qnately attained in this work, in some instances by ample detail, in others by incidental mention sufficient for the purpose in view. Thus while the general means by which each particular poison may be distinguished, are fully treated of, in a special instance, one very common and highly injurious, that of arsenic green in wall paper, the most ready mode of detection is so clearly described that but little chemical knowledge is reqnired for its practice.

The work is comprised in four parts. The first treats of matter and its properties, under the general relations of the physical forces, crystallization, affinity —equivalents, nomenclature, and notation. Those departments of physics which are usually found in this portion of the text-books, caloric, &c., are not included as distinct subjects of study, but sufficient for the purposes is introduced incidentally in appropriate places to render the absence of special consideration of no disadvantage. The second part contains the account of the metalloids or non-metallic elements, and here the importance of this division is shown by the more elaborate detail in the explanation of processes, properties, and applications. The aim of the author being "directed to the elucidation of the most important facts and principles, omitting altogether those details which are either of a controversial nature or not yet established on a satisfactory basis." It may here be remarked, that in the first part when speaking of the constitution of salts, the theory which considers them as composed of acids and bases is adopted, and in the American edition, which has received additions from one of the authors, it is advocated to a greater extent than in the original work. It is in this portion that we miss the illustrations, which have of late become so common in the text-books of science. Those which are useful to the beginner, especially if absent from large cities, would take up space which is otherwise better occupied in a work intended either as a text-book in following a course of lectures or for the use of more advanced students, and their want can be readily supplied in the works on practical chemistry which are now attainable. The third part gives a condensed view of the metals and their principal combination, considered in all their ordinary relations so as to be consulted by persons with diverse view, without disappointment.

The last part is devoted to organic chemistry. This department of the science has latterly progressed with such rapid strides that it requires no little amount of moral courage even to undertake the labour of giving a condensed exposition of its present condition, and it is hardly a matter of surprise, therefore, that this part should be less complete and satisfactory than the previous ones. At the same time it must be admitted that the subjects are treated in the same clear and practical manner, and the amount of new information is equal in proportion to that contained in the former portions. We feel confident that this work will recommend itself to all for whom it is intended, not only to study for a time, but to be placed on the shelf as a work of frequent reference.

R. B.

ART. XXIII.—*Researches upon the Anatomy and Physiology of Respiration in the Chelonia.* By S. WEIR MITCHELL, M. D., and GEORGE R. MOREHOUSE, M. D. Washington City: Published by the Smithsonian Institution, April, 1863. 4to. pp. 39. Illustrated with 8 wood-cuts.

IN this admirable monograph we recognize another important step in the onward march of physiological research. A long-accepted error is herein exposed and rectified, and new landmarks of facts, concerning both structure and function, are set up as guides for future investigators. The facts are the more valuable inasmuch as they aid materially in forming in the abstract a true conception of the respiratory function—that mainspring of all the complicated acts which collectively constitute organic life.

The object of this memoir is to show that turtles, unlike the frogs, do not inspire by an act of deglutition, but that their respiration is effected by inspiratory and expiratory muscles situated within the trunk.

The opening pages are devoted to a brief account of the anatomical history of the organs of respiration in Chelonians. The earliest work upon this subject, noticed by our authors, is a "Dissertation on the Respiration of the Tortoise," by Robert Townson, LL. D., written at Göttingen in May, 1795. This is a short but highly interesting tract; and as it contains a brief review of all that was previously known upon the subject of Chelonian respiration, it has been republished entire in the essay under notice. This procedure was adopted as an act of justice, moreover, to the singularly truthful views of Townson, which are but little known, and where known are either unappreciated or condemned as erroneous. From this brochure we derive the following facts.

In the frog-tribe, as is well known, the absence of ribs and a diaphragm necessitates a departure from the mammalian type of respiration. In the turtles the diaphragm is absent also, while the bones of the trunk are quite immobile. Blasius, indeed, asserted the existence of the diaphragm, but Gotwald, Wallbaum, and the French academicians were unable to find it. Townson also sought for it in vain. In consequence of this deficiency of the requisite mechanism for respiration Perault was led to attribute the expansion of the lungs and consequent inspiration to the elasticity of the membranes forming their cells; and the expiration to muscular compression. Varnier thought that the process of respiration was effected by the muscular texture of the lungs themselves. Tauvry and Haro maintained that turtles breathed only while walking. Townson by two simple and conclusive experiments showed the fallacy of this opinion. Morgagni supposed that the tortoise respired like the frog, and in this opinion he was supported by some observations of Coiter and Varnier. Townson combats this idea with vigour, and gives us the following explanation :—

"My attention was soon called to observe the structure and office of some muscles in the region of the flanks, which I observed often to be in motion, contracting and extending alternately, and though placed by the side of the hind legs, these were not moved by them. Further, they were placed at the end of the last lobule of the lungs, and they appeared to retain their irritability the longest. This was sufficient to lead me to conjecture that these might be the parts by which respiration in these animals was performed; and to see them act in their natural position I sawed off, in another tortoise, that part of the shell which covers them, and I then saw them constantly working. One was now placed nearly in a perpendicular direction, and another, or part of the same, was placed nearer the sternum, lying almost in a horizontal direction. The first in its contraction, receded from the testa inwards, whilst the latter, in its contraction, observed a contrary direction. When I attributed to them the office of expirator and inspirator muscles, which I supposed them to perform, I was embarrassed, because I could not conceive how a muscle could be a constrictor with its convex side; yet when the expirator, by contracting, had receded from the shell inwards, it appeared, when viewed from without, to be concave. But this difficulty ceased as soon as I had opened the animal and dissected the parts, for I then found the following admirable contrivance of nature. This part is composed of two distinct muscles, with their risings and insertions quite different, yet firmly connected in the middle by cellular membrane. The first rises from the testa near the spina dorsi, and is inserted into the peritoneum; this is the constrictor of the lungs, or the muscle of expiration. The other is nearly spread over the whole cavity between the upper and under shell, where the hind legs are drawn in during the contracted state of the animal, being inserted into the margin of the testa above, and the margin of the sternum below. The places of insertion of these muscles, and their connection in the middle being known, there is then no difficulty in explaining why the muscle, while acting as a constrictor, appeared concave, as it was only the inspirator brought into that position by its antagonist; nor any difficulty in conceiving how they carry on the function of respiration; for the expirator being connected, as I have already said, to the testa below and to the peritoneum above, envelops in a manner the last movable lobule of the lungs; when, therefore, it contracts, it compresses this part of the lungs, and by that means expels the air; then ceasing to act, the other contracts, and draws the former with it, thus a vacuum is formed, into which the air rushes, as in the respiration of those animals which have a thorax.

"To prove that this explanation was well founded, and that the motions of these muscles were really those of respiration, I made the following experiment. I fastened on the nose of a tortoise a little valve made of white paper, which covered the nostrils, and with the assistance of a friend, I watched the motions of the soft parts lying within the hollow where the hind legs came out, and I found that these motions perfectly corresponded with the motions of the valve, which was put into motion by the expirations and inspirations of the animal. In this manner I conceive respiration to be carried on in the tortoise, without, however, meaning to extend this explanation to the whole of the genus Testudo, some families of which I have never yet had an opportunity to examine. These animals will therefore materially differ from those of the two preceding families in the mode of respiring; the air in them being driven into the lungs by the muscles of the throat, which act like a pair of bellows, whilst in these it is performed by the lungs following the motions of their containing parts, and they will therefore differ from the animals having a thorax chiefly in the form and situation of the parts."

In 1819 Bojanus published an important work on the anatomy of Testudo Europææ, in which the inspiratory muscle and the posterior belly of the expiratory muscle are grouped as abdominal muscles. In his *Leçons d'Anatomie Comparée*, Cuvier asserts that inspiration is effected by the alternate contraction and dilatation of the throat, which are movements of deglutition. According to Dumeril and Bibron, air enters the buccal cavity through the nose, then the fleshy tongue is applied to the posterior nares so as to close them, and the mylohyoid floor of the mouth contracts to force the imprisoned air into the lungs.

As long ago as 1719 Malpighi and his contemporaries described the respiration of turtles as similar to that of frogs. Muller, Carpenter, T. Rymer Jones, Milne Edwards, Agassiz and others have, one after the other, reiterated this opinion.

From the paper under consideration we learn that—

"In the summer of 1861, Dr. Weir Mitchell, while engaged in studying the blood-pressure in the snapping turtle, Chelydra serpentina, became convinced that the prevailing views as to the respiratory mechanism of Chelonian reptiles were totally incorrect. Accordingly he partially studied the subject, and incidentally embodied his opinions in an essay upon the blood-pressure in the snapping turtle. At the time referred to, Dr. Mitchell was unacquainted with Townson's researches. The views of Dr. Mitchell, and the experiments by which he supported them, will be found scattered through the text of the present essay, of which, indeed, they form the basis. In the summer of 1862, the present authors took up anew the study of the respiration in turtles, and have endeavoured to render it as complete as possible. In so doing they have been fortunate enough to carry the subject far beyond the crude experiments of Townson, and to discover anatomical and physiological facts of the utmost interest and novelty, which have hitherto escaped attention."

Our limited space will not permit an extended account of the experiments and observations of Drs. Mitchell and Morehouse. While we refer our readers to the paper itself for many interesting details, we must content ourselves with furnishing in this place a résumé of the more important results arrived at.

The physiological portion of the essay treats of, 1st, the externally visible phenomena of respiration; 2d, the physiology of the muscles of respiration; and 3d, the physiology of the respiratory nerves.

The respiratory process is thus described:—

"Turtles breathe easily with the mouth open or shut. This fact alone deprives their respiration of all resemblance to that of Batrachians.

"The respiratory process is threefold, and consists of—

"1. Complete expiration.

"2. Complete and very full inspiration.

"3. An appearance of slight, or partial expiration, followed by a pause of greater or less duration.

"During the period which precedes this series of movements, the turtle being at rest, the spaces between the posterior members and the plastron and carapace are nearly level, or only a little concave. The shoulders are pushed forward somewhat, the lungs being full at this time, while the large hyoid apparatus is

usually dilated or drawn backwards and downwards. Sometimes it is in continual motion, like that of the frog when breathing, but in the turtle this rise and fall of the hyoid arches has no essential connection with that function. When, during the inter-respiratory pause, we open the jaws, the same movements of the hyoid apparatus may still be seen, nor is it easy at these times to assign to them any very obvious purpose. The glottis may be seen at rest, as a linear slit, in the centre of an ovoidal slightly elevated mound, just back of the tongue, on the floor of the mouth. The first respiratory act is one of expiration. Whether the mouth be opened for observation or not, the following movements occur: The hyoid apparatus descends and broadens laterally especially at its posterior part, carrying the glottis back and a little down. The object of this action we suppose to be, the separation of the glottis from contact with the roof of the mouth, in order that the air may the more readily enter it after passing through the nares. At the moment of beginning to expire the glottis opens wide, so as to form a rhombic figure. It remains thus until the whole respiratory act is completed. Meanwhile, during expiration the limbs fall in towards the shell quite passively, and the flank spaces in front of the posterior limbs sink so as to present deeply concave surfaces.

"A full inspiration instantly follows. The flank spaces become flat and tense, rising to a level. The glottis remains open. The hyoid arches advance, and at the close of the inspiration the shoulders are pushed passively forward.

"As soon as the lungs are completely filled, a very slight expiration relieves them of the surplus air, the flank spaces sinking a little, the hyoid arch at rest, the glottis closing at the end of the expiration. The final action here described appears to be due to the cessation of activity on the part of the inspiratory muscles and to the passive falling in of the limbs displaced during their contraction. The lungs are thus left full of air, and ready for the next act of respiration. Whenever a turtle in air breathes, these triple actions occur, but when under water it occasionally expires air, and does not rise to renew the supply until some time has passed by."

In the following extract will be found the explanation, given by our authors, of the function of the respiratory muscles of the turtle:—

"A large snapping turtle was secured on its back, and an incision made over the flank space, between the posterior limb and the plastron and carapace. The skin and superficial fascia were then carefully removed so as to expose the whole muscle which fills this space, and which has already been fully described.

"When inspiration took place, the muscle contracted, and as it is possessed of a central tendon from which radiate fibres in all directions, the result of their shortening was to convert its previous deeply concave surface into one which was nearly level, while at the same time the air rushed through the open glottis into the lung. The analogy between this muscle and the diaphragm of mammals was absolutely perfect. The central tendon, the converging muscular fibres, and the form of movement resulting from this beautiful arrangement, all united to suggest the resemblance. The inspiratory function of this muscle was palpably evident, nor could any other office be possibly assigned to it, because it was attached to no movable bone or other parts susceptible of motion.

"Repeated galvanization of this muscle served further to demonstrate its purpose. Finally, the muscles on both sides were removed, when all inspiratory power was lost. The turtle could empty its lungs, but possessed no power to fill them anew.

"The muscles engaged in expiration were next made the subject of study. At first we were led to believe, that the elastic contractility of the lungs might alone suffice to empty them, but this was opposed to all physiological analogy, and the power with which expiration occurred was too great to allow us to suppose that no muscular force intervened for its production.

"To examine this part of the subject, a turtle (snapper) was secured, as usual, and the plastron removed, with the exception of a rim at the back and on each side, to which remained attached the fibres of the inspiratory muscles. After a few minutes the turtle expired the air in the lung. During this action, the fascia covering the lungs below, and lying between the peritoneum and the plastron, was observed to become tense, owing to the contraction of the two

sheets of muscle, which terminate this tendon anteriorly and posteriorly, and find origin in the carapace.

"Recalling the full anatomical description already given, it will be remembered, that the lungs and abdominal viscera are covered outside of, and below the peritoneal sac, by a white membranous tendon, which extends across the middle line, and is firmly attached to the pericardium, as well as by firm areolar tissue to the central line of the plastron or lower shell. The muscular bellies arising from this covering tendon, fold over the lung in front and behind. Opposite to the inspiratory muscles are also areolar fibres, binding its tendon to the fascia of the expiratory muscle above it. When the four bellies of this muscle, or muscles contract, the lungs are acted upon directly, or by being compressed through the medium of the other viscera which are, so to speak, grasped during this powerful movement. At the same time, the passive inspiratory muscles are drawn up with the retreating lungs, owing to the pressure of the external air, and to the close union between the two sets of antagonistic muscles. Although the pericardium is also fastened to the expiratory tendon, this sac is so firmly bound to the plastron below it, that it does not appear to be disturbed during expiration, unless the connecting fibres are divided, in which case the heart sac and its contents are strongly drawn from the plastron, as the air is expired from the lung.

"As in the case of the inspiratory muscle, the expiratory muscle was also tested by observing its action when exposed in the living animal, and by galvanizing its fibres. The purpose of this singular sheet of muscle and connecting tendon admits then of no doubt. Aided by the elasticity of the lung, it empties that viscus of air, and no other muscle appears to lend it any aid.

"The third period of respiratory movement is marked by the closure of the glottis, and by the relaxation of the muscle of inspiration, the limbs then settling passively to their new positions. Hence the general appearance of a slight expiration at the end of the inspiratory act.

"It is impossible to review this account of the respiration in chelonians, without being struck with the simplicity of the plan. A box containing all the viscera of the chest and belly has an open space on each side, filled by a muscle of peculiar form, whose contraction increases the size of the visceral cavity, and thus causes air to rush into it. Within the breast-box, the lungs and visceral mass embraced by a single muscle, obey its contraction in effecting expiration, and as the visceral cavity thus becomes smaller, the inspiratory flank muscles curve in to fill the gap.

"After the most careful investigation, we can discover no other respiratory muscles within the breast-box.

"The muscular apparatus of the glottis is equally simple. There is a muscle to open it, and another muscle to close it. Here, as in the rest of this portion of our essay, we shall not commit ourselves by names, which, although they may recognize homologies, confuse the reader, who has sometimes to bear in mind that their functions may be exactly the reverse of those of the human muscle whose name they carry.

"The two glottic muscles have already been fully described; when both are cut away or paralyzed, by section of their nerves, the glottis still closes, owing to the elasticity of its cartilages, but it does not shut firmly, and if the lungs be previously filled with air, a large part always escapes. Under ordinary circumstances, the glottic lips are closely pressed together by the sphincter-like muscle which we have described and figured. The mass of its fibres lie below the opening muscle, and are parallel to the direction of the glottic lip, while its connections are principally at the anterior and posterior end of the glottic line. When contracted, as it always is more or less strongly during the interval between two respirations, it would tend to pucker the glottis somewhat, if it were not that the anterior and posterior insertion are firmly fixed, by the parts in front of and behind them respectively. Thus attached, the only influence it can exert, is to close the glottis whose lips stiffened by the arytenoid cartilages facilitate the process.

"The opening muscle lies outside of the closing muscle, nearly at right angles to it, and immediately under the mucous membrane of the glottic mound. At

the moment when expiration begins the respiratory act, this opening muscle contracts so as to draw the glottic lips wide open and permit the air to escape. Then follows a full inspiration, the glottis still open, and lastly it is closed by the constrictor muscle just after the great flank muscles of inspiration cease to act.

"The downward movement of the hyoid arches is effected by the omo-hyoid and other muscles of the neck. It appears to be intended to remove the glottis from contact with the roof of the mouth during the act of respiration. The upward motion of the hyoid apparatus is produced by a thin sheet of muscular fibres spread transversely across it and over the whole upper part of the neck.

"The function of all of the above muscles was determined by simple observation, by stimulating them directly, and by irritating their nerves."

With regard to the nerves employed in respiration the conclusions experimentally ascertained are, that the superior laryngeal nerves in turtles are the nerves of sensibility for the mucous membrane of the larynx and glottis; that they are the motor nerves of all the true glottic muscles, and enjoy thus the ability to open and to close this orifice; that the inferior laryngeal nerves are the motor nerves of the dilating muscles only, and have not sensibility or power to close the glottis; and that there exists a communication between the right and left superior laryngeal nerves, of the nature of a true chiasm, precisely like that of the optic nerves.

In concluding their paper, our authors bespeak attention for the following principal points as interesting novelties:—

"1st. In Chelonians the superior laryngeal nerve is distributed both to the opening and closing muscles of the glottis.

"2d. The inferior laryngeal nerve is distributed solely to the opening muscle of the glottis.

"3d. A true chiasm exists between the two superior laryngeal nerves.

"4th. The expiratory muscle lies within the breast-box, and consists of anterior and posterior bellies connected by a strong tendon continuous across the middle line, and common to both sides of the animal.

"5th. The inspiratory muscles occupy the flank spaces on either side.

"6th. Inspiration is effected by the contraction of the flank muscles, which in appearance strongly resemble the diaphragms of superior animals.

"7th. Expiration is effected by the consentaneous action of the four muscular bellies above described, which thus compress the viscera against the lungs. The act of respiration consists of an expiration and an inspiration, during which the glottis remains open.

"8th. The opening of the glottis is effected through the agency of the superior and inferior laryngeal nerves, both of which are distributed to the dilating muscle of the glottis. The superior laryngeal nerve presides over the closure of the glottis, being in part distributed to its sphincter muscle. The elastic contractility of the glottic cartilages aids in closing this orifice. After section of the superior laryngeal nerves, the glottis may still be opened by the agency of the inferior laryngeal nerves, its imperfect closure being then effected by means of the elasticity of its cartilaginous lips. The chiasm of the superior laryngeal nerves enables one of these nerves to open and shut the glottis after section or disease of the opposite nerve and of both inferior laryngeals.

"Physiologists have therefore been in error when describing the respiration of Chelonians as analogous to that of Batrachians, since it far more closely resembles the breathing of the higher vertebrates."

We cannot conclude this brief notice without expressing the earnest hope that investigations so interesting, and so auspiciously begun, will not be discontinued, but, on the contrary, prosecuted with vigour, until other and still more important results are obtained. J. A. M.