large cavity produces a tone strong or loud in intensity and low in pitch, while a small one yields a weak or soft tone which is higher in pitch. The pitch is also affected by the *tension*, *thickness*, and *density* of the vibrating membrane, so that if the membrane, say of a drum, be overstretched, the tone produced will be higher pitched, because of the quicker vibrations, and these will not consonate with the vibrations in the air-containing space within the drum, and, therefore, the tone will be less intense.

When a resonant space is partly open a smaller cavity will suffice to produce a resonant tone, and the size of the opening modifies the pitch—the wider it is, the higher the pitch, as may be demonstrated by filliping the cheeks and gradually opening the mouth.

In speaking of intensity, several terms have been used which call for explanation. The intensity may be said to be strong or loud as opposed to weak or soft. Sometimes the word *dull* is used. The opposite of dull is *clear*, and hence clearness and dulness are terms often used in medicine in relation to the different degrees of intensity. These terms, however, are applied incorrectly, and they refer to the *quality* (timbre) rather than the intensity of a sound. A note struck forcibly upon the pianoforte will yield a sound strong in intensity or loud, and if struck gently, a soft or weak sound, which, however, may be perfectly clear. Long use has apparently sanctioned these terms in medical works, and hence in percussion, strong, loud, and clear are often applied to the intensity as opposed to weak, soft, and dull, the combination of the terms really including the *timbre*, along with the intensity. Physicians percussing the base of the lung often compare the *intensity;* and the same, when percussing the apices, will talk of high and low *pitch*.

Vibratile membranes enclosing air-containing spaces, which sometimes communicate with the external air, are the physical conditions concerned in the production of resonant percussion tones; and the two properties of sound which are the most important, are the *intensity* and the *pitch*. Irrespective of the force used, the relations of these conditions may be thus shown :—

		Intensity (and *timbre*).	Pitch.
Membrane, . .	Flexible	Strong (clear)	Low.
	Tense	Weak (dull)	High.
Cavity, . . .	Large	Strong (clear)	Low.
	Small	Weak (dull)	High.
Opening, . . .	Narrow	Strong (clear)	Low.
	Wide	Weak (dull)	High.

It is possible to conceive of these relations of the membrane and cavity being disturbed as regards the intensity and pitch. A very tense membrane, for instance, which would otherwise give a high-pitched tone, enclosing a large cavity which would emit a tone clear

and strong. More forcible percussion, by increasing the amplitude, would then bring out the low-pitched tone by setting up vibrations of the contained-air, while light percussion would only give the higher-pitched note of the vibrating membrane.

Application.—In the application of the foregoing to percussion of the lungs, the vibrating membrane is not simple as in the case of the drum, but it is composed of layers of different density and tension, and must be held to include the component parts of the thoracic parietes, pleura, and lung tissues. The air-containing space also differs, inasmuch as its contained air is limited by multitudes of sacs, ranging in size and shape from the small air vesicles up to the large bronchial tubes.

With such a large number of resonant chambers, varying in size and tension, it is obvious that there can be no fundamental note, and the sound heard upon percussing a healthy chest is made up of a large number of tones which do not blend, and which have no definite or fixed relations. It is, in fact, a mixture of musical notes and noise.

The normal thoracic percussion-sound is produced by (1) the vibration of the thoracic parietes, pleuræ, and lung-tissues; and (2) by the vibration of the air contained in the pulmonary air vesicles and bronchial tubes.

Some authors consider the chest-wall the only part concerned in the production of the tone. Williams, adopting this theory, explains that the normal lung, filled with air, propagates the vibrations of the wall, and when the lung is consolidated it acts as a damper or *mute*, and hence the higher pitch, &c. This theory does not satisfactorily explain all the conditions. Other writers again deny that the chest-wall takes *any* part in the production of the sound. With regard, also, to the vibration of the air, Gee considers the vesicular elements too small to resonate, and that the percussion-tone is yielded by the larger bronchial tubes alone, the spongy lung-tissue interfering with its conduction. When, according to his view, consolidation takes place, the tone yielded is higher in pitch and clearer—the latter term being applied to the *quality* alone and not relating to the intensity.

The percussion-sounds possess *intensity* and *pitch*, and are *poor in timbre*, but in certain pathological conditions they may acquire this latter quality; and although the resonant chambers of the lung communicate with the external air, the *tissues* conduct the sounds.

Some writers consider the *intensity* of the percussion-tone as of little value, depending, as it does to a great extent, upon the force used and upon the state of the vibrating membranes. These authors consider the whole subject in relation to the *pitch*, the lung being normally a bad conductor unless consolidated, when it then yields quicker vibrations, and hence is higher in pitch.

According to Guttman "elevation of the pitch from *pathological* causes never occurs alone, unaccompanied by decrease in the intensity; the sound generally rises in pitch as it loses in clearness."

This dictum is practically, if not absolutely, correct, if we view the percussion-tone as resulting certainly from the resonance of a great number of unequal chambers, but still striking the ear as a single sound, and all that is available for the comparison of the healthy with the consolidated lungs. The variations in the intensity and pitch in relation to this single percussion-sound would then be in harmony with the law already stated concerning resonant chambers, viz. :—that the smaller the air space the weaker is the intensity and the higher the pitch.

If, on the other hand, we attempt to regard the percussion-sound as a combination of sounds produced by *distinct and separate* resonance chambers all varying in size, *and each having its own intensity and pitch*, it is possible to conceive that the removal (by consolidation) of a number of the smaller and high-pitched elements (vesicles), while it diminishes the *intensity* of the percussion-tone as a whole, might *not* raise the pitch, as the larger elements (bronchi), if between the pleximeter and the consolidation, would tend to keep the pitch low. As this can only apply to small consolidations—the larger ones diminishing the air spaces to such an extent as to diminish the intensity and raise the pitch, as a whole—Guttman's dictum may be accepted for practical purposes.

Although the membranes and resonant spaces are indissolubly associated in the production of percussion-sounds, they are here considered separately, in order to make clear the part each plays in the alterations of the intensity and pitch of the sounds.

I. **The Membranes.**—A. **The thoracic parietes**; B. **The lung.**

A. **The thoracic parietes** affect the intensity and pitch by the state of their tension and density. Increase of muscle on one side (labourers), deposit of fat, œdema, rigid and curved ribs, local thickening externally, or internally (pleura), and deep inspiration, will all diminish the intensity and raise the pitch, because the vibrations of the chest-wall are diminished in amplitude, and quicker in time. In these cases the percussion requires to be more forcible to bring out the resonant-tone, light percussion giving only a dull or flat note unless the air spaces beneath are caused to vibrate. On the other hand, the intensity is increased and the pitch lowered by muscular atrophy, emaciation, &c.

B. **The lung**, which may be regarded as the much thickened and altered internal layer of vibrating membrane, plays an important part in the production of the percussion-tone, as the state of tension of this organ is subject to variations which may affect the intensity and pitch. The lung in its normal state is slightly over-distended, and it has its peripheral surface to a great extent applied accurately to the external layers (thoracic parietes), and by virtue of its own elasticity it has a marked tendency to collapse. Should this occur from any pathological cause (as in early pleuritic effusion), the percussion-tone over it would become more intense and lower pitched because the lung-tissue has become more flexible. Should the collapse, however, become more complete, the lung then becomes more compact, ceases to yield flexible vibrations, and may now be regarded as a condensed body separated from the external layers of vibrating membrane by some pathological product, which may itself

(as in pneumothorax) form a resonant chamber; but where the lung remains in contact with the thoracic parietes, it now yields a note diminished in intensity and higher in pitch because of its increased density.* On the other hand, the tension of the lung may be increased (and with it the thoracic parietes) by full inspiration, and notwithstanding the increase in the volume of air within the lungs, the increased tension of the vibrating membranes diminishes the intensity and raises the pitch, unless more forcible percussion be used.

II. **The Resonant Spaces.**—As the object of percussion is to ascertain the amount of resonance, or state of the air-containing spaces, either in relation to lung disease itself or to diseases which affect the lung secondarily, it is obvious that this is the most important division of the subject.

A knowledge of the conditions which influence the state of the vibrating membranes is essential for the purpose of avoiding the sources of fallacy, and to indicate the necessity for more forcible percussion being used, when from changes in the thickness and tensity of the membranes they interfere with the production of the true resonant percussion-tone. Assuming for the moment that the tension of the membranes undergoes no change, or at least produces no antagonistic conditions, it may be stated that *the intensity of the percussion-tone is increased or diminished and the pitch lowered or raised, with the increase or diminution of the volume of air within the resonant spaces.*

In the practical percussion of the lungs, it will now be clear that for the proper interpretation of the percussion-sounds, the state of the three factors concerned in their production (parietes, lung, and resonant spaces) must always be kept in view. These may act *pari passu* to produce a tone diminished or increased in intensity and altered in pitch, but frequently they act in opposition, and the resulting tone is the balance or excess of the strongest element producing the tone. For example, the lung becoming relaxed in early pleuritic effusion tends to produce a tone low in pitch, even although there must now be *less* air within the air spaces—*i.e.*, the diminution in the tension of the lung-tissue more than compensates for the diminution in the volume of air, which would otherwise give a higher pitched note. Again, in deep, forced inspiration, the increased tension of the thoracic walls and lungs more than compensates the increased volume of air, and the tone becomes higher pitched. In *quiet* respiration, the air inspired tending to increase the intensity by its increased volume, is balanced by the increased tension of the lung and chest-walls, and hence the resonance remains practically the same.

The *pathological conditions* which alter the intensity and pitch of the resonant percussion-tones of the lung, are consolidations and

* The diminution in the volume of air which must necessarily result from collapse of the lung is not considered at present, although, of course, it also is the cause of diminished intensity; the object being, at present, to consider the different factors separately and independently.

exudations, collapse, œdema, excavations, &c.: while effusions of fluid or gas within the pleural cavity, enlarged organs, or the growth of tumours, affect it by their pressure. These conditions are described with the physical signs of their respective diseases.

It may be said of consolidations, &c., that they must be of sufficient *size* to alter the intensity and pitch of the percussion-tone, and that the more superficial they are the more readily are the differences noted. This latter fact may be due not only to a diminution of the size of the resonant spaces as a whole, but also sometimes to the consolidation, by its contiguity with the vibrating thoracic parietes, acting as a damper or *mute* to their vibration. Compensatory emphysema, also, may so surround a consolidation as to completely mask or neutralise the effect of percussion.

The tones produced by percussion are sometimes classified, as Tympanitic (stomach), Sub-tympanitic or Pulmonal (lung), Tracheal or Tubular, and Osteal. These are best learnt practically. Dr. John Wyllie's classification is as follows, viz.:—

Percussion.

(1) Hyper-Resonance.
- (*a*) Slight.
- (*b*) Marked.
- (*c*) Very marked (Tympanites). α High-, β Medium-, γ Low-pitched.

(2) Deficient Resonance.
- (*a*) Slight, comparative dulness.
- (*b*) Marked dulness.
- (*c*) Absolute dulness.

(3) Mixture of Dulness and Resonance, *i.e.*, a "Wooden or Boxy Note."

(4) Special Quality.
- (*a*) Cracked-pot sound.
- (*b*) Dulness with vibratile thrill to finger.
- (*c*) Bell sound, got with two coins and stethoscope.

Cavities.—These produce tones more or less resonant or tympanitic, but to do so the cavity must be at least the size of a pigeon's egg and superficial, with firm smooth walls surrounding the space.

If the cavity communicate with the external air, the pitch is higher when the mouth is open. Should it contain some fluid, changing the posture of the patient may modify the intensity and pitch, by the fluid altering the length of the vibrating column of air, thus—

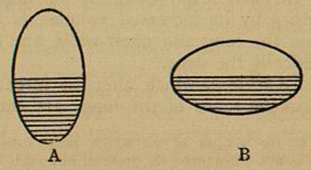

Fig. 13.—A, Cavity with fluid while in the erect position. B, Cavity while lying down.

A pyo-pneumothorax may affect the tone in the same way.

The *cracked-pot sound* (*bruit de pot fêlé*) is produced by strong percussion, during expiration, causing the sudden expulsion of air from a cavity or tube, the slight *hissing* noise attending the sound arising either at the outlet of the cavity or at the glottis. The sound may be imitated by loosely clasping the hands and knocking the back of one of them smartly on the knee.

The cracked-pot sound occurs in phthisical excavations, thoracic fistulæ, and in diseases associated with relaxed lung-tissue. It occurs also when forcible percussion is made upon the thorax of a screaming child.

Amphoric resonance (metallic ring, &c.) is a somewhat tympanitic note which is high in pitch. The membranes are tense and they probably produce over-tones of the fundamental or ground tone. It occurs chiefly in pneumothorax, but it may also be produced in smaller cavities with smooth walls. The combined auscultation and percussion with two coins renders the tone very distinct and metallic.

The *tracheal resonance of Williams* arises when the upper lobe of the left lung is collapsed or consolidated around the left primary bronchus. Opening the mouth raises the pitch.

Hydatid thrill is the tremulous sensation sometimes felt by the fingers on percussing a superficial tumour containing fluid.

Methods of Percussion.

The *immediate* method consists of tapping the chest directly with the tips of the fingers, but except as a preliminary to the mediate, or *to test the resonance behind the clavicles*, it is not much used.

The *mediate* percussion may be performed with a pleximeter and hammer, or with the finger acting as a pleximeter, and the stroke made (from the wrist) with a bent finger of the other hand. The latter is the usual and the best method, as the fingers adapt themselves to the irregularities of the chest, and are, at the same time, able to appreciate the *sense of resistance*, an important aid sometimes, in the diagnosis. The patient should keep the muscles of each side in the same state of tension, and should cross the arms well over when the back is percussed. The head should be held in the middle line when the apices are being examined. The percussion—with equal amount of force—should then be made symmetrically—*i.e.*, the corresponding parts should be compared as far as possible. As the stronger the force used the larger is the area over which the vibrations will be distributed, so will the tone produced vary in intensity. In percussion the force must be greater when it is desired to bring out the resonant tone through dense membranes, &c.; but it must be light when mapping out the edges of a solid which borders on a resonant space. The art of percussion is fully taught in the tutorial classes and clinical wards, but it can only be acquired by much practice.*

* The *lungs* extend about an inch above the level of the clavicles. The course of the anterior borders varies (*see* Medical Anatomy of the Heart, Fig. 2).

Auscultation.

The properties of sound, briefly sketched in relation to percussion, may all be applied to the sounds heard in auscultation of the lungs; but it is the *quality* (*timbre*) and the *duration*, which are generally of importance, the intensity and pitch being usually of secondary interest.

Origin of the Breath-Sounds.—A fluid—liquid or gaseous—passing along a narrow tube, does not produce sound unless an obstruction, constriction, or relaxation (by causing an increase in the calibre of the tube) set up vibration of the particles of the fluid vein.

In the respiratory tract such a constriction occurs at the glottis, and the vibration produced there during respiration is the cause of the breath-sound. These vibrations—like the vocal vibrations—are reflected down the windpipe, and they become weaker as they are conducted and diffused throughout an enormous number of bronchial tubes. According to Beau, Baas, and Gee, the glottis is the *only* source of the breath-sounds, and the loud *tracheal* murmur heard on placing the stethoscope upon the windpipe, the *bronchial* character of the respiration heard in the interscapular region, and the faint, breezy, *vesicular* murmur, heard best at the base of the lung posteriorly, all originate at the glottis, and are altered in character, according to the medium through which the vibrations are transmitted—the *vesicular* character of the murmur over lung being due to the bad conducting power of the spongy lung-tissue. This theory is supported by comparing the alterations in the character of the vocal vibrations, which are undoubtedly produced at the glottis, and which become muffled, or less clear, the further we proceed from the source of the sound in the respiratory tract.

The second theory in connection with the cause of the respiratory sounds applies only to the vesicular murmur. Chaveau, Niemeyer,

For practical purposes, it is sufficient to remember that in the mammary lines the lower borders are about the level of the *sixth* ribs; in the axillary lines, at the level of the *eighth* ribs; and in the back the lower borders are defined by lines sweeping round from the axillary points across the *tenth* ribs (about two and a half inches from the spine) to reach the spinous process of the tenth dorsal vertebra.

The lower border of the *liver*, in the mesial line, extends about two inches below the xiphoid cartilage; in the right mammary line it extends to the margin of the lower rib; and in the right axillary line it reaches the tenth intercostal space. The upper margin of the liver, *yielding absolute dulness*, is outlined by the lower border of the lung. The liver margins vary slightly with the position of the patient, and with deep respiration. The average area of hepatic dulness *in adults* is about *three* inches in the mesial line, *four* inches in the mammary line, and *five* inches in the axillary line.

The *spleen* lies parallel with the *ninth*, *tenth*, and *eleventh* ribs, of the left side, beginning one inch and a half from the spine, and extending as far as the left posterior axillary line. The upper part of the spleen is covered by the lower border of the left lung. Enlargements take place downwards and forwards, so that percussion from above, downwards, just in front of the left posterior axillary line (at the level indicated), is best calculated to detect an *early* increase in the size of the organ (see Fig. 14).

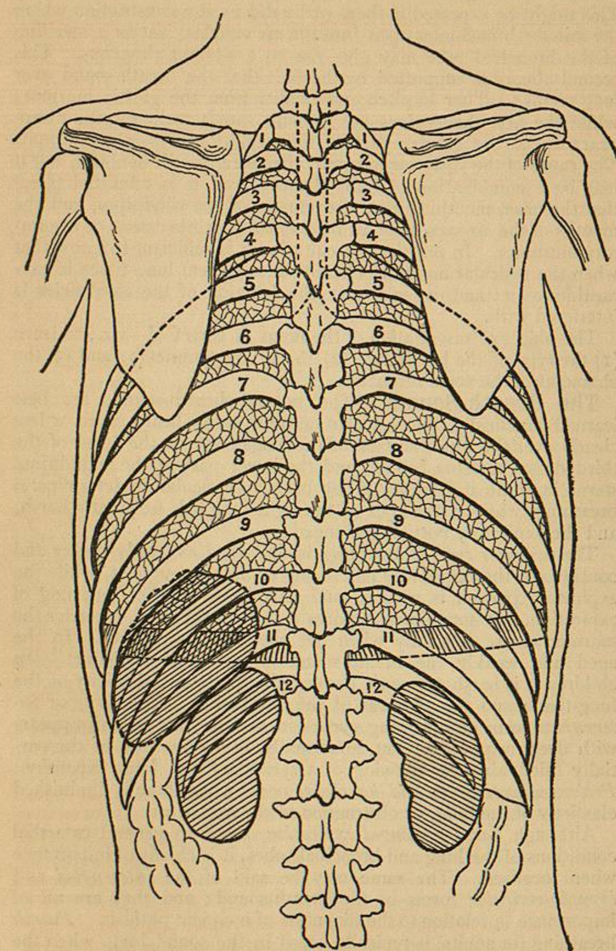

Fig. 14.—(Based upon Ferber.)

(*Note.*—The kidneys should be nearer the vertebral column.)

and others consider it to be produced by the vibration of the air particles entering the alveoli—*i.e.*, by numerous *stenosis murmurs.* This might be expected if there really did exist a constriction where the minute bronchioles open into the air vesicles, just as a swelling of the bronchial tube may give rise to a sibilant rhonchus. This second theory is supported by the fact that the breath-sound over lung seems to differ in pitch and quality from the glottic murmur; while the first theory does not account satisfactorily for the disappearance of the greater part of the expiratory vesicular murmur. The cause of the vesicular murmur, therefore, is still doubtful, but it may be a combination of both theories, and it is admitted (Gee) that the nose, mouth, throat, unevenness of the windpipes, and the mouths of the air-sacs, may all be deemed possible causes of respiratory murmurs. In practical auscultation it is sufficient to know that when the vesicular murmur is heard the subjacent lung-tissue is permeable to air; and, when absent, the function of the air vesicles is interfered with.

The object of auscultation of the lungs is threefold—viz., to learn (1) the type of the breathing; (2) the accompaniments; and (3) the character of the vocal resonance.

The Breath-Sounds.—The normal breath-sounds are best learned practically, the vesicular murmur being heard more or less clearly over the whole surface of the lungs; but at the level of the third dorsal vertebra behind, and the lower part of the manubrium sterni in front, it is replaced by broncho-vesicular (indeterminate) breathing, while at the apex of the right lung it is frequently harsh, and the expiratory portion prolonged.

The *vesicular type of breathing* is described as faintly breezy and continuous, the inspiratory part being audible throughout, while the expiratory portion is weaker, and only heard at the beginning of expiration. It sometimes requires a deep inspiration to render the murmur clear, especially when the chest-walls are thick. In the aged and weakly the breath-sound is *feeble* and indistinct. In children it is harsh (*puerile*), because of the greater elasticity of the lung-tissue and the thinness of the chest-walls. The *jerky* or *interrupted* form of breathing occurs in the nervous, and disappears with deep inspiration; but, abnormally, it may be due to the partially filled air-cells allowing of a secondary and later expansion. *Prolonged expiration and harshness* occur when there is diminished elasticity of the lung, or obstruction to the exit of air.

Although *harsh prolonged expiration* occurs in general catarrhal conditions of the lung and bronchial tubes, it is chiefly of importance when localised. The same may be said of the *interrupted* and *broncho-vesicular* forms of the breath-sound; and they are all of importance in relation to the diagnosis of incipient phthisis. *Puerile* breathing (in adults) is typically heard in the sound lung, when the other lung is collapsed by the pressure of a pleuritic effusion. The normal vesicular murmur—if there be no interference with its production by obstructions in the respiratory tract—may be rendered *feeble or indistinct* (distant) by enlarged organs and tumours, large

pericardial effusions, and pleuritic effusions, causing some collapse of the lung by pressure; and it may be *entirely abolished* by consolidations, large effusions, and in vesicular emphysema. The vesicular murmur, in some of these conditions, may be entirely replaced by harsh bronchial respiration, or it may be masked by accompaniments.

The *bronchial type of breath-sound* is not heard in the healthy chest, because the bronchial murmur being produced at the glottis, the spongy lung-tissue is a bad conductor of the sound. The character is harsh and guttural ("ch"), the inspiratory and expiratory portions being equal in duration, and with a short pause between them. Irrespective of the energy of the breathing, and assumiug that the bronchi are unobstructed, the intensity of the bronchial murmur depends upon the extent of the morbid condition (consolidation), and whether superficial or not.

Consolidations and compression of the lung, while obliterating the vesicular murmur, render the lung more homogeneous, and hence a better conductor of the glottis vibrations.

Excavations and cavities, with rigid and dense walls, give rise to bronchial breathing by the increased reflection of the vibrations. These conditions are produced by phthisis, pneumonia, collapse of the lung (effusions, pneumothorax, &c.), and new growths. Bronchial breathing is sometimes heard when a large pleuritic effusion exists, even although this tends to obliterate the bronchial tubes, and hence there is less sound to propagate. According to Guttman, when the fluid is abundant, bronchial breathing is only heard posteriorly where the lung is pressed close to the chest-wall. It may, however, be occasionally heard over the whole area of dulness, if the fluid is insufficient to obliterate the larger bronchial tubes. A tumour pressing upon a bronchus may cause stenosis, and originate a bronchial murmur; and a small solid in direct contact with a bronchus may conduct the sound with great distinctness.

Tubular breathing is a modified form of the bronchial breath-sound often heard in pneumonia. It is higher in pitch and less guttural in character ("hoo"). It has been suggested that when disease consolidates the air vesicles and bronchiola proceeding from a larger air tube, a current of air passing across the mouth of such a tube would produce the tubular tone—an effect concurrent with inspiration and expiration (Gee).

Cavernous breathing is the low pitched and reverberating breath-sound, not unlike the normal tracheal murmur. It generally indicates, but not always, the presence of a vomica.

Amphoric breathing may be low or high in pitch, and it resembles the sound made by blowing into an empty bottle. It is produced by air passing into a large cavity, and it occurs in large pulmonary excavations which have smooth walls, are superficial, and which communicate with a bronchus; and in pneumothorax it is well marked when there is a fistulous opening allowing the air to enter the cavity, and before there is complete collapse of the lung.

The *broncho-vesicular* or *indeterminate* breathing comes between the vesicular and the bronchial, and it partakes of the character of each. It is heard normally in the right clavicular region of healthy men when breathing superficially, and at the level of the third dorsal vertebra behind, and at the lower part of the manubrium sterni in front, as already stated. It is (abnormally) due to insufficient expansion of the alveoli, or to obstruction by mucus; or it may result from the accompaniments masking the true respiratory murmur. When local, indeterminate breathing points to incipient phthisis; but it occurs in many other conditions.

Laennec's *souffle* or *puff*, Skoda's *veiled puff* (*souffle voilé*), and the *metamorphosing murmur of* Seitz are not of practical importance.

Accompaniments of Respiration—Râles.—In health there are no râles; but after a patient has been lying upon his back for some time a few crepitations may be heard at the base of the lung posteriorly. These, however, disappear with a few deep inspirations. At the apex, also, a clicking râle is often heard which a cough may remove. It is only when râles are persistent that they have pathological significance.

Râles occur in cavities and in the bronchi, and they are caused by the passage of air through fluid which, either by agitation or by originating bubbles, produce sounds appreciable by the stethoscope. Swollen mucous membranes may even produce them by vibration, but these sounds are generally *dry;* while sudden separation of the smallest bronchioles, when moist and cohering, is the accepted cause of the fine crepitant râles. The secretions may be serous, mucous, purulent, or sanguineous—the moist râles suggesting thin and watery secretions, while the *dry* sounds appear to be more tenacious and thick. Râles occur during inspiration chiefly, but also during expiration, and only rarely during the latter alone. A *post-expiratory* râle (Baas) is sometimes heard in large vomicæ. The intensity or clearness of the râles depends upon the energy of the respiration, and upon their size and seat (whether superficial or not). The ear soon learns to recognise whether they are transmitted or superficial, as in the former case they are more scanty and feeble (distant). Râles are not heard unless the bronchi are unobstructed.

Râles are frequently intensified by consonance in the cavity of the mouth, &c. They also become clear and high pitched when resonant, as occurs when the lung-tissue is sufficiently consolidated, or when associated with a cavity having smooth, dense walls, and which is superficial. The *metallic* character of a râle is due to consonance in a large cavity with smooth firm walls; but the râles may originate in the bronchi, and a pneumothorax or distended stomach may transmit them. Dry râles render the respiratory murmur harsh, and they lengthen the expiratory sound.

The râles may be thus classified:—

The *dry* (*rhonchi*)—

1. The high-pitched, *sibilant* or *cooing* rhonchus.
2. The medium-pitched; and
3. The low-pitched, *sonorous* rhonchi.

The *moist* râles—

1. Fine crepitations.
2. Medium sized, *sub-crepitant*, *fine mucus*, and *clicking râles;* and
3. Coarse, *bubbling*, *gurgling*, or *cavernous* râles.

The dry rhonchi, and the medium sized and coarse moist sounds, occur chiefly in bronchitis, in catarrhal conditions, and in phthisis. The fine crepitations are heard in pneumonia, in pulmonary œdema, and in collapse of the lung with slight catarrh. The fine crepitations are like the sounds produced by rubbing a few hairs between the fingers, close to the ear. The other sounds need no description, and they are best learned by experience. It is possible to find two or more different rales combined, as in œdema—the fine crepitations mixing with the coarser râles in the bronchial tubes. Hairs upon the chest may simulate fine crepitations; but moistening the chest with water will prevent these.

Pleuritic Friction.—The moist pleuritic surfaces, in health, glide over each other and produce no sound. When they become roughened by inflammatory deposit, and if no effusion separate the surfaces, a friction sound is produced. It may only be the slightest rub, or it may be well marked, and like the creaking of leather. The friction may often be felt (friction fremitus). The sound is best heard at the acme of inspiration, and it is not modified by coughing, and it is usually more localised than any of the intra-pulmonary sounds. Pressure with the stethoscope sometimes intensifies the friction sound. Peritoneal friction, and friction at the shoulder joint, &c., are sources of fallacy. Pericardial friction may be differentiated by instructing the patient to hold his breath during auscultation. Pleurisy, fracture of the ribs, &c., and inequalities of the pleural surfaces (as by tubercular and cancerous deposits) are the chief causes of pleuritic friction.

Hippocratic succussion is the splashing sound heard on shaking the patient during immediate auscultation of the chest. It frequently can be heard in pyo-pneumothorax, &c., and sometimes even in large cavities when the secretions are thin.

The Vocal Resonance.—The vibrations produced in speaking are conducted and diffused throughout the bronchial tubes, and the spongy lung-tissue, being a bad conductor, renders the sound indistinct. Practice alone can teach the normal resonance, and it varies in individuals, and depends upon the strength of the voice and the thickness of the chest walls. It is usually louder upon the right side, owing to the right bronchus being larger. The vocal resonance is sometimes better tested by *immediate* auscultation—the ear being applied directly to the chest, a soft handkerchief intervening.

The *vocal resonance* may be—

Impaired:	Normal.	Increased:
(*muffled*)	...	(*Bronchophonic*)
(*absent*)	...	(*Pectoriloquous*)
...	...	(*Ægophonic*)
...	...	(*Amphoric*)

Assuming that the bronchial tubes are not blocked and that there is no interference with the conduction of the vibrations, the vocal

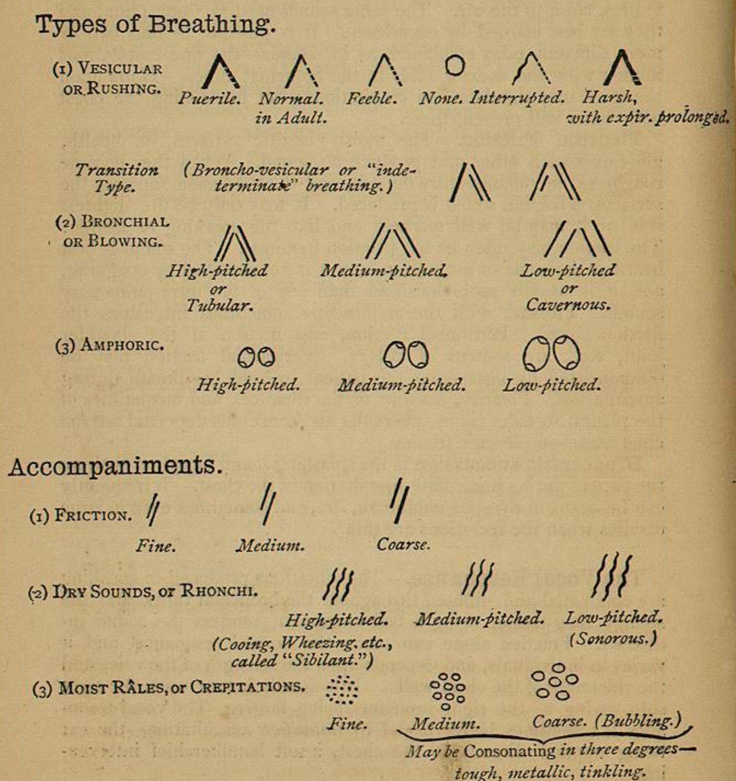

Fig. 15.—Breath-sounds and Accompaniments.

resonance is impaired (muffled) or absent, when the lung from any cause is separated from the chest-wall (pleuritic effusions—liquid or gaseous—tumours, &c.). This is not *always* the case in pleurisy with effusion, as occasionally even the whispered voice may be heard over the dull part. The vocal resonance is intensified by whatever makes the lung approach nearer to simple solid, or simple air, as in all *consolidations* (pneumonia, phthisis, &c.), and especially is it intensified over *cavities*. *Bronchophony* is that clear resonance which is generally compared with that normally heard in the inter-scapular region. It has sometimes a *sniffing* character. *Pectoriloquy* is very clear bronchophony, heard usually over a limited area, and it is reverberating in its quality; but it does not always indicate a cavity. *Ægophony* is the bleating (Punch) voice sometimes heard in pleuritic effusions. *Amphoric* resonance is metallic in character, and it resembles the blowing or speaking into a large empty bottle, the sounds having a distinct echo. It occurs chiefly as a symptom of pneumothorax, but it may occur in large cavities.

The character of the vocal resonance (clearness) is more important than its actual *loudness*, and it sometimes is necessary to test the whisper over cavities, &c., as "the ground-tone of the voice drowns the articulated over-tones." The thoracic resonance may also be tested by the cough and cry—the latter especially in children. Dr. Wyllie graphically represents the breath-sounds and accompaniments, as on the preceding page.

CHAPTER IV.

DISEASES OF THE RESPIRATORY SYSTEM—

Section II.

Contents.—Pertussis—Asthma—Hay asthma—Acute bronchitis—Fibrinous bronchitis—Pulmonary collapse (Atelectasis)—Catarrhal pneumonia—Congestion and œdema of the lungs—Croupous pneumonia—Hæmorrhagic infarction—Chronic bronchitis—Cirrhosis of the lungs—Emphysema—Fœtid bronchitis—Bronchiectasis—Gangrene of the lung—Phthisis, and miliary tuberculosis—Cancer of the lung—Hydatids—Pleurisy—Hydrothorax—Pneumothorax, hydro-pneumothorax, and pyo-pneumothorax—Pleurodynia—**The classification and diagnosis of the diseases of the pulmonary organs**—Causes of hæmoptysis.

Pertussis—Whooping-cough.* —The pathology is still doubtful. It is admitted that the disease is the result of a specific organism, but its exact nature has not been made out. Burger and Afanassieff have found organisms, cultures of which, when injected

* Before reading the following diseases of the pulmonary organs, the student should revise the classification and the notes upon the same on p. 115.