the tissues; that in pneumonia and in pleurisy the tissues lost their contractility, become lax, and thus resemble the known condition of the stomach, when it produces the sound. One fact, however, is certain, that the natural amount of air within the lungs is diminished when the abnormal sound presents itself beneath the clavicle in pleurisy, and over or around the inflamed portion of lung in pneumonia.

In conclusion, we would observe, that our main object in making the foregoing remarks has been to call more particular attention than has yet been generally bestowed upon it, to the fact, that an alteration of the normal percussion sound is observable in the subclavicular, and occasionally even in the mammary regions, in cases of pleurisy, where the fluid is present in such quantity as to compress the upper portions of the lung against the walls of the thorax. That the same character of altered percussion sound may be also observed, but much less frequently, in cases of pneumonia, over and around the parts inflamed. That in both cases, where the sound is produced, the pulmonary tissue contains less than its normal quantity of air; and that a correct knowledge of this sign cannot but be of considerable practical importance in the diagnosis of thoracic disease.

ARTICLE IV.—*On the Pathology of the Bronchio-Pulmonary Mucous Membrane.* By C. BLACK, M.D., Chesterfield, Bachelor of Medicine, and formerly Medical Scholar in Physiology and Comparative Anatomy in the University of London; Fellow of the Royal College of Surgeons of England, etc. etc.—(*Continued from page* 425.)

Specific Inflammation of the Bronchio-pulmonary Membrane.

THE specific inflammations, to which the above-named structure is liable, depend on the different poisons of scarlatina, rubeola, variola, erysipelas, continued fever, syphilis, and the morbific agents of gout and rheumatism. The general pathological conditions of the membrane, and consequently, the phenomena arising out of them, are so similar to those of the simple forms of inflammations, that it were unnecessary to review them in detail. It must, however, be observed of all, that they, like the simple forms of inflammation, assume the epithelial or the more severe variety of the disease—that the latter variety is sthenic or asthenic according to the particular type of the affection—and that it is also liable to assume a chronic character.

When specific inflammations of the bronchio-pulmonary membrane exist as the epithelial variety, they precede the development of the particular diseases of the nature of which they are significant, and they usually subside directly after such diseases have invaded

their accustomed locality. Thus, in many instances, at the very outset of rubeola, variola, scarlatina, erysipelas, and the cutaneous eruptions of syphilis, the pathological condition of the bronchio-pulmonary membrane is similar to that of the first stage of simple inflammation, for which it is very possible to mistake it, provided the concomitant symptoms and the history have not engaged the particular attention of the physician. But, at the time such diseases should appear on the surface of the body, the engorged condition of the bronchio-pulmonary membrane declines with the evolution of the cutaneous eruption; but it does not generally entirely subside for several days afterwards. This time is occupied by partial desquamation of the epithelium, and by a slightly increased development of mucus-corpuscles by those portions of it which have retained their vitality. Hence the constituents of the slightly increased sputa which now exist, consist of an undue proportion of epithelial patches and well developed mucus-cells.

The epithelial variety of arthritic and rheumatic inflammation of the bronchio-pulmonary membrane is always shifting in its character, and, contrary to the disposition of the other specific epithelial inflammations, it will recur again and again, but for a few hours only, during the course of the specific affections in their accustomed localities.

When the more severe form of inflammation of the bronchio-pulmonary membrane depends on the above morbific agents in the blood, the pathological condition of the membrane is similar, in every respect, to that which accompanies simple acute inflammation of that structure; but the products of the inflammation are occasionally modified by the particular poison or diathesis which influences the system at the time.

Thus the sputa discharged in variolous inflammation, invariably contain pus-cells during the period of the maturation of the pustules on the surface of the body; because, contemporaneously with the formation of the latter, pustules of a similar nature, but differing somewhat in structure, owing to the anatomical relation of the parts, are evolved in the basement structure of the bronchio-pulmonary membrane, and these, on bursting, yield their contents to the sputa, of which they form the chief constituent. Again, in erysipelatous, arthritic, and rheumatic inflammation of the membrane, I have frequently, although by no means in every case, found, in addition to the ordinary products of the more severe kind of simple inflammation, urate of ammonia; and more seldom, in the arthritic variety, the urates of soda and of lime. These salts I have as yet, when present, invariably observed as existing in a free state in the sputa, and likewise as a deposit in the mucus, but not in the exudation-cell. The reason of the immunity of the latter cell I have endeavoured to assign in my previous account of pulmonary cellulitis, to which the reader is, therefore, referred. In the sputa of rubeolous, scarlatenic, and syphilitic inflammation, as well as in that which accompanies

continued fever, I have observed no positive difference from the ordinary products of simple inflammation of the membrane. Nevertheless, in the sputa of syphilitic inflammation, I have, in addition to portions of the bronchial cartilages, which are seldom or never seen in other kinds of sputa, not unfrequently observed a peculiarity in some of the constituent cells, which may possibly hereafter prove to be a characteristic of syphilitic exudation, but which has not yet afforded me sufficient data to justify a positive declaration.

The indications of treatment, in the above specific inflammations of the bronchio-pulmonary membrane, are, in the epithelial variety,—

1. To solicit the eruption to the surface of the body, to relieve the engorged capillaries, and to subsequently excite and maintain their natural diameter by the means advised in the simple epithelial form of the disease.

2. To treat the specific disease in the general system, with a view of counteracting its injurious tendency, and of promoting its elimination from the blood, by remedies which experience has determined to be the most effectual.

In the more severe specific inflammations of the membrane, the indications are, in the main, similar to those of the simple severe inflammations, regard always being had to the second indication stated above.

How far are the different forms of Asthma dependent on Inflammation of the Bronchio-pulmonary Membrane?

Two distinct forms of asthma may be recognised—the one in which the paroxysm comes on suddenly, and is followed by an interval of perfect ease, during which there is neither the slightest difficulty of breathing, nor the least increase of the bronchio-pulmonary secretion; the other, in which the invasion of the paroxysm is more gradual, in which there is more or less straitened breathing during the interval, and in which the secretion of the membrane is somewhat greater than that of health, and is also changed, as to its physical appearance to the naked eye, as well as being microscopically and chemically different.

The history of the former kind of asthma shows it to be frequently connected with previously disordered general health, by which the nervous system is rendered morbidly sensitive, or with some local disease apart from the lungs, upon which this form of asthma supervenes. The morbid appearances are unconnected with the least trace of organic change in the bronchio-pulmonary membrane itself—the epithelium, basement structure, and areolar fibres, vessels and nerves being, so far as the microscope can determine, perfectly normal; but they (the morbid appearances) may show tumour of the vagus nerve, inter-thoracic tumour, diseased heart, or organic affection of one or other of the abdominal organs. Other cases again, falling under this category, show no organic change of any organ whatever. Such cases are invariably associated with a highly

sensitive or hysterical condition of the system, and frequently with a morbid sensibility of the bronchio-pulmonary membrane to particular odours. It is hence evident, that there is a form of asthma, to which inflammation of the above membrane bears no pathological relation; and to this form, viewed in the light of the mode in which the attack is produced, the term "Nervous Asthma" is appropriate; but regarded in relation to its pathological cause, that of "Symptomatic Asthma" is the more applicable.

With this form I have nothing further to do.

There is, however, another form of the disease, which embraces by far the majority of cases, and which includes all the varieties of the true spasmodic asthma of authors.

In tracing the history of the occurrence and full establishment of such cases, it will invariably be found, that the spasmodic seizure is preceded by several marked attacks of inflammation of the bronchio-pulmonary membrane—that this inflammation is never entirely eradicated—that, even when the more marked symptoms of disease are absent, the breathing is not so free as in perfect health—that it is rendered more difficult by even moderate exercise—that there are more or less of cough and increased expectoration; and that the physical signs of the chest are indicative of a partial spasm of some of the bronchial tubes in one or both lungs, generally the latter. If, at this time, the sputum be microscopically examined, it is found to consist of the same structures as that of chronic bronchitis—namely, of exudation, mucus and pus-cells, basement patches, a few epithelial patches, bronchial casts, and portions of undeveloped exudation-plasma, together with an amorphous sediment of the sulphate and phosphate of lime. The condition, therefore, of the bronchio-pulmonary membrane, at this period, is one of chronic inflammation, which, left, as it were, to itself, as it frequently is, owing to the comparative mildness of the symptoms, is gradually progressive, as I have already shown when treating of chronic bronchitis. The existence of chronic inflammation of the membrane is not only thus demonstrated by the microscopy of the sputum, but also by the morbid appearances of that structure itself. Thus, on inspection, it is found to present rose-coloured patches throughout the bronchi, chiefly of the middle and lower lobes, which patches are owing to epithelial ulceration, as is shown by careful dissection of the part, and by subsequent microscopical examination. The same means of examination also demonstrates the existence of basement ulceration, together with a general thickening of the basement membrane throughout the affected bronchi and the cells to which they lead. This structure, instead of measuring $\frac{1}{18,000}$th of an inch in the affected bronchi, will not unfrequently be found of the diameter varying from $\frac{1}{8000}$th to $\frac{1}{12,000}$th of an inch; whilst that of the cells to which the morbid action has extended, varies from $\frac{1}{14,000}$th to $\frac{1}{16,000}$th of an inch. Besides these positive evidences of inflammatory disease in the membrane, we also find, that the fibres of

which that structure is in part composed, are hypertrophied, and that, in every case which manifested a distinctly spasmodic seizure before death, the fibres known as the bronchial muscles, have undergone a manifest increase in their diameter, and are as yet distinct in their outline. The coats of the capillary blood-vessels are likewise observed to be more or less thickened; and, in several cases, I have succeeded in tracing a degree of hypertrophy of the sentient nerves of the membrane.

Such, then, is the history of the gradual occurrence of nearly every case of true spasmodic asthma, and such are the morbid appearances of the bronchio-pulmonary membrane, and of the other bronchial tissues, with which spasmodic asthma is invariably associated, and on which it assuredly depends as its primary pathological cause. If the history of asthma is still further traced, we reach a period, at which distinct paroxysms of dyspnœa have ceased to occur. The respiratory function is now always performed within narrowed limits, which neither admit of that sudden extension, nor yet of that violent contraction which attends and characterises the remissions and invasions of spasm in the earlier stages of the disease. Still the respiration is somewhat improved under conditions which are known to be of benefit during those stages; whilst it is rendered more difficult by conditions of an opposite tendency. But the degree of respiration having been brought, as a permanent condition, below the standard of health, the bulk of the body has fallen in a corresponding ratio, and it now gives expression to the general system in a thin, cadaverous, and attenuated appearance, which attends the patient throughout the remainder of his life. Years elapse, after the full establishment of the spasmodic seizures, before the above permanently restricted limitation of the breathing supplants, as it were, intermittent paroxysms of dyspnœa, followed by ease and comparative freedom from disease; but the exact period required for such an occurrence cannot be correctly stated, inasmuch as it depends, to a very considerable extent, on the peculiarities of every individual case. It is, however, sufficient for my purpose to indicate that such an occurrence does sooner or later take place, and that, in addition to the reduction in the bulk of the body before noticed, it is accompanied by certain conditions of the sputum and of the bronchio-pulmonary membrane and other bronchial structures, to be next examined.

The sputum, to the naked eye, still presents most of the physical appearances which characterise that of an earlier chronic bronchitis; but it is not unfrequently of a more uniform consistence, less clotted in its appearance, and of a somewhat more muco-puriform colour. On close inspection, it is seen to contain the same yellowish-white, semi-flocculent, isolated portions, which, according to Lænnec, characterise chronic inflammation of the bronchio-pulmonary membrane, and which consist of exudation-plasma in different degrees of cell-growth.

This variety of sputum is seen, by the microscope, to consist of fully-formed mucus and pus-cells, the latter of which are proportionately more numerous than those of the sputa of the earlier stages of chronic bronchitis, and of exudation-cells, intermixed with a very few of the plastic kind, owing to the rapid conversion of the latter into pus-cells, after they have ceased to be living structures. Besides these, there are a few superficial basement patches, a few minute, opaque nodules of fibrine, and transparent, irregular layers of exudation-plasma, which seem to take the place of the large opaque masses of the same substance so common in the sputa of acute, and also of the earlier stages of chronic, bronchitis. But very few bronchial casts, and, as a general rule, quite as few epithelial patches, are observed in this kind of sputum.

On tracing the morbid appearances at this stage, the bronchio-pulmonary membrane is less turgid, and therefore of a less vivid colour than at the stage previously noticed. Often, indeed, the coloration is not deeper than that of health; but it is never uniform; because epithelial and basement ulceration is always present; and, at these points, the colour is more vivid than in those parts of the membrane which are yet protected by epithelium. The fibres of the membrane, together with the capillary vessels, lymphatics, and nerves, are so matted together, as to render their distinct definition a matter of some difficulty; whilst the circular and longitudinal fibres of the bronchi are hypertrophied and so amalgamated by inter-fibrous exudation, that their power of contracting is, in a great measure, abolished. Very frequently, indeed, the submucous tissue, the circular and longitudinal fibres of the bronchi are incorporated in one mass of organized exudation, in which also the outer surface of the capillary blood-vessels is imbedded—a condition which, in some measure, limits the degree of congestion to which such vessels are henceforth liable, and which can now only allow exudation to take place from that surface of them which is in direct contact with the basement membrane. This matting together of individual tissues increases the density of the bronchial walls, the rigidity of which is further increased, in the larger bronchi, by an increased thickness and hardness of the circular, and in the smaller tubes, by the same condition of the irregular, cartilages, as an invariable concomitant of such an amount of structural disease of the other bronchial tissues as has just been indicated. In addition to these results, we find more or less of bronchial occlusion, lobular collapse, and vesicular emphysema, often of the flaccid kind.

Thus, then, the characteristics of the sputa during life, and the pathological appearances after death, in every case of true spasmodic asthma, except those of the purely nervous or symptomatic kind, clearly demonstrate the existence of chronic inflammation of the bronchio-pulmonary membrane; and as this condition is recognised as invariably preceding, for a length of time, the development of the spasmodic seizure, it is evidently the pathological cause of the latter

—a fact, which will be further illustrated by considering the proximate cause of the attack, and the conditions under which the paroxysm is excited. To properly illustrate this point, it will be necessary to revert to the bronchial muscular fibre before named, and to show, by experiment, the properties with which it, as constituting a part of the healthy organism, is endowed, and from which a logical deduction is derived of its great influence in the production of the asthmatic paroxysm. These fibres, like the muscular fibres of the intestines, of the arteries, of the organic fibres of the heart, of the elongated tubular uteri of the inferior mammalian animals, of the crop of Hymenopterous, Lepidopterous, and Dipterous insects, and of similar structures in other classes of animals, are endowed with the power of contractility, which is excited by certain stimuli placed in direct contact with them, and, according to Volkmann, by galvanism applied to the vagus nerve of a decapitated animal. To ascertain how far the statements of Williams and Volkmann on this point could be substantiated by direct investigation, I repeated their inquiries in the following experiments :—

Experiment 1.—A young, healthy rabbit, six months old, was decapitated, the right vagus nerve was isolated, and the large end of a blow-pipe was introduced into the trachea, and there secured by ligature. The free extremity of this instrument was next directed towards the flame of a taper, and the poles of a two-celled electro-galvanic battery were brought into contact with the isolated nerve. Not the slightest movement in the flame was noticed. The sympathetic nerve was next isolated, and its course followed to the root of the neck; but, wishing to perform this experiment under precisely the same conditions as the previous one upon the vagus, the chest was not now opened. Having, by tracing its cervical route and connections, fully satisfied myself that I had isolated the sympathetic, the poles of the battery were applied to the communicating branch between the second and third ganglia, but no influence on the flame of the taper resulted from the application of the galvanic stimulus. A repetition of the same experiments on the left vagus and sympathetic, gave the same negative result.

The chest was now opened, the lungs were removed, and the poles of the battery applied to the large divisions of the bronchi, when the flame of the taper was, on several intermittent applications of the stimulus, thought to bear from the open extremity of the tracheal tube; but the inclination was certainly so slight, that I would not affirm it as an undoubted fact. Thus far, then, the contractility of the bronchial tubes, by direct stimulation of their muscular fibre, or by indirect stimulation through their nerves, was by no means proved.

Experiment 2.—A large, healthy, and strong dog, of the spaniel breed, was destroyed by hydrocyanic acid, immediately after which the right vagus nerve was isolated, the trachea divided, and a glass tube, tapering to a point at one extremity, was inserted in the latter,

and there secured by ligature. A lighted taper was now held, at a distance of a few lines only, from the open extremity of the tube; whilst the poles of a six-celled electro-galvanic battery, in powerful action, were applied to the isolated nerve; but no palpable movement of the flame was observed.

The sympathetic nerve was next isolated and submitted to the poles of the battery with the same result. During the application of galvanism to this nerve, rapid and snake-like movements of the œsophagus took place.

The chest was next opened; and as the lungs lay in situ, one pole of the battery was placed on the surface of the right lung, and the other at the lower part of the back of the trachea, between the extremities of the annular cartilages. The result of this was the same as that of the previous experiments. The open extremity of the tube was next directed beneath the surface of water in a vessel, and a pole of the battery was simultaneously applied to each of the lungs; but neither did the water move, in the slightest degree, within the tube, nor did the least bubble of air escape from its open extremity. The same negative result followed the application of the poles to the large bronchi before they enter the lungs. The latter organs were now removed from the thoracic cavity, and placed in a tepid solution of salt in water, after which a taper was held directly opposite to the free extremity of the tube, whilst the poles of the battery were applied to all parts of the lungs, to the large bronchi, and to the back of the trachea itself; but still the flame of the taper was not blown aside in anything like a satisfactory manner. Different portions of the lungs were next incised, and the poles of the battery were so placed, that a bronchus was included in the galvanic circuit. This experiment produced no palpable contraction of the larger bronchi; but in tubes from the third gradation in size downwards, evident contraction took place. In bronchi, from one to two lines in diameter, the contraction, as observed by the aid of a simple lens, was so great as to obliterate, for the time, their caliber, and thus to confirm the statement of Wedeymer on this point.

Experiment 3.—A large, full-grown rabbit was decapitated, after which the same proceedings as in the first experiment were adopted; but here, instead of a two-celled, a six-celled electro-galvanic battery was employed; and the taper, instead of being exposed as in the first experiment, was placed in a lantern, in order that slight currents of air might be shut out, and thus be prevented from vitiating the result. The flame was not, in the slightest degree, visibly affected on galvanizing the vagus or sympathetic nerve.

The lungs were now carefully removed, together with the trachea attached, and as they thus lay exposed, a pole of the battery was simultaneously applied to the lower lobe of each lung, and was gradually moved upwards towards the trachea; whilst the open extremity of the tracheal tube was directed beneath the surface of water at perfect rest in a shallow vessel. At intervals of about half a

minute, a single bubble of air escaped through the water from the open extremity of the tube; thus proving, beyond all doubt, the contractility of the bronchio-pulmonary fibre. When one pole of the battery was placed on the lower lobe of the lung, and thence gradually passed upwards, whilst the other pole was applied, for some short time together, to the fibrous coat, between the annular cartilages, at the very lowest point of the back-part of the trachea, the escape of single bubbles of air through the water took place at shorter intervals. In from five to ten minutes, the almost-continued application of the galvanic stimulus seemed to exhaust, for the time being, the contractility of the bronchio-pulmonary fibre, as was evidenced by the cessation of this intermittent escape of air from the tracheal tube; but after gentle artificial inflation of the lung, and after allowing these organs to collapse to the full extent of which they were capable under the pressure of the atmosphere alone, they were shown to have regained, at least to a certain extent, their power of contractility, as was manifested by the re-escape of isolated bubbles of air on the application of the poles of the battery to the tissue of the lungs, to the bronchi, and to the lowest point of the trachea. On incising the lungs, and directing the galvanic current through the smallest bronchi, these tubes were observed, by the aid of a lens, to gradually contract in this as in the previous experiment.

Experiment 4.—A full-grown rabbit was killed by a blow at the back of the head, its right vagus was isolated, the trachea divided, and a tube inserted in the latter as in the previous experiments. The open extremity of the tube was directed beneath the surface of water at rest (a mode of testing much more delicate, in my opinion, than that of the application of a taper to the open extremity of the tracheal tube), and the vagus, and subsequently the sympathetic nerve were galvanized, without the least manifestation of the escape of air from the lungs. These organs were next removed, a large bronchus was slit open, and a portion of its mucous lining was carefully dissected away. This was immersed, for a few minutes, in distilled water, at a temperature of 94° F., for the purpose of decolorising it, after which it was spread out, on a glass slide, with its lower surface uppermost, and on this surface a drop of warm distilled water was placed.

The microscope being adjusted, the poles of a one-celled electro-galvanic battery were brought into contact with the structure under observation, the fibres of which were seen to contract, and to agitate the fluid on its surface.

The result of these experiments shows that the muscular fibre of the bronchi, as also the fibrous tissue of the mucous lining, is endowed with the power of contractility—that this property is excited by stimuli directly applied to it—that it is highly questionable whether such property can be called into action by stimulation of the trunks of the bronchio-pulmonary nerves—that the mode of contrac-

tion is similar to that of the non-striated muscular fibre, commencing at the point of stimulation, and gradually propagating itself to neighbouring fibres—that the expulsion of air from the minute bronchi is, by virtue of their structure, more rapid than from the larger bronchi —that, in the latter tubes, the presence of their cartilages, the consequently limited action of their muscular fibres, and the greatly increased area of such tubes passively retard, rather than actively augment, the speed of the outward column of air set in motion by contraction of the smaller bronchi—that this negative opposition of forces is further increased in the trachea—and that, therefore, the expulsion of air from the lungs can never, under the above circumstances (*i.e.*, unaided by contraction of the expiratory muscles), take place in a forcible manner; but must, on the contrary, be a slow, continued, or intermittent oozing of air, according to the continued or intermittent action of the cause of the contraction of the bronchial and other fibres. On these grounds, I have no hesitation in stating my conviction, that some source of fallacy attended the experiment of Volkmann, which led him to assert that the galvanic stimulus, applied to the vagus nerve, produced such a sudden and forcible expulsion of air from the bronchi, that the flame of a taper was thereby extinguished.

The experiments above detailed rather lead me to the opinion, that we might in vain look through the whole range of the animal kingdom for such a result. Although my experiments tend to negative the opinion, that contraction of the bronchial fibres may be produced by galvanism applied to the vagus nerve; yet I had, during their conduction, sufficient proof that such an occurrence is readily produced by the direct application of the galvanic stimulus to the mucous lining of the tubes themselves.

Now, in order to arrive at a correct knowledge of the pathological cause of asthma, it was necessary to determine the capability of the bronchial fibre to diminish the caliber of the tubes; and having done this by direct experiment, as above stated, we have only to conceive this capability or power of contraction to be called into action, in an inordinate degree, to understand the proximate cause of the asthmatic paroxysm. I say, "in an inordinate degree," because I regard these fibres as taking part in the ordinary movements of respiration. It is evident, that the volume of the lungs, at the extreme point of inspiration, is considerably greater than at the extreme point of expiration; that this increase of volume is due to the distension of the pulmonary tissue with air; that this distension must have, as a necessary condition, a stretching or elongation of the pulmonary tissue; that, from the mode of termination of the minute bronchi, the distension of the pulmonary cells to which they lead must act upon the longitudinal fibres of these tubes; and that, from the arrangement of other pulmonary cells along the sides of such tubes, their distension must, in like manner, act upon the circular fibres. The minute bronchi, then, and consequently the muscular fibres

which they contain, undergo, during the inspiratory movement, a longitudinal and a lateral expansion, by which their power of contractility is excited, which, coming into play during the expiratory movement, enables them to regain the exact caliber which they had at the very commencement of the inspiratory act.

If, in opposition to this statement, it is urged, that the regaining of the normal caliber of the bronchi, after their expansion during the inspiratory act, is due to the property of elasticity with which their longitudinal fibres are said to be endowed, such an objection seems to be negatived by the following facts:—

1. That simply elastic bodies, by constant use, ultimately become permanently more or less lengthened; whereas the bronchial tubes of healthy lungs are neither widened nor lengthened by the incessant use of even four score years.

2. That, microscopically considered, there is no greater difference between the longitudinal and circular fibres than between the yellow and white fibrous tissues.

3. That the galvanic and other stimuli directly applied, prove that they both possess the power of contractility.

4. That striated and non-striated muscular fibres are capable of being elongated, as is proved by suspending a weight from a piece of voluntary muscle immediately after death, by the inordinate distension of the stomach by food, and of the bowels by a collection of flatus.

In reply to the first objection here stated, it may be remarked, that the molecular change, which is continually in operation in the bronchial fibres, as in all other living structures, prevents them from becoming old, in the common acceptation of that term, and therefore preserves intact their properties, and consequently their property of elasticity, simply considered as such, during the period of their ordinary functions in the organism. Such a statement is indeed true, in reference generally to the simply elastic structures; but, with respect to the bronchial fibres, it is somewhat otherwise; because, in advanced life, the number of respirations bears a greater ratio to the pulse than at an earlier date; consequently the nutrition of these fibres, which involves the idea of the molecular change above stated, is below the active ratio of the respiration; therefore such fibres do really become old, and in this condition they ought, if endowed only with the property of elasticity, to exhibit, in old lungs, the permanent elongation which constant use produces in all simply elastic bodies; but such is not the case. Hence the objection does not hold good; and as there are direct proofs of similarity of structure between the longitudinal and circular fibres of the bronchi, as these tubes have been shown to possess an inherent contractile power, and as both striated and non-striated muscle admits of elongation, we are, I conceive, justified in concluding, that whatever capability of expansion and power of contraction are manifested by the minute bronchi, are alike the conjoint properties of both the

circular and longitudinal fibres. To separate these properties in this particular instance; to assign, as some authors have done, the property of elasticity to the longitudinal fibres, and the power of contractility to the circular fibres, is opposed to the microscopic anatomy of such fibres, to their arrangement, and to all hitherto ascertained facts, relative to the physiology of organic muscle.

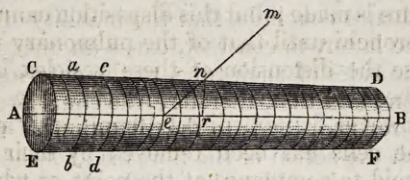
The similarity of structure and of function in these fibres, and their expansion during the inspiratory act, having been proved, it follows that the latter condition,—*i. e.*, their expansion by inspiration—becomes the exciting cause of their contraction during expiration, and that this contraction is a regular and an important auxiliary to the muscles of expiration. The cause of this contraction being the mechanical pressure of the air at the extreme point of inspiration, it is evident that the disposition to contraction exists at every point on which the pressure is made; but this disposition cannot be manifested by the minute bronchi until that of the pulmonary vesicles has been exerted; because the distension of these vesicles, in the inspiratory act, keeps in check the contractile power of the minute bronchi, which power, however, is immediately manifested after the restraining force of the cells has been removed by their contraction, and which may be said to commence at the point at which the contraction of the cells ceases, thus forming with the latter one continuous action during the expiratory movement. In the special anatomy and physiology of the bronchial tubes we thus find a wise adaptation of means to an end; inasmuch as the structure of the tubes is favourable to a considerable amount of contraction where such an effort is necessary; and to a very slight diminution of caliber where such a condition is required. Thus, in the very commencement of expiration, the expiratory muscles can exert but little influence in expelling the air from the pulmonary cells and minute bronchi, therefore considerable contractile power is required of these parts themselves; and we see, from their anatomy, that they are peculiarly adapted to such a purpose. On the contrary, as the expiratory muscles increase their force in the inverse ratio of their shortening during contraction, a less amount of contractile power is required of the bronchial tubes, which, consequently, become less and less mobile, and more and more patent, as we progress from the smallest bronchi to the trachea; in which latter, as also in its divisions, but little contractility is necessary, and to which, therefore, the means of contracting are much more sparingly dealt than to the minute bronchi, of which so much action during expiration is required.

We may thus give expression to the expiratory forces by the following formula:—

During the commencement of Expiration, . .	Vesicular and Bronchial Contraction, maximum. Muscular Contraction, minimum.
At the end of Expiration,	Bronchial Contraction, minimum. Muscular Contraction, maximum.

By the contraction of the pulmonary vesicles and minute bronchi, during each expiratory movement, the outward tendency of the natural secretion of the bronchio-pulmonary membrane is secured; but when this means fails to remove any unusually viscid secretion or other fluid, the co-operation of the sudden contraction of the expiratory muscles is excited; and, in this way, the cause of the obstruction is removed by cough, and the patency of the bronchi thereby maintained. The following diagram will illustrate the direction of the resultant of the component forces of the longitudinal and circular fibres of the minute bronchi, and of the important part which they play in the respiratory movement:—

Fig. 20.



Let A B represent the axis of a portion of the bronchial tube; C D, E F, two of its longitudinal fibres, directly opposite to each other, so that a plane passing through them would likewise pass through the axis A B; and let *a b*, *c d*, be circular fibres, and *n r* a radius of one of the circles. Now, if we suppose the expansive and contractile forces of the circular fibres to be in operation, it is evident that the circumferences of these circles, and likewise their radii, increase and decrease respectively. It is also evident, that if the forces of the circular fibres alone are in operation, motion of any point *n* takes place in the direction of the radius *n r*, because *n* is the extremity of that radius, which increases or decreases during the act of expansion or contraction. But we have likewise the expansive and contractile forces of the longitudinal fibres in operation, which tend to move the point *n* in the direction C D. Hence, by the principle of the parallelogram of forces, motion of that point takes place in the direction of a straight line, *m n e*, lying in the plane C D E F, and passing obliquely through the centre of the tube, with an angle, *m e r*, greater or less, according as the ratio of the expansive and contractile forces of the circular fibres to those of the longitudinal is greater or less.

From the above representation it is evident, that the expansion and contraction of the minute bronchi are in the diagonal of a parallelogram described on one of the longitudinal fibres, the sides of which parallelogram represent the two forces of the longitudinal and circular fibres; and we have only to conceive the maintenance of the contraction of these fibres at any and all points of their range of

action, to understand the proximate cause and the different degrees of the asthmatic paroxysm. The attack is, therefore, one of tonic spasm; and in proportion to the degree of contraction of the above fibres, so will be the urgency of the symptoms. When this power of contraction is destroyed by the confused amalgamation of the longitudinal and circular fibres by repeated exudations, the asthmatic paroxysm ceases to recur, as is almost invariably the case after the existence of the disease for a number of years; but the breathing is, nevertheless, laboured during the remainder of life, and liable to considerable aggravation on the slightest increase of the vascular condition of the bronchio-pulmonary membrane. As, in the progress of the disease to complete amalgamation of both the longitudinal and circular fibres of the affected bronchi, the fibres of one portion of a tube may be thus far advanced, whilst those of another part are as yet free, we thence conclude, that the inability of the former, and the ability of the latter, to contract, cause an unequal resistance to be offered, by the sides of such tube, to the entering column of air, during inspiration; and that, therefore, the equal pressure of the air, being unequally resisted, tends to the dilatation of those portions of the tube in which the action of the fibres is abolished.

Hence occurs saccular dilatation of the bronchi at the isolated points where the fibres of these tubes are imbedded in one mass of organised exudation; or general dilatation when the whole extent of their fibrous tissue is involved; and more particularly so, when with the above mentioned condition, the complete or partial obliteration of other bronchi causes more air to be forced into such tubes than they are accustomed to receive in the healthy action of the lungs. It is certain that, with an unequal pathological condition of a bronchus, there is a corresponding inequality of function, and hence the existence of the passiveness of one part with the active condition of another portion of the same tube. Hence also, as a dependent corollary, the transition from tubular to cavernous breathing, and from bronchophony to pectoriloquy, in the paralysed portion of the tube; whilst those parts of it, in which the fibrous tissue is yet free to act, produce various modifications of the sibilant and sonorous rhonchi, according to the degree of constriction which exists. This constriction is always more or less present even during the interval of the asthmatic paroxysm; because its seat corresponds with either epithelial or basement ulceration of the bronchial membrane, and with free, yet hypertrophied, bronchial fibre, which latter, prone to action, is directly excited by the entering column of air during each inspiratory movement. The breathing, therefore, owing to irregular and partial constriction of the bronchi, is wheezing even in the absence of an asthmatic paroxysm.

Now, the paroxysm has been shown to occur when the muscular fibres of the bronchi are free, and, therefore, able to contract; and to cease to recur when these fibres have been so amalgamated by inflammatory exudation, that they are no longer able to exercise an

individual contraction. The question then to be determined, is not the proximate cause of the paroxysm, which is proved to be an irregular contraction of the bronchial fibres; but rather, on what pathological condition does it depend, and in what way, or through what media, does the exciting cause operate. Does the contraction of these fibres depend on any influence of the nerves with which the bronchi are supplied? The experiments before detailed, fail to prove that the nerves exert the slightest influence over them; therefore, on this evidence, the direct cause of their contraction cannot exist at a remote part of the system. It must, then, have a local origin; and this statement is quite in harmony with the previously described result of the direct application of the galvanic stimulus to the bronchial fibre. Now, the local disease which precedes, accompanies, and, I may say, even outlives the recurrence of the asthmatic paroxysm, is that of chronic inflammation of the bronchio-pulmonary membrane; and as asthma is never truly established independently of bronchitis or of its results upon the bronchial tissues, we are justified in concluding, that its necessary pathological condition is, inflammation and its consequences of the bronchio-pulmonary membrane. This being admitted, the exciting cause resolves itself into any agent which is capable of irritating the bronchial fibres to contraction by direct application, or by inordinately increasing the vascular condition of the bronchial membrane. Hence a sudden reduction in the temperature of the atmosphere, and particularly so when combined with considerable humidity—the inhalation of air impregnated with irritating vapours or loaded with dust, together with the accumulation of mucus, are capable of exciting the spasmodic action of the above fibres, the contraction of which commences at those points of the bronchi, in which epithelial or basement ulceration of the membrane exists; inasmuch as these are the most sensitive parts, from which the contraction propagates itself, after the manner of that of organic muscular fibre, to the adjoining fibres, until the whole is more or less implicated. The paroxysm thus commencing, indicates its approach by minor degrees of the particular sensation to which the full development of the fit gives rise; but the duration of the premonitory symptoms depends, in a great measure, on the intensity of the exciting cause, and on the number of foci or points of epithelial or basement ulceration, from which the contraction simultaneously propagates itself. Clinical experience demonstrates the truth of this observation, and that the attack in such instances, depends on the direct action of one of the above mentioned causes. But many attacks commence during sleep, when none of the above causes are in operation; and, in such cases, the bronchial fibre is evidently excited to contraction by the vascular congestion of the bronchio-pulmonary membrane, the enlarged vessels of which exert unusual pressure on the bronchial fibres, the contraction of which may be further excited by the accumulation of mucus in the bronchi, and possibly, by the slight retention of carbonic acid

in the blood, as the result of the languid circulation and diminished respiratory movement produced by sleep. This congestion, however, may, and frequently does, take place during the waking state, when it never fails to excite more or less spasmodic action of the tubes in those in whom a confirmed paroxysm has once occurred.

From the views above detailed, it will be seen, that the pathological cause of true spasmodic asthma is inflammation and its consequences of the bronchio-pulmonary membrane, and other bronchial tissues—that the proximate cause of the attack is inordinate contraction of the bronchial fibres, which are hypertrophied—that the exciting cause must operate directly on these fibres, the mode of contraction of which is similar to that of organic muscle—that the contraction commences in the bronchial fibres, at the points of epithelial and basement ulceration of the membrane; or, when vascular congestion is the exciting cause, wherever the engorged blood-vessels produce unusual pressure upon such fibres—that such contraction cannot, in all probability, be excited by direct influence of the bronchial nerves—and that consequently, impressions, transmitted through these nerves, operate indirectly upon the bronchial fibre through the medium of the capillary blood-vessels, which are themselves influenced in either a primary or secondary manner. Hence the influence of a disordered stomach, which is so frequent a cause, and an accompaniment, of the spasmodic paroxysm, and which, in exciting it, is thought to do so by reflex action through the motor fibres of the vagus nerve; but which does not appear thus to manifest itself. On the contrary, the paroxysm, in such cases, is rather due to the upward pressure of the stomach when distended by flatus, which mechanically irritates the bronchial fibres directly, and also indirectly, by the vascular congestion of the bronchio-pulmonary membrane thereby occasioned; or the impression is conveyed from the stomach, either through the sensitive portions of the par vagum to the medulla oblongata, and thence through its motor fibres, which communicate with the sympathetic nerve, by which latter the influence is transmitted to the bronchial capillaries; or it reaches the latter destination directly through the route of the solar plexus, and its upward connection with those sympathetie fibres which are distributed to the bronchial capillaries.

The pathological cause, then, of true spasmodic asthma, being inflammation of the bronchio-pulmonary membrane, the indications of treatment, with a view of effecting a permanent benefit, are clearly those of chronic bronchitis; whilst the indications, during the paroxysm, have for their object,—

1. To relieve spasm of the bronchial fibres.

2. To withdraw the exciting cause, and to correct any condition of the system which may indirectly contribute to an attack.

The spasm is relieved by the exhibition of ether, opium and its different preparations; by lobelia inflata, camphor, conium, henbane; by extensive counter-irritation to the chest, and by the cautious in-

halation of chloroform when no cardiac disease exists. Benefit is likewise derived from the use of assafœtida and turpentine enemata; and, during the intervals of the paroxysm, from the exhibition of belladonna and stramonium, in conjunction with the remedies already indicated in the treatment of chronic bronchitis.

In withdrawing the exciting cause, regard must be had to its particular nature. If it depends on any irritating qualities of the air breathed, these must, as far as is practicable, be obviated, by removal to the more congenial air of another apartment. If, on suddenly increased vascular engorgement of the bronchio-pulmonary capillaries, derivation to the skin should be energetically solicited by counter irritation to the chest, the warm stimulating pediluvium, by warmth to the general surface, in the form of the warm water or vapour bath, and by the internal administration of the acetate of ammonia, camphor julep, coffee, and the different carminatives, followed immediately by a brisk purgative. If, on the accumulation of mucus in the bronchi, or the presence of indigested food in the stomach, an emetic of antimony, ipecacuanha, or the sulphate of zinc, must be exhibited, according to the particular features of the case,—antimony being the preferable where the patient manifests a moderate degree of constitutional vigour, and ipecacuanha or the sulphate of zinc in cases attended by marked debility.

To correct any condition of the system, which may indirectly contribute to an attack, it will be necessary to inquire into the state of the general functions, and particularly those of the digestive organs, and to treat any deflection from the standard of health according to the recognised principles established by experience.

(*End of Part First.*)

ARTICLE V.—*Reports and Observations in Surgical Practice.* By E. R. BICKERSTETH, Esq., Surgeon, Liverpool.

LARGE SUBCUTANEOUS NŒVUS IN PROCESS OF UNDERGOING A PECULIAR TRANSFORMATION.

M. E. C., a healthy little girl, æt. 18 months, was brought to me in the beginning of April last, with a tumour on the back and upper part of the left shoulder, which presented peculiar characters. It was of flattened oval form, about the size of a small fist, and had upon its summit a red mark as large as a shilling piece, possessing the ordinary appearance of a simple cutaneous nœvus. The tumour beneath was firm, minutely lobulated, and felt very like a fatty