whose existence we infer from alteration in the pitch of the percussion-note, from the presence of the tympanitic sound, from variation in the pitch of the sound on opening or closing the mouth, from the bruit de pot fêlé and the amphoric resonance. The increased sense of resistance, by which dense organs may at once be detected on percussion, is perceptible to but a very slight degree in the phonometric method.—I consider phonometry badly adapted for the examination of the abdomen, except, perhaps, in the delimitation of the liver and spleen. There is almost no difference between the phonometric sound of the thorax and that of the abdomen, though the percussion-notes of these parts are so exceedingly unlike and characteristic; while even the most pronounced pathological changes in the abdomen,—very abundant ascites, for instance,—announce themselves very much less distinctly by phonometry than by percussion. Finally, a phonometric examination of the whole thorax, as may be inferred from the description of it already given, cannot be made in a shorter time than a period at least three times as long as that required for examination by percussion. For all these reasons phonometry,—however interesting it may be scientifically, and however certain it may be that in the hands of those skilled in its use it may suffice for the recognition of very fine shades of difference in resonance,—has hitherto found little favour with practical physicians as a means of physical diagnosis.

AUSCULTATION OF THE LUNGS.

Historical Note.

The knowledge of at least some of the phenomena of auscultation, more particularly of the sign known as *Hippocratic succussion*,* observed in pyo-pneumothorax, dates from the time of Hippocrates. That Hippocrates was also acquainted with the friction†-sound of pleurisy and many of the catarrhal sounds seems equally unquestionable, not merely from the description of these given in his works, but also from his account of the diseases in which they were heard.

His observations, however, seem soon to have been entirely forgotten, as there are only a few scattered and obscure references to auscultation, but no precise enumeration of signs, in the works of certain of the ancient writers who came after him.

The real discoverer of auscultation, and of almost all its phenomena in the domain of the respiratory and circulatory organs, is *Lænnec* (born 1781, died 1826). The discovery was made in the year 1816, the first stethoscope which Lænnec used, to enable him to hear better the beat of the heart in a case of cardiac disease, being a roll of paper. Three years' further study and observation in the Hôpital Necker made him acquainted with nearly all the auscultatory signs, the result of his labours being first given to the world in 1819, in a work entitled "Traité de l'Auscultation médiate et des maladies des poumons et du cœur."—*Skoda* has submitted Lænnec's teaching to a most searching criticism, and, by tracing each of the auscultatory phenomena to its physical cause, has worked as great a reformation in this department of physical diagnosis as in the science of percussion. He has not only simplified matters by setting aside many of the points which found a place in Lænnec's system, but has also established, on physical principles, a classification of the phenomena of auscultation which has found universal acceptance up to the present time.

Our knowledge of the signs revealed by auscultation has received

* . . . . . ἕτερος μὲν τὰς χεῖρας ἐχέτω. σὺ δὲ τὸν ὦμον σείων ἀκοάζεσθαι, ἕως ὁκότερον ἂν τῶν πλευρέων τὸ πάθος ψοφέῃ. (Another holds the hands of the patient, whilst thou, shaking him by the shoulders, listenest from which side the sound proceeds.)

† . . . . . τρίζει τὸ πνεῦμα οἷον μάσθλης . . . . . (the respiratory sound is attended by a creaking, as of leather.)

Another passage, relative to the presence of fluid in the chest, is to the following effect:—τούτῳ ἂν γνοίης, ὅτι οὐ πῦον, ἀλλὰ ὕδωρ ἐστὶ, καὶ ἢν πολλὸν χρόνον προσέχων τὸ οὖς ἀκουάζῃ πρὸς τὰ πλευρὰ, ἐστὶν ἔσωθεν οἷον ψόφος. (Hereby mayst thou know that the fluid is water, not pus,—by holding thine ear to the side and listening, when it is as if a sound came from within.)

Catarrhal sounds also are repeatedly mentioned by Hippocrates. A very complete collection of the passages in which he treats of the above subjects and of physical diagnosis generally, has been made and published by Küchenmeister.

certain not unimportant additions *since the time of Lænnec;* amongst these should be mentioned the sound of pleuritic friction (Reynaud, 1829), that of pericardial friction (Collin, 1831), and the proper interpretation of the sounds heard over the vessels, and of many other facts connected with the auscultation of the heart and abdomen. (See the chapters in which these points are discussed.)

Methods of Auscultation.

Of these there are two, *immediate* and *mediate;* in the former the ear is applied directly to the chest, in the latter the stethoscope is interposed.

1. Immediate auscultation has these advantages, that the sounds generated within the respiratory apparatus are heard more loudly with the unaided ear than through the stethoscope, and that a larger area can be examined at a time; when it is necessary, therefore, that the chest should be gone over rapidly, especially its posterior surface, (as in very exhausting diseases, in which the patient is unable to sit up any length of time), immediate auscultation is to be preferred.

It has many drawbacks, however; not only is it, from the form of the thorax, attended by great inconvenience both to the patient and to the examiner, but it also involves many sources of error. It is frequently a matter of considerable difficulty, sometimes it is even impossible, to apply the ear accurately to certain parts the exploration of which is of the utmost importance,—the supraclavicular regions, for instance, especially when, as is so commonly the case, they are hollowed out by emaciation. In the supraspinous regions also this method is usually equally inapplicable.

The practice of immediate auscultation is, further, always associated with certain circumstances which are very apt to mislead; thus, the rubbing of the hair in the neighbourhood of the ear on the surface of the thorax in inspiration, and to a certain extent also in expiration, may give rise to artificial sounds which, as they closely simulate the so-called crepitant râles, sometimes prove very deceptive. And in those cases in which abnormal sounds are strictly limited in distribution, or in which the sounds vary greatly in character within a small area, immediate auscultation is obviously an untrustworthy method of examination.

Auscultation is best practised on the exposed skin. When female delicacy absolutely forbids this,—which comparatively seldom happens, most of the laity being fully aware of the great importance of auscultation,—the parts may remain covered by the chemise; and although in such circumstances perplexing friction-sounds are usually mingled with the proper respiratory murmur, the practised auscultator soon learns to recognise these and to distinguish them from the sounds really originating in the organs of respiration. A skilful examiner is able also to appreciate, through the clothes, both the normal and the abnormal respiratory sounds. No one will, of course, rest completely satisfied with such a superficial examination, more particularly when the disease is in its earlier stages and when it is desired to determine exactly its extent and nature.

2. Mediate auscultation, by means of the stethoscope. The various forms of stethoscope, though there are a great many in general use, are widely known and need little description. In the most useful form of instrument the ear-plate is somewhat concave and fits closely to the external ear, so as to facilitate the free and unobstructed entrance of the waves of sound. This condition is still more completely fulfilled when the stethoscope is furnished, not with an ear-plate, but with a small conical plug which is introduced into the auditory meatus; the flexible stethoscope, the auricular and thoracic ends of which are connected by a tube of india-rubber, is constructed in this fashion.—All the acoustic phenomena are heard much more distinctly through the binaural stethoscope,—a simplification of that so much used in America, having one cup-shaped thoracic end from which proceed two flexible tubes, each provided with a small conical ear-piece to fit the meatus. But its great advantage, the exceeding clearness with which it conveys sound, is nullified by an objection which even long practice is not always able to overcome, namely, that the slightest movement of the tube or of the ear-piece in the ear excites loud accessory sounds.—This variety of stethoscope is obviously well suited for self-auscultation.

In applying the ear to the stethoscope it is necessary to guard against pressing too firmly on the thorax, as this is decidedly unpleasant even to persons in good health, and is often positively painful to those suffering from any illness, especially if they are to any extent emaciated. In cases in which the acoustic phenomena are feeble and difficult to catch, the ear which is not employed in auscultating may be filled with cotton-wool, to exclude such sounds as would be likely to confuse those coming from within; a little experience, however, renders

this unnecessary.—In auscultating the lungs the examination should be begun at the apices and continued regularly downwards towards the bases, the symmetrical spots on each side being compared with each other, though this latter part of the proceeding is not absolutely indispensable.—The sounds may be rendered more audible by causing the patient to breathe deeply, especially if the respiration be shallow.

The objects aimed at in auscultating the lungs are :

I. To obtain a knowledge of the sounds which accompany both of the respiratory acts. These fall naturally into three groups ;
   a. *Simple respiratory murmurs ;*
   b. *Râles*, produced during respiration, by the presence of fluid in the bronchi or in the substance of the lung ;
   c. *Friction sounds*, arising from the rubbing of the roughened pleural surfaces on each other.

II. The auscultation of the cough and voice.

Simple Respiratory Murmurs.

Strictly speaking this expression includes only those breath-sounds which may be heard over the *thorax ;* more generally, it comprehends also those which originate, during respiration, in the nose, mouth, and larynx. The sounds produced by the current of air in the nasal and buccal cavities (the mouth being open) and in the pharynx not unfrequently, especially if the breathing be hurried or irregular, become intermingled with and obscure the true respiratory phenomena, and as they possess the same blowing character as the laryngeal and bronchial sounds they often prove a source of great confusion to beginners. To eliminate the buccal sound the patient should be made to close the mouth and to breathe only through the nose ; with regard to the nasal and pharyngeal sounds it is necessary to be able to recognise them readily and to distinguish them from the pulmonary respiratory murmur, as they are sometimes audible even over the whole of the thorax. The laryngeal sounds do not complicate the auscultation of the chest, as, if the laryngeal mucous membrane be normal and the passage of the current of air be unimpeded, they are quite inaudible over the thorax, except at certain parts, which are mentioned in detail on p. 130.

The simple respiratory sounds produced in the lungs, both in

health and in pathological conditions, are divided by Skoda into three groups :

1. *Vesicular respiratory murmur.*
2. *Bronchial respiratory murmur.*
3. *Indeterminate respiratory murmur.*

The Vesicular Respiratory Murmur.

The characteristic features of this sound may be easily reproduced by nearly closing the lips and gently drawing a current of air inwards ; there is obtained in this way a sighing or slightly whiffing sound, which closely resembles that of vesicular respiration.—The vesicular respiratory murmur owes its name to the circumstance that *it is produced at the instant at which the air enters the alveoli.* That it is generated just at this stage of the respiratory act seems placed beyond doubt by the fact that the sound disappears in all cases in which the entrance of air into the vesicles is prevented (as when they are filled with fluid), even though the bronchi, from the largest to the smallest, be perfectly free and pervious.—With respect to the actual cause of the vesicular murmur no adequate explanation can be given. Whilst most hold that it is no way connected with the bronchial sound, some authors have lately attempted to show that it is merely a modification of the sound originating in the larynx,—that the sonorous waves, in passing from that part into the relatively wide resonant chamber presented by the lungs, travel more slowly, are reduced in force and intensity, and lose the timbre and other properties they possessed while still in the larynx (Baas). It is undoubtedly the case that the laryngeal sound suffers considerable alteration in transmission through permeable, air-containing lung tissue. If, for example, a piece of the lung of some animal be inflated (but not too much) and laid on the larynx the characteristic laryngeal sound is no longer heard through it, but a sound which, in proportion to the thickness of the portion of lung used, is less tubular in quality and less clear in tone, and which may even possess all the properties of the ordinary normal vesicular murmur (Penzoldt) ; but if a piece of *liver* be substituted for lung the laryngeal sound is heard through it quite unchanged. Possibly the sound of vesicular respiration noticed in the experiment described may have had its origin not merely in the propagation of the laryngeal

sound through other resonant spaces, but also in the simultaneous vibration of the inflated and tense lung-substance (see below).

The various theories regarding the cause of the vesicular respiratory murmur are the following:—

According to Lænnec, Skoda, and others, it arises from the friction of the air against the walls of the alveoli while the latter are being dilated; the results of experimental investigation, however, tell against this view, as the inflation even of large chambers (large caoutchouc balloons, for instance) is accomplished noiselessly. If the ultimate ramifications of the bronchi be represented by a piece of indian cane (which consists of extremely fine tubules of equal diameter), and to this a thin elastic bladder be attached, it is found that on blowing through the cane and distending the bladder no sound is produced.—Others ascribe the vesicular murmur to vibration of the air as it enters the alveoli; the condition necessary to the occurrence of this "oscillation" of the current of air Chauveau, Bondet, P. Niemeyer, &c., professed to find in a constriction of the most minute bronchioles which takes place at the point at which they open into the funnel-shaped infundibula; they thus held that the vesicular murmur is made up of numberless stenosis-murmurs.—Talma adduces certain experiments, in which a current of air was forced through india-rubber tubes, in support of the hypothesis that the vesicular murmur is caused by the "friction of small bodies of air on each other." Over the middle of these tubes the bruit heard is continuous, while on contracting the orifice of entrance the sound becomes weaker at the middle of the tubes, but stronger at the constricted point; from these facts he infers that the sound heard at the centre originates at that part (from friction of the particles of air on each other) and is not transmitted to it from the orifice.—Baas, in opposition to those who look upon the vesicular murmur as an independent phenomenon, unconnected with the other respiratory sounds, holds that the tracheal sound is the one source of all the pulmonary respiratory murmurs, and that it is merely variously modified at different parts according to the dimensions of the resonant spaces to which it is conducted; thus, in the bronchi it becomes bronchial, in the alveoli vesicular.—Gerhardt and Penzoldt attribute the vesicular murmur to still another cause, to vibration of the lung tissue, as its state of tension is increased during inspiration; they suppose that these vibrations, when added to the bronchial sound, give it the vesicular character. Penzoldt was led to that conclusion by the following experiment: if a stethoscope, formed of several separate parts screwed together, having a thin tense membrane (the air-bladder of a fish) interposed between each two pieces to represent the tissue of the lung when distended, be applied over the larynx, or over those parts of a diseased lung at which, with an ordinary instrument, the respiration is bronchial, the sound now heard is no longer bronchial but vesicular.

The vesicular respiratory murmur is audible *only during*

inspiration, usually throughout its whole duration, but only towards the end of the act if breathing be superficial. The intensity (clearness) of the sound depends in most cases on the energy with which respiration is carried on; in general, however, it varies greatly in different individuals, even though their lungs be equally well developed and respiration be equally energetic. These differences have no great diagnostic significance.

In health the vesicular murmur is heard over the whole thorax, most loudly at those parts where the soft coverings are thinnest and offer least opposition to the propagation of the sound. The inspiratory murmur is therefore louder anteriorly than posteriorly, loudest in the infraclavicular region, feeblest in the supra- and infra-spinous regions; it is also weak wherever the subjacent layer of lung is thin,—at the apices and the anterior and inferior borders. The two sides of the chest often show marked differences in the intensity of the sound, the latter being louder sometimes on one side, sometimes on the other. Occasionally, though not always, there are obvious local causes for the enfeeblement of the murmur at certain parts,—such as increased thickness of the soft parts and abnormal convexity of the ribs, both of these conditions being highly unfavourable to the transmission of sounds.—If inspiration be sufficiently vigorous the vesicular murmur may be perceived not only in those parts behind which lung substance is situated, but also at other parts —the hepatic region, for instance,—to which the sound is conducted.

With regard to the character of the vesicular respiration, a distinction is made between the *soft* and the *harsh* or *rough* vesicular murmur. In normal circumstances, when the mucous membrane lining the air-passages is in a healthy state, the sound is soft; but in *catarrh and swelling of the membrane*, it becomes *rough*, the normal sound being altered by the addition of vibrations from the folds and prominences on the mucous surface. Following the distribution of the catarrhal affection, this harsh respiratory murmur may be strictly circumscribed or may be diffused over the whole thorax.—The detection of rough respiration over a limited area is of diagnostic importance as serving to determine the cause of the catarrh. Experience shows, for example, that catarrh of the apices is seldom primary, but usually secondary, indicating the beginning of caseous con-

densation in these parts. A rough respiratory murmur, therefore, localised in one or both apices, presenting no variation as regards its site on repeated examination, furnishes good ground for the suspicion that the catarrh is secondary to a phthisical affection; the same sound, however, is heard over the whole of one or both lungs, both in primary simple bronchial catarrh and in the secondary catarrh associated with various diseases of the lung-substance and air-passages.

The harsh vesicular murmur occurs sometimes alone, but more frequently combined with certain accessory sounds,—the râles, to be considered further on.

Harsh respiration is, nevertheless, quite consistent with perfect health; thus, in children, till they are about twelve years of age, the vesicular murmur is exaggerated and rough, and so characteristic is this sound that harsh respiration generally is often spoken of as *puerile*. This peculiarity of the respiratory murmur in children may be due to the fact that comparatively little opposition is offered to the transmission of sound by the thin chest-wall, and to the resistance to inspiratory expansion presented by the greater elasticity of the lungs in early life.—After the twelfth year the peurile breath-sound passes gradually into the softer vesicular murmur of adults.

A special variety of the vesicular respiratory bruit is the *jerking* inspiration. This term is used to describe a vesicular inspiration divided into two or more parts,—a phenomenon which may be imitated by contracting the lips and drawing the air through them in several quick, sudden draughts repeated at short intervals. Such an interrupted inspiratory sound is often audible over a large extent of the thorax when the individual under examination breathes irregularly or very slowly, in such a way that the air gains earlier access to one part of the lung than to another. A quick deep inspiration, by which the lungs are speedily and evenly expanded, causes this physiological variety of jerking respiration to disappear.—From this is to be distinguished an interrupted vesicular murmur of pathological origin, occurring in one or both apices, and usually confined to these parts. Thus if the air-cells in the apices be partially occupied by infiltration, and the finer bronchi be also somewhat reduced in calibre by tumefaction of their mucous membrane, the affected portions of the lungs are less readily

accessible to the air, and are rather later in expanding, than the freely permeable lung-substance lying between them, and inspiration becomes jerking or interrupted. After repeated deep inspiration, or an attack of coughing, it disappears for a time, but returns shortly afterwards.—From the physical point of view interrupted inspiration indicates merely the existence of some obstacle to the entrance of air into the pulmonary parenchyma; this obstacle is sometimes of short duration, and then is of no particular moment; at other times it is found to persist for a considerable period, and then may be accepted as pointing to incipient catarrh in the apices. In such cases also there are usually other auscultatory phenomena (prolonged expiration, perhaps even a few feeble râles) which warrant the same diagnostic inference.

Another modification of the normal respiratory sound is the so-called *systolic* vesicular murmur, sometimes heard at the borders of the lungs, near the heart; it is caused by the sudden rush of air into the alveoli of these parts of the lung, which rapidly expand and occupy the space rendered vacant by the shrinking of the heart in systole. This sound, nevertheless, occasionally occurs quite independently of inspiration, and in such circumstances is very feeble, though most commonly it is perceptible only when inspiration happens to coincide with a cardiac contraction,—when the portions of lung immediately adjoining the heart receive more air than the other parts of the lung.

The only diagnostic conclusion that can be drawn from the existence of the vesicular respiratory sound is that wherever it is audible the subjacent lung-tissue is permeable to air; but it does not necessarily follow that the part is capable of admitting a *normal quantity of air*.—The expansibility of the lung may, from various causes, be considerably diminished without involving any marked alteration in the vesicular murmur, so long as between these denser parts others intervene still having the normal spongy texture; and any deficiency is still further masked by the breath-sounds proceeding from the adjoining healthy tissue. In all these cases, however, the diagnostic inference, that the part under examination has suffered *diminution* of its air-contents, is rendered easier by the presence of other physical signs, such as changes in the percussion-note

(muffling of the sound) and certain auscultatory phenomena, especially fine bubbling râles.

If the air be *entirely excluded* from a larger or smaller portion of the lung the vesicular murmur within the region so affected is lost, being either totally suppressed, or replaced by a sound of no determinate quality or by bronchial breathing.

The vesicular respiratory murmur is *abolished* over a large area, sometimes even over the whole of one side of the chest, when the lung is *completely collapsed* by the *pressure of fluid* or *air* in the *pleural cavity* or by any other cause; it disappears to a less extent when the lung is compressed by mediastinal tumours, large pericardial effusion, an excessively hypertrophied heart, &c.; it becomes inaudible on both sides in very aggravated cases of vesicular emphysema; and finally, when the lung is completely *solidified* the vesicular murmur is no longer heard, but is replaced by other auscultatory signs.

The vesicular respiratory murmur is *weakened*, over a greater or less extent of surface, by the presence of minor degrees of the above-named affections, by marked reduction in the calibre of the larynx and trachea; temporarily, also, by obstruction of any of the larger bronchi.

Such constrictions of the air-passages may result from the formation of croupous membranes, swellings, cicatricial (syphilitic) adhesions, &c., more rarely from paralysis of the dilators of the glottis on both sides; when it arises from the latter cause the rima glottidis, instead of dilating in inspiration, contracts, sometimes even to absolute closure, the vocal cords falling asunder again only in expiration.—In cases of obstruction of the bronchi by superabundant mucous secretion the vesicular murmur is weakened only in circumscribed spots, and regains its intensity after an attack of coughing. If the embarrassment of respiration be due to the partial or *complete closure* of one of the *principal bronchi* by the impaction of a foreign body (a somewhat rare occurrence), the vesicular murmur over the greater part of one side of the chest is so enfeebled as to be almost inappreciable.

Weakening, or even abolition, of the respiratory sounds may thus spring from so many diverse causes that it admits only of the general diagnostic interpretation,—that the air gains access to the alveoli with difficulty or not at all.

In those pathological conditions in which vesicular respiration is abolished (in cases of compression of the lung by pleuritic exudation or air, or of severe pulmonary emphysema, for instance), inspiration is attended either by no audible sound or only a faint, undefined whiffing generated in the bronchi.—In another group of cases, characterised by *complete infiltration* of the air-cells, the respiratory sound is no longer vesicular, but bronchial, and accompanied usually by râles, when the bronchus leading to the hepatized part is not stopped-up by secretion. The vesicular murmur, in becoming weaker, becomes also less clearly defined in character, till it passes gradually into the indeterminate respiratory murmur.

The Expiratory Murmur.

In auscultating the normal chest in expiration only a weak and soft *whiffing* or buzzing, *indefinite* sound is heard, which bears no trace of resemblance to the vesicular inspiratory murmur; it is usually much shorter than the latter, and is produced by the outward current of air through the bronchi.

The principal pathological alterations of the expiratory murmur are *prolongation* and *harshness*. Very frequently, indeed usually, both changes are observed together and are due to the same cause.

Prolongation of the expiratory murmur occurs over extensive or circumscribed areas, the breath-sounds being either otherwise unaltered or accompanied by accessory sounds. It always indicates that there exists some hindrance to the free escape of the respired air. It is one of the physical signs, therefore, that attend severe bronchial catarrh, being caused by the diminution in the lumen of the bronchi which takes place from swelling of their mucous lining; it is met with particularly in the diffuse bronchial catarrh which is associated with vesicular emphysema.—It is also very frequently heard, but more strictly localised, as the result of the bronchial catarrh connected with condensation of the lungs. Limited to one or both apices, prolonged expiration is one of the earliest signs of incipient catarrh, and may then be regarded as evidence of the commencement of cheesy degeneration; in such circumstances it is often combined with other auscultatory phenomena (dry or moist râles) pointing to the same conclusion.

A *harsh* expiratory murmur, like one which is prolonged, being caused by obstruction to the expiratory current of air and vibration of the swollen bronchial mucous membrane, indicates equally clearly the presence of bronchial catarrh. It merges gradually into that form of expiration to which the accessory sounds,—particularly the dry râles, sonorous, buzzing, sibilant,—are