causes and Treatment. By ARTHUR LEARED, M.D., F.R.C.P.,
Senior Physician to the Great Northern Hospital. Fifth Edition,
fcap 8vo, 4s. 6d.

STRICTURE OF THE URETHRA

and Urinary Fistulæ; their Pathology and Treatment: Jacksonian
Prize Essay by Sir HENRY THOMPSON, F.R.C.S., Surgeon-Extra-
ordinary to the King of the Belgians. Third Edition, 8vo, with
Plates, 10s.

BY THE SAME AUTHOR,

PRACTICAL LITHOTOMY AND LITHOTRITY;

or, An Inquiry into the best Modes of removing Stone from the
Bladder. Second Edition, 8vo, with numerous Engravings, 10s.

ALSO,

DISEASES OF THE URINARY ORGANS.

(Clinical Lectures on). Second Edition, crown 8vo, with En-
gravings, 5s.

MENTAL DISEASES

(The Pathology and Therapeutics of). By J. L. C. SCHROEDER VAN DER KOLK. Translated by Mr. RUDALL, F.R.C.S. 8vo, 7s. 6d.

THE CLIMATE AND RESOURCES OF MADEIRA,

as regarding chiefly the Necessities of Consumption and the Welfare of Invalids. By MICHAEL C. GRABHAM, M.D., M.R.C.P. Crown 8vo, with Map and Engravings, 5s.

A MANUAL OF THE DISEASES OF THE EYE

by C. MACNAMARA, Surgeon to the Calcutta Ophthalmic Hospital. Second Edition, fcap 8vo, with Coloured Plates, 12s. 6d.

BY THE SAME AUTHOR,

A TREATISE ON ASIATIC CHOLERA.

8vo, with Maps, 16s.

PHTHISIS AND THE STETHOSCOPE;

or, the Physical Signs of Consumption. By R. P. COTTON, M.D., F.R.C.P., Senior Physician to the Hospital for Consumption, Brompton. Fourth Edition, fcap 8vo, 3s. 6d.

PRACTICAL ANATOMY:

a Manual of Dissections by CHRISTOPHER HEATH, F.R.C.S., Surgeon to University College Hospital. Second Edition, fcap 8vo, with 226 Engravings, 12s. 6d.

BY THE SAME AUTHOR,

MINOR SURGERY AND BANDAGING

(A Manual of) for the Use of House-Surgeons, Dressers, and Junior Practitioners. Fourth Edition, fcap 8vo, with 74 Engravings, 5s. 6d.

ALSO,

INJURIES AND DISEASES OF THE JAWS:

JACKSONIAN PRIZE ESSAY. Second Edition, 8vo, with Engravings, 12s.

HUMAN OSTEOLOGY:

with Plates, showing the Attachments of the Muscles. By LUTHER HOLDEN, F.R.C.S., Surgeon to St. Bartholomew's Hospital. Fourth Edition, 8vo, 16s.

BY THE SAME AUTHOR,

THE DISSECTION OF THE HUMAN BODY

(A Manual of). Third Edition, 8vo, with Engravings on Wood, 16s.

MANUAL OF THE DISEASES OF CHILDREN

(A Practical), with a Formulary, by EDWARD ELLIS, M.D., Physician to the Victoria Hospital for Children. Crown 8vo, 6s.

INJURIES AND DISEASES OF THE KNEE-JOINT

and their Treatment by Amputation and Excision Contrasted: Jacksonian Prize Essay by W. P. SWAIN, F.R.C.S., Surgeon to the Royal Albert Hospital, Devonport. 8vo, with 36 Engravings, 9s.

A TREATISE ON SYPHILIS

by WALTER J. COUBSON, F.R.C.S., Surgeon to the Lock Hospital. 8vo, 10s.

BY THE SAME AUTHOR,

STONE IN THE BLADDER:

Its Prevention, Early Symptoms, and Treatment by Lithotrity. 8vo, 6s.

PRINCIPLES OF HUMAN PHYSIOLOGY.

By W. B. CARPENTER, M.D., F.R.S. Seventh Edition by Mr. HENRY POWER, 8vo, with nearly 300 Illustrations on Steel and Wood, 28s.

BY THE SAME AUTHOR,

A MANUAL OF PHYSIOLOGY.

Fourth Edition, fcap 8vo, with 252 Illustrations on Steel and Wood, 12s. 6d.

A MANUAL OF PRACTICAL HYGIENE

by E. A. PARKES, M.D., F.R.C.P., F.R.S., Professor of Hygiene in the Army Medical School. Third Edition, 8vo, with Plates and Woodcuts, 16s.

ON KIDNEY DISEASES, URINARY DEPOSITS

and Calculous Disorders by LIONEL S. BEALE, M.B., F.R.S., F.R.C.P., Physician to King's College Hospital. Third Edition, much Enlarged, 8vo, with 70 Plates, 25s.

BY THE SAME AUTHOR,

DISEASE GERMS;

and on the Treatment of the Feverish State. Second Edition, crown 8vo, with 28 Plates, 12s. 6d.

ON DIGITALIS,

with some Observations on the Urine, by T. L. BRUNTON, M.D. D.Sc. Fcap 8vo, 4s. 6d.

THE SURGEON'S VADE-MECUM

by ROBERT DRUITT. Tenth Edition, fcap 8vo, with numerous Engravings on Wood, 12s. 6d.

HOOVER'S PHYSICIAN'S VADE-MECUM:

or, Manual of the Principles and Practice of Physic, Seventh Edition by W. A. GUY, M.B., F.R.S., and JOHN HARLEY, M.D., F.R.C.P. Fcap 8vo, with Engravings. 12s. 6d.

THE APPLICATIONS OF CHEMISTRY

and Mechanics to Pathology and Therapeutics (Lectures on some of) by H. BENICE JONES, M.D., F.R.C.P., D.C.L., F.R.S. 8vo, 12s.

BY THE SAME AUTHOR,

CROONIAN LECTURES ON MATTER AND FORCE.

Fcap 8vo, 5s.

MEDICAL ANATOMY.

By FRANCIS SIBSON, M.D., F.R.C.P., F.R.S., Consulting Physician to St. Mary's Hospital. Imp. folio, with 21 coloured Plates, cloth, £2 2s.; half-morocco, £2 10s.

TEMPERATURE OBSERVATIONS

containing (1) Temperature Variations in the Diseases of Children, (2) Puerperal Temperatures, (3) Infantile Temperatures in Health and Disease, by WM. SQUIRE, M.R.C.P. Lond. 8vo, 5s.

A DICTIONARY OF MATERIA MEDICA

and Therapeutics by ADOLPHE WAHLTUCH, M.D. 8vo, 15s.

DIABETES:

Researches on its Nature and Treatment by F. W. PAVY, M.D., F.R.S., F.R.C.P., Physician to Guy's Hospital. Second Edition, 8vo, with Engravings, 10s.

BY THE SAME AUTHOR,

DIGESTION:

its Disorders and their Treatment. Second Edition, 8vo, 8s. 6d.

A MEDICAL VOCABULARY;

or, an Explanation of all Names, Synonymes, Terms, and Phrases used in Medicine and the relative branches of Medical Science by R. G. MAYNE, M.D., LL.D. Third Edition, fcap 8vo, 8s. 6d.

IRRITATIVE DYSPEPSIA

and its Important Connection with Irritative Congestion of the Windpipe and with the Origin and Progress of Consumption. By C. B. GARRETT, M.D. Crown 8vo, 2s. 6d.

THE PARASITIC AFFECTIONS OF THE SKIN.

By McCALL ANDERSON, M.D., F.F.P.S., Professor of the Practice of Medicine in Anderson's University, Glasgow. Second Edition, 8vo, with Engravings, 7s. 6d.

BY THE SAME AUTHOR,

ECZEMA.

Second Edition. 8vo, 6s.

ALSO,

PSORIASIS AND LEPROA.

8vo, with Chromo-lithograph, 5s.

STRICTURE OF THE URETHRA

(On the Immediate Treatment of) by BARNARD HOLT, F.R.C.S., Senior Surgeon to the Westminster Hospital. Third Edition, 8vo, 6s.

OXYGEN:

its Action, Use, and Value in the Treatment of various Diseases otherwise Incurable or very Intractable. By S. B. BIRCH, M.D., M.R.C.P. Second Edition, post 8vo, 3s. 6d.

BY THE SAME AUTHOR,

CONSTIPATED BOWELS:

the Various Causes and the Different Means of Cure. Third Edition, post 8vo, 3s. 6d.

OBSCURE DISEASES OF THE BRAIN AND MIND.

By FORBES WINSLOW, M.D., D.C.L. Oxon. Fourth Edition, post 8vo, 10s. 6d.

ULCERS AND CUTANEOUS DISEASES

(A Manual of the Pathology and Treatment of) of the Lower Limbs by J. K. SPENDER, M.D. Lond. 8vo, 4s.

A COMPENDIUM OF PRACTICAL MEDICINE

and Morbid Anatomy by WILLIAM DALE, M.D. LOND. 12mo, with Plates, 7s.

GERMINAL MATTER AND THE CONTACT THEORY:

an Essay on the Morbid Poisons by JAMES MORRIS, M.D. Lond. Second Edition, crown 8vo, 4s. 6d.

BY THE SAME AUTHOR,

IRRITABILITY:

Popular and Practical Sketches of Common Morbid States and Conditions bordering on Disease; with Hints for Management, Alleviation, and Cure. Crown 8vo, 4s. 6d.

A MANUAL OF MATERIA MEDICA

by J. F. ROYLE, M.D., F.R.S., and F. W. HEADLAND, M.D., F.R.C.P. Fifth Edition, fcap 8vo, with numerous Engravings on Wood, 12s. 6d.

DISEASES OF THE CHEST:

Contributions to their Clinical History, Pathology and Treatment by A. T. H. WATERS, M.D., F.R.C.P., Physician to the Liverpool Royal Infirmary. 8vo, with Plates, 12s. 6d.

HOSPITALS, INFIRMARIES, AND DISPENSARIES;

their Construction, Interior Arrangement, and Management, with Descriptions of existing Institutions, by FRANCIS OPPERT, M.D., M.R.C.P. Royal 8vo, with 58 Engravings, 10s. 6d.

THE STOMACH AND DUODENUM

(The Morbid States of) and their Relations to the Diseases of other Organs. By SAMUEL FENWICK, M.D., F.R.C.P., Assistant-Physician to the London Hospital. 8vo, with 10 Plates, 12s.

BY THE SAME AUTHOR,

THE STUDENT'S GUIDE TO MEDICAL DIAGNOSIS.

Second Edition, fcap 8vo, with 60 Engravings, 6s. 6d.

REVIEW OF THE HISTORY OF MEDICINE

among Asiatic Nations by T. A. WISE, M.D., F.R.C.P. Edin. Two Vols., 8vo, 16s.

DISEASES OF THE EYE

(Illustrations of some of the Principal), with an Account of their Symptoms, Pathology, and Treatment, by HENRY POWER, F.R.C.S., M.B. Lond., Ophthalmic Surgeon to St. Bartholomew's Hospital. 8vo, with twelve Coloured Plates, 20s.

ON HAY ASTHMA

and the Affection termed Hay Fever by WILLIAM PIRRIE, M.D. Fcap 8vo, 2s. 6d.

OBSTETRIC MEDICINE AND SURGERY.

(The Principles and Practice of). By F. H. RAMSBOTHAM, M.D., F.R.C.P.. Fifth Edition, 8vo, with One Hundred and Twenty Plates on Steel and Wood, 22s.

LECTURES, CHIEFLY CLINICAL

by T. K. CHAMBERS, M.D., F.R.C.P., Lecturer on Medicine at St. Mary's Hospital. Fourth Edition, 8vo, 14s.

BY THE SAME AUTHOR,

THE INDIGESTIONS

or Diseases of the Digestive Organs Functionally Treated. Second Edition, 8vo, 10s. 6d.

THE LUNGS AND AIR PASSAGES

(On Diseases of) by W. H. FULLER, M.D., F.R.C.P., Senior Physician to St. George's Hospital. Second Edition, 8vo, 12s. 6d.

THE MEDICAL REMEMBRANCER;

or, Book of Emergencies. Fifth Edition by JONATHAN HUTCHINSON, F.R.C.S., Senior Surgeon to the London Hospital. 32mo, 2s. 6d.

UTERINE DISORDERS:

their Constitutional Influence and Treatment. By HENRY G. WRIGHT, M.D., M.R.C.P. 8vo, 7s. 6d.

ON THE ACTION OF MEDICINES

in the System by F. W. HEADLAND, M.D., F.R.C.P., Professor of Medicine in Charing Cross Medical College. Fourth Edition, 8vo, 14s.

ON MALFORMATIONS OF THE HUMAN HEART,

with Original Cases and Illustrations, by T. B. PEACOCK, M.D., F.R.C.P., Physician to St. Thomas's Hospital. Second Edition, 8vo, with 8 Plates, 10s.

BY THE SAME AUTHOR,

VALVULAR DISEASE OF THE HEART

(On some of the Causes and Effects of). 8vo, with Engravings, 5s.

ON THE DISEASES OF THE SKIN

by GEORGE NAYLER, F.R.C.S., Surgeon to the Hospital for Diseases of the Skin, Blackfriars. 8vo, with Plates, 10s. 6d.

A MANUAL OF MEDICAL DIAGNOSIS

by A. W. BARCLAY, M.D., F.R.C.P., Physician to, and Lecturer on Medicine at, St. George's Hospital. Third Edition, fcap 8vo, 10s. 6d.

BY THE SAME AUTHOR,

GOUT AND RHEUMATISM

in relation to Disease of the Heart. Post 8vo, 5s.

MEDICAL JURISPRUDENCE

(The Principles and Practice of). By ALFRED S. TAYLOR, M.D., F.R.C.P., F.R.S. 8vo, with 176 Wood Engravings, 28s.

OPHTHALMIC MEDICINE AND SURGERY

(A Manual of the Principles and Practice of) by T. WHARTON JONES, F.R.C.S., F.R.S., Professor of Ophthalmic Medicine and Surgery in University College. Third Edition, fcap 8vo, with Nine Coloured Plates and 173 Wood Engravings, 12s. 6d.

DISEASES OF THE RECTUM

(Observations on) by T. B. CURLING, F.R.C.S., F.R.S., Examiner in Surgery to the Royal College of Surgeons. Third Edition, 8vo, 7s. 6d.

BY THE SAME AUTHOR,

DISEASES OF THE TESTIS,

Spermatic Cord, and Scrotum (A Practical Treatise on). Third Edition, 8vo, with Engravings, 16s.

DISEASES OF THE EYE

(A Guide to the Practical Study of) by JAMES DIXON, F.R.C.S., Consulting Surgeon to the Royal London Ophthalmic Hospital. Third Edition, post 8vo, 9s.

CLINICAL SURGERY IN INDIA.

By J. FAYRE, M.D., F.R.C.S., C.S.I., Professor of Surgery in the Calcutta Medical College. 8vo, with Engravings, 16s.

LECTURES ON MENTAL DISEASES

by W. H. O. SANKEY, M.D. Lond., F.R.C.P., Lecturer in University College. 8vo, 8s.

CHLOROFORM:

its Action and Administration: a Handbook by A. E. SANSOM, M.D. Lond., M.R.C.P., Physician to the North Eastern Hospital for Children. Crown 8vo, with Engravings, 5s.

The following CATALOGUES issued by Messrs CHURCHILL
will be forwarded post free on application :

1. *Messrs Churchill's General List of 400 works on Medicine, Surgery, Midwifery, Materia Medica, Hygiene, Anatomy, Physiology, Chemistry, &c., &c.*

2. *Selection from Messrs Churchill's General List, comprising all recent Works published by them on the Art and Science of Medicine.*

3. *A descriptive List of Messrs Churchill's Works on Chemistry, Pharmacy, Botany, Photography, and other branches of Science.*

4. *Messrs Churchill's Red-Letter List, giving the Titles of forthcoming New Works and New Editions.*

[Published every October.]

5. *The Medical Intelligencer, an Annual List of New Works and New Editions published by Messrs J. & A. Churchill, together with Particulars of the Periodicals issued from their House.*

[Sent in January of each year to every Medical Practitioner in the United Kingdom whose name and address can be ascertained. A large number are also sent to the United States of America, Continental Europe, India, and the Colonies.]

MESSRS CHURCHILL have concluded a special arrangement with MESSRS LINDSAY & BLAKISTON, OF PHILADELPHIA, in accordance with which that Firm will act as their Agents for the United States of America, either keeping in Stock most of Messrs CHURCHILL's Books, or reprinting them on Terms advantageous to Authors. Many of the Works in this Catalogue may therefore be easily obtained in America.

