[44] St. Petersburger medicin. Wochenschrift, No. 18, May 19th, 1900.
[45] Morfologia del corpo humano, Milan, 1891.
[46] Thèse de Paris, 1899.

CHEST, PHYSICAL EXAMINATION OF THE.—Physical examination of the chest is accomplished by the use of the special senses of sight, hearing, and touch in the application of the methods of inspection, palpation, mensuration, percussion, and auscultation. The phenomena observed by these methods of investigation are called physical signs. To recognize and properly interpret the physical signs caused by abnormal conditions of the thoracic viscera it is essential that the observer should thoroughly understand the normal physical signs and be able to recognize them.

The physical signs obtained on examination indicate to the observer the condition of the organs examined, and from the consideration of these physical signs together with the subjective symptoms and history of the patient, the diagnosis of the disease producing the pathological changes is made. The diagnosis should never be made from the physical signs alone.

Physical Examination of the Lungs.

Topography of the Chest.—For convenience in description and for reference the surface of the chest is divided into anterior, lateral, and posterior regions by vertical and transverse lines.

Vertical Lines.—Anterior median or mid-sternal; sternal line drawn parallel to the edge of the sternum; mid-clavicular line drawn downward from the middle of the clavicle, usually passes through the nipple in men, and is, therefore, sometimes called the mammary line; parasternal line, drawn midway between the sternal and mid-clavicular lines; anterior axillary line drawn through anterior fold of axilla; mid-axillary line and posterior axillary line drawn through middle of axilla and posterior fold respectively; scapular line drawn vertically through angle of scapula when the arm hangs at the side; posterior median line.

Transverse Lines.—On the anterior surface of the chest transverse lines are drawn parallel to the lower borders of the third and sixth ribs, the latter of these lines prolonged also divides the upper from the lower axillary

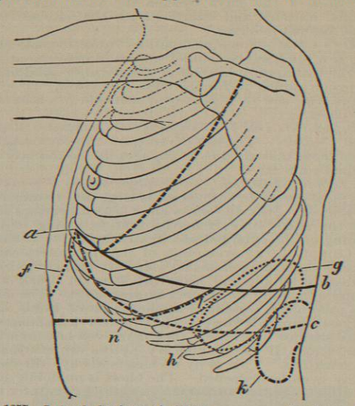

Fig. 1257.—Lateral Surface of Chest. ———, Continuous line, lower border of left lung; - - - - - -, broken line, fissure between left upper and lower lobes, lower border of pleura; . . . . . , dotted line, spleen and liver; — . — . —, dot and dash line, stomach and kidneys; *ab*, lower edge of left lung; *ac*, lower border of pleural sac; *f*, edge of left lobe of liver; *g*, posterior, *h*, anterior end of spleen (when oval in shape); *k*, lower edge of left kidney; *n*, greater curvature of stomach. (From Sahli.)

regions; on the posterior surface lines are drawn parallel to the second rib, through the spine of the scapula, and joining the angles of the scapulæ.

Anterior Regions.—Supraclavicular, above the clavicle; clavicular, that portion of chest covered by clavicle; infraclavicular region, from lower border of clavicle to lower border of third rib; mammary region, from lower border of third to lower border of sixth rib; inframammary region, from lower border of sixth to free border of ribs; upper sternal to lower border of third rib, and lower sternal, from lower border of third rib to ensiform cartilage.

Lateral Regions.—Axillary region to lower border of sixth rib; infra-axillary, from lower border of sixth to free margin of ribs.

Posterior Regions.—Upper scapular, from second rib to line of spine of scapula; lower scapular, from spine of scapula to angle of scapula; infrascapular, from line joining angles of scapulæ to twelfth rib; interscapular region, that portion of posterior surface which lies between the scapula and the spine.

Relation of the Borders and Fissures of the Lungs to the Surface of the Chest.—Anteriorly, the apices extend from half an inch to an inch and a half above the clavicle, and posteriorly as high as the seventh cervical vertebra (Fig. 1259). The anterior borders pass down behind the sterno-clavicular articulation and meet in the median line opposite the

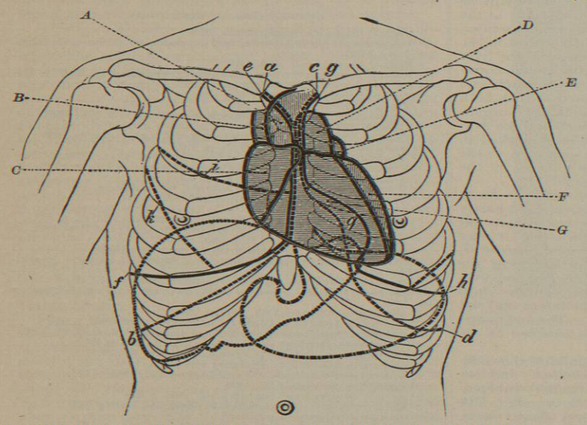

Fig. 1256.—Anterior Surface of Chest. ———, Continuous line, border of lungs; - - - - - -, broken line, fissures between lobes and line of pleura; . . . . . , dotted line, liver; — . — . —, dot and dash line, stomach; ═══, double line, heart and great vessels. *A*, Aorta; *B*, vena cava superior; *C*, right auricle; *D*, pulmonary artery; *E*, left auricle; *F*, left ventricle; *G*, right ventricle; *ab*, border of right pleural sac; *cd*, border of left pleural sac; *ef*, edge of right lung; *gh*, edge of left lung; *i*, fissure between right upper and middle lobes; *k*, fissure between right middle and lower lobes. (From Sahli's "Lehrbuch der klinischen Untersuchungs-Methoden," etc.)

second ribs. They remain in contact as far as the fourth ribs; at this point the right border passes down to the sixth rib in the median line, thence passing outward and downward, the lower border in quiet respiration reaching the sixth rib in the mid-clavicular line, the eighth in the mid-axillary line (Fig. 1257), the ninth or tenth rib in the scapular line, and the eleventh rib near the spine; at the fourth rib the left border passes outward to the fifth costo-chondral junction, then downward and inward to the sixth rib, and then outward and downward. The lower border of the left lung is usually a little lower than the right.

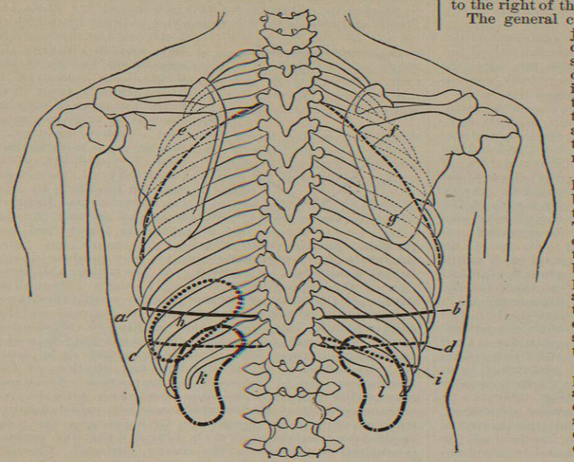

Fig. 1258.—Posterior Surface of Chest. ———, Continuous line, lower border of lungs; - - - - - -, broken line, fissures between lobes, and line of pleura; . . . . . , dotted line, spleen and liver; — . — . —, dot and dash line, kidneys. *e*, Fissure between left upper and lower lobes; *f*, fissure between right upper and lower lobes; *g*, beginning of fissure between right upper and middle lobes; *ab*, lower edge of lung; *cd*, lower border of pleural sac; *h*, spleen; *i*, lower border of liver; *k*, left kidney; *l*, right kidney. (From Sahli.)

The Fissures between the Lobes.—The fissure between the left upper and lower lobes and between the right middle and lower lobes may be indicated by a line drawn from the third dorsal vertebra to the sixth rib in the mid-clavicular line (Fig. 1258). This line corresponds roughly with the vertebral border of the scapula when the elbow is raised and the hand placed on the head. The fissure between the right upper and middle lobes meets the fissure between the upper and lower lobes at the axillary border of the scapula and passes almost horizontally forward to the junction of the fourth costal cartilage with the sternum (see Figs. 1256, 1257, 1258).

The right lung consists of three lobes, which bear the following relations to the surface of the chest: Anteriorly the upper lobe extends to the fourth or fifth rib, and the middle lobe from the fourth to the sixth rib. Laterally the upper lobe extends to the fourth rib, the middle lobe to the sixth rib, and the lower lobe to the eighth rib. Posteriorly the upper lobe extends from the apex to the spine of the scapula, the lower lobe extends from this point to the base. On the left side the upper lobe occupies the whole of the front of the chest; laterally the upper lobe extends to the fourth rib, below this the lower lobe to the base (Figs. 1256 to 1259).

Trachea and Bronchi.—The trachea deviates in its lower part a little from the median line and bifurcates behind the right edge of the sternum at the junction of the lower border of the second costal cartilage and the sternum. This point corresponds posteriorly with a point a little to the right of the spine of the fourth dorsal vertebra.

The general course of the main bronchi may be projected on the posterior surface of the chest as follows: The right bronchus starts at a point to the right of the spine of the fourth dorsal vertebra and extends in nearly a straight line to a point on the eighth rib two inches to the right of the spine. The left bronchus originating at the same point, passes outward and then downward to a point on the eighth rib three inches from the median line.

The calibre of the right bronchus is larger than that of the left, and this bronchus forms a more direct continuation of the trachea than does the left. This explains the fact that most foreign bodies which pass into the trachea through the larynx are found in the right bronchus. The bronchi are nearer to the posterior surface of the chest than to the anterior. The position and relations of the bronchi are important and help to explain the physical signs in the interscapular regions, and the differences in the signs at the apices of the lungs.

Diaphragm.—The dome of the diaphragm on the right side extends as high as the fourth intercostal space in the mid-clavicular line, in the axillary line to the sixth rib, and in the scapular line to the eighth rib. On the left side the diaphragm occupies a somewhat lower position.

Liver.—On the right side in mid-clavicular line the liver extends from the fourth space to the free border of the ribs. From the fourth space to the sixth rib the liver is separated from the chest wall by a wedge of lung tissue, below this point it is in contact with the chest wall. In the right axillary and the scapular lines the liver's upper border corresponds with the lower border of the lung (Figs. 1256 to 1258).

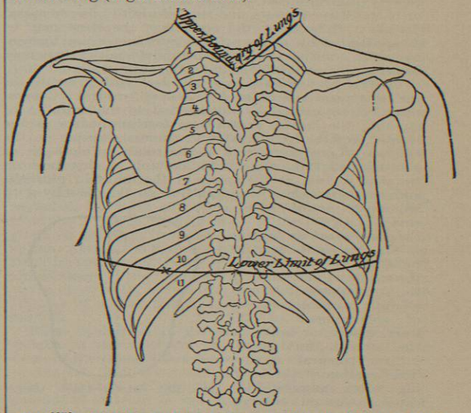

Fig. 1259.—Posterior Surface of Chest, Showing the Relation of the Upper and Lower Limits of the Lungs to the Chest Wall. (From Sahli.)

Spleen.—The spleen lies beneath the ninth, tenth, and eleventh ribs. Its upper border follows the ninth rib, and its anterior border extends to a line drawn from the tip of the eleventh rib to the left sterno-clavicular articulation (Figs. 1257 and 1258).

The lungs may be examined with the patient in either the standing, or sitting, or recumbent position. It is important that the position be a comfortable one, and that the patient's arms and legs are symmetrically placed. The patient should also be stripped to the waist.

INSPECTION.—By this method of examination the form, the size, and the movemenst of the chest in respiration are studied, and under this head the investigation of the organs of the thoracic cavity by means of the *x*-rays may also be included.

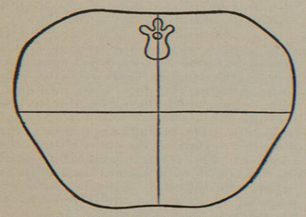

FIG. 1260.—Normal Chest. (Gee.)

Form.—The normal adult chest is elliptical in shape, the transverse diameter longer than the antero-posterior, and the two sides practically symmetrical; on measurement, however, the right is usually about half an inch larger than the left (Fig. 1260).

The supraclavicular regions are somewhat depressed, and there is generally a slight depression just below the clavicles; the remainder of the anterior surface of the thorax is convex from above downward and from side to side. The epigastric angle is nearly a right angle. The spine is usually straight, but may incline slightly to the right in the upper and middle dorsal regions. In children's chests the two diameters are nearly equal, and the chest nearly circular in form. The apex beat of the heart is often visible in the fifth intercostal space about one inch inside the mid-clavicular line.

As the result of disease deviations from the normal form of the chest occur; the more common of these are the rickety, pigeon-breast, phthisical or alar, emphysematous or barrel-shaped chests, and the deformities due to spinal disease. Changes in the contour of the chest may be demonstrated by means of the cyrtometer (see *Cyrtometer*). In addition to these general deformities there may be retraction or enlargement of the chest walls.

Retraction or *sinking in of the chest wall*, generally of the intercostal spaces, may be general or local. General retraction is caused by obstruction to the entrance of air into the larynx or trachea, foreign bodies in the larynx, diphtheritic membrane, tumors pressing on the trachea. Local retraction is the result of collapse or contraction of the lung. An example of this local retraction is seen at the apices of the lungs in phthisis, and at the bases as the result of an old pleurisy with adhesions, or of empyema.

Enlargement or *bulging of the chest wall* may be localized or may involve the whole of one side. In the former case it is usually due to abscess, tumor, or enlargement of the liver, spleen, or heart; in the latter to fluid or air in the pleural cavity. The location of the bulging often suggests the cause. General enlargement of the chest is also seen in cases of emphysema.

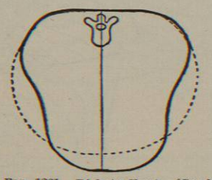

FIG. 1261.—Rickety Chest. (Gee.)

The *size of the normal chest* varies greatly; the average circumference at the level of the nipples is thirty-four inches; it may vary from twenty-eight to forty-four inches. A tape measure is a sufficiently accurate means of determining the size of the chest.

Movements.—During normal respiration the chest expands and contracts, the expansion varying from two to four or five inches. In men and in children the respiration is chiefly abdominal, in women it is of the thoracic type. The normal number of respirations is 18 or 20 per minute; women habitually breathe more rapidly than men. The mobility or expansibility of the chest may be modified by diseased conditions. Emphysema and asthma cause a generally diminished expansion; pleurisy with effusion, pneumonia, and pain, the result of dry pleurisy or injury, may produce a unilateral diminished expansion. At the apices a diminution of the expansibility is usually due to tuberculous disease, at the bases to chronic pleurisy with adhesions.

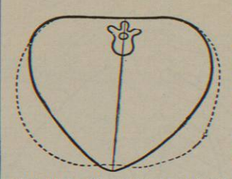

FIG. 1262.—Pigeon Breast. (Gee.)

Expansion is generally increased by exercise, and locally when one lung, or part of one lung, is called upon to do extra work; for example, the sound lung in pneumonia, or the upper lobe of the diseased side in a pleurisy with effusion. The rapidity and rhythm of the respirations are to be noted on inspection. Dyspnœa may be due to fever or to some interference with the free entrance or exit of air, in which case it is called inspiratory or expiratory dyspnœa. Orthopnœa is the term applied to breathing of such difficulty that the patient is obliged to remain in the sitting posture. Cheyne-Stokes respiration is the marked irregularity in rhythm seen in cases of uræmia and cerebral disease.

Litten's sign or the shadow on the lower portion of the chest due to the movements of the diaphragm may also be seen on inspection. To observe this phenomenon, the patient should lie on his back in a slightly raised position with his feet toward the light, which need not be very intense. The observer stands with his back to the light three or four feet from the patient and looks at the chest at an angle of about 45°. During respiration a shadowy line is seen to move over the surface of the chest from above downward. This shadow begins at the sixth rib and moves down with inspiration over two or more intercostal spaces; during expiration the shadow moves upward. This moving shadow is caused by the separation of the diaphragm from the walls of the thorax during inspiration and the returning contact during expiration.

The sign indicates the mobility of the lungs, and its absence, or restriction in the excursion of the shadow, is noted when there is fluid or air in the pleural sac, when pneumonia of the lower lobe exists, when there are pleuritic adhesions or thoracic tumors, and when the lungs are emphysematous. In very stout persons and in patients with very thick chest walls it is sometimes impossible to detect this sign.

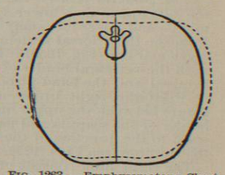

FIG. 1263.—Emphysematous Chest. (Gee.)

Examination by x-Rays.—The *x*-ray has been utilized in the examination of the chest. The use of the method depends on the fact that normal lung tissue is easily traversed by the ray, and any change in density in the lung tissue is indicated in the fluoroscope by lighter or darker areas; lighter than normal when the density of the lung is less than normal, as in emphysema or pneumothorax, and darker than is usual when the density is increased,

as in tuberculosis, pneumonia, carcinoma, pleurisy, or empyema. The diaphragm can be seen to move up and down during respiration; normally it should descend from one to two and a half inches in inspiration, and any diminution in the movements of the diaphragm is suggestive of disease; frequently this limitation in the excursion of the diaphragm is one of the earliest signs of tuberculosis. In pneumonia the darkened areas are distinct, and in a central pneumonia the consolidated area may be seen before any physical signs are noted by percussion or auscultation; the movement of the diaphragm is also limited on the affected side.

In pleurisy with effusion the lower part of the chest is dark and the heart is displaced toward the sound side.

In emphysema the lungs appear brighter than normal and the diaphragm does not rise as high during expiration as it does in the healthy chest.

PALPATION.—This is the examination of the chest by the application of the hand to the chest walls; by this means irregularities in form, local points of pain or tenderness, local expansion, and vocal or friction fremitus can be appreciated. Vocal fremitus is the thrill conveyed to the hand placed upon the chest wall while the patient is speaking. It is due to the transmission downward through trachea, bronchi, and lung substance of the vibrations produced by the vocal cords in the act of speaking. The intensity of the fremitus varies in different individuals, and is always more marked in men than in women; it is diminished by anything which interferes with the transmission of the vibrations to the palpating hand. Thus thick chest walls, from muscle or fat, thickened pleura, or bronchi partially occluded with mucus diminish the fremitus. The fremitus is absent when there is fluid or air in the pleural cavity, or when the pleura is greatly thickened. Consolidation of the lungs, on the other hand, by making a better conducting medium for the vibrations, causes distinct increase of the vocal fremitus.

In some cases of bronchitis in which the breathing is of the sibilant and sonorous variety, vibrations which arise from the sibilant and sonorous rhonchi can be felt. This is called "bronchial fremitus." Friction fremitus, caused by the rubbing together of roughened pleural surfaces, is occasionally felt in cases of pleurisy.

PERCUSSION.—The sounds produced by percussion enable the examiner to determine the condition of the organ beneath the part of the chest percussed. To recognize the difference in percussion sounds, it is necessary to analyze each sound with regard to its quality, pitch, intensity, and duration.

Percussion may be either immediate or mediate. It is important that the patient should be stripped, and that the arms and legs should be in symmetrical positions. For the examination of the anterior surface of the thorax, the patient should stand erect with the hands hanging at the sides and the face pointed straight forward. For examination of the axillary regions, the hands should be placed on the head, or elevated above it; and for the examination of the posterior surface, the arms must be crossed and the hands placed on the opposite shoulders, the back slightly bowed, and the head bent forward. The object of these positions is to put the skin and the underlying muscles on the stretch, and, in the examination of the back, to increase the breadth of the interscapular space.

In immediate percussion the chest wall is struck directly by the finger or the percussor; this method is rarely used. In mediate percussion the finger of one hand, or an instrument called a pleximeter, is interposed between the chest wall and the percussing finger or percussor; this is the method commonly practised. The pleximeter or the finger, used as such, should be applied firmly to the chest wall in the intercostal spaces, and the blow of the hammer or the striking finger should be given as quickly, evenly, and as nearly at a right angle to the pleximeter as possible. For the examination of organs lying near the surface, the pleximeter should be lightly applied, and the blow of the percussor should also be light; for deep-seated organs, the pressure must be firmer and the blow more forcible.

When using the finger for the percussor, the blow must be given from the wrist and not from the elbow or shoulder. The blow should strike the middle of the pleximeter, and the finger striking the blow must be quickly lifted, as the character of the note is decidedly changed and dampened if the finger is allowed to remain in contact with the pleximeter.

It is more satisfactory to use the hands for percussion than to depend entirely on the percussor and pleximeter. The hands are always ready; and, when percussing with the fingers, the observer appreciates the sense of resistance beneath the finger, in addition to the sound produced by the blow. When demonstrating the sounds produced by percussion to a large number of students, the use of hammer and pleximeter is more satisfactory. When it is necessary to compare the percussion notes on the two sides of the chest, the percussion for comparison must be made at the same point on each side, the force of the blows must be the same, the position of the patient must be so arranged that the two sides will be symmetrical, and the percussion should be made at the same period of the respiratory cycle.

On percussing a normal chest beneath the left clavicle a sound is produced, due to the vibration of the lung tissue and the thoracic walls. This sound is called the normal or pulmonary resonance, and it is recognized by the following characteristics: the quality is pulmonary or vesicular, pitch is low, intensity variable, and the duration considerable. The intensity depends on the force of the blow, on the thickness and elasticity of the chest walls, and on the volume of air contained in the portion of lung under percussion. The finger appreciates with this pulmonary resonance an elastic feeling, which is characteristic when percussing over normal lung substance.

The percussion note in the right infraclavicular region is usually slightly less resonant than that on the left side, the quality is less pulmonary, the pitch higher, the intensity less, and the duration shorter. This is probably dependent on the greater muscular development on the right side, and also on the larger amount of connective tissue in the right lung, the result of the greater size of its bronchi.

Normal pulmonary resonance is heard in the following regions: supraclavicular, infraclavicular, axillary, interscapular, and infrascapular.

If percussion is made in the lower part of the mammary region on the right side, a sound is produced differing from the normal pulmonary note in that the quality is dull, the pitch higher, the intensity less, and the duration shorter. This change in the character of the note in this region is due to the presence beneath the lung of the liver, and this solid organ modifies or dulls the normal sound produced by percussing over lung tissue.

Dulness is heard wherever the amount of lung tissue is small, or is encroached upon by solid organs, or when the normal amount of air-containing tissue is diminished as the result of disease.

In the normal chest dulness is found in the mammary region on the right side from the liver and on the left from the presence of the heart. In the infra-axillary regions, on the right from the liver and on the left from the spleen; also in the scapular regions from the excessively thick layers of muscles and bone. Disease, by producing airless tissue in the lungs, the pleura, the pleural cavity, or the chest walls, causes dulness, and, depending on the amount of airless tissue, the dulness may be slight or marked.

There is dulness in the early stages of tuberculosis, usually at the apices of the lungs, from the presence there of the tuberculous deposit. In the second stage of pneumonia there is marked dulness over the consolidated area. In cases of pleurisy with effusion, where the amount of exudate is not large, there is dulness. The same sign is produced by thickened pleura, or by chest walls much thickened by muscle or fat. Enlargements of the heart, liver, or spleen, tumors, aneurisms or ab-

scesses, if covered by a thin layer of lung, will cause dulness on percussion. When percussing over a dull area, the finger appreciates a sense of resistance. This feeling of resistance or lack of elasticity increases as the dulness is more marked.

Flatness.—When the percussion note is entirely without resonance it is said to be flat. The quality is flat, intensity not great, pitch high, and duration short. A typical flat note can be obtained by percussing the thigh. This sound is heard when the percussion is made over solid organs, or over organs, normally air-containing, in which, as the result of disease, the air has been displaced by dense tissue or fluid. Flatness indicates absence of air. In the normal chest flatness may be obtained on the right side in the inframammary region and in the infra-axillary region below the eighth rib from the underlying liver; also in the left infra-axillary region over the spleen.

Percussion over the fluid, in cases of pleurisy with effusion, gives typical flatness, and it is in these cases that the very marked sense of resistance on percussion is so easily appreciated. Flatness on percussion may be heard in cases of pneumonia where the consolidation is complete, also in phthisis, where the consolidated area is extensive; and over tumors and enlarged solid viscera, where the mass or organ is in contact with the chest wall.

Tympanitic Resonance.—Percussion over a hollow viscus containing air elicits a drum-like or tympanitic note; the quality is tympanitic, pitch high or low, intensity usually marked, and duration variable. Typically tympany is heard on percussing over the stomach and intestines; in the normal chest it is heard only over the larynx, trachea, and in Traube's space. The variety in pitch depends on the size of the viscus and the tension of the contained air. Percussion over the stomach gives a much lower note than that over the intestines, the former being a much larger viscus than the latter. Tympanitic resonance is caused by the following conditions:

1. Large collections of air, for example over the trachea, the stomach, the colon, and small intestines; over cavities in the lung substance, especially if superficial, and over pneumothorax, when there is a free communication with a bronchus; if the opening is not free, the air in the pleural sac is under pressure, and the note on percussion is not tympanitic but dull.

2. Percussion over consolidated or compressed lung, which is in contact with a hollow viscus or air-containing organ, often produces tympanitic resonance, by conduction from the adjacent air-containing viscus. This tympanitic resonance is not uncommon over the lower lobe of the left lung even in health, and is the resonance transmitted from a stomach distended with air through the normal lung.

3. Lung that has lost its normal tension or is in a condition of relaxation is tympanitic on percussion. This occurs in cases of pleurisy with effusion, in the early stages of consolidation, pneumonic or tuberculous, and in œdema of the lungs.

4. In emphysema tympanitic percussion is common.

The presence and location of cavities may be determined by careful recognition of the tympanitic note. Several methods have been described by observers, the following being the most useful:

Wintrich's change of note. If the cavity communicates directly with a bronchus, the percussion note varies in intensity and pitch, and also in the distinctness of its tympanitic quality, as the patient opens and closes his mouth. When the mouth is open the percussion note is of greater intensity, higher pitch, and more markedly tympanitic in quality than it is when the mouth is closed.

A change in the patient's position by altering the relation of the bronchus to the cavity may also produce a change in the tympanitic quality of the percussion note.

Gerhardt's change of note depends on the presence of fluid in the cavity, the level of which is changed as the position of the patient is varied from the upright to the recumbent. In the upright position, over the lower portion of the cavity there may be dulness or even flatness on percussion, and tympany over the upper part of the cavity. This condition of physical signs is due to the fact that the fluid gravitates to the lowest part of the cavity. When the patient assumes the recumbent position the fluid level is changed, and tympany is elicited on percussion over that portion of the chest wall which was dull when the patient was erect. This sign, though seldom found, is a positive indication of the presence of a cavity.

In addition to the varieties of percussion resonance already mentioned, the following are heard in diseased conditions of the chest:

Vesiculo-Tympanitic Resonance.—The quality is a combination of normal pulmonary and tympanitic resonance, the pitch high; the more the tympanitic quality predominates the higher will be the pitch; the intensity is increased, and the duration varies. This is the resonance heard commonly in cases of emphysema, and it is often called the wooden or "bandbox" resonance. It may be heard in pleurisy with effusion over that portion of the lung which is above the fluid, and over the sound lobe in pneumonia.

Amphoric Resonance.—The quality is amphoric, pitch variable, intensity and duration are considerable. This sound is like that produced by flipping the cheek when tense, and has a peculiar musical quality. To produce the sound well the percussion should be practised during expiration, and the patient should be instructed to keep the mouth open; it is also necessary that the ear of the observer should be near the patient's mouth. This sound is heard over cavities, usually of considerable size with smooth and rigid walls, which communicate freely with a bronchus. It may more rarely be heard over pneumothorax, but only when there is free communication between the air-containing pleural sac and a bronchus. Percussion over consolidated lung, which is in contact with a large bronchus, may give amphoric resonance.

Cracked-Pot Sound.—The quality of this sound is jingling, pitch high, intensity and duration not marked. It is like the sound produced by striking the hands folded together on the knees. This sound is indicative of cavities with flaccid walls which contain air, and which communicate with a bronchus. Percussion should be practised in the same manner as has been described under amphoric resonance.

Auscultation.—Auscultation is examination of the chest by the ear to hear the sounds produced in normal and abnormal conditions of the lungs during respiration, coughing, and speaking, also to detect the presence of any adventitious sounds.

There are two methods of auscultation, the immediate and the mediate. In the former the ear is placed directly on the chest, or on the chest covered with a thin cloth; and in the latter the stethoscope* is used.

The immediate method is more satisfactory for the examination of the lungs than the mediate method, except in cases in which it is necessary to localize faint adventitious sounds, or when it is desirable to auscultate those portions of the chest where it is difficult or impossible to place the ear in close contact with the thoracic wall; for example, in the supra- or infraclavicular fossæ. Under these conditions the stethoscope is of great use, not only from the fact that it can be used where the ear cannot, but also because it eliminates outside sounds and intensifies the sounds produced within the chest. The stethoscope, however, by modifying and intensifying the respiratory sounds, may cause confusion, and it is only after considerable practice that true deductions can be made as to the conditions of the lungs from the sounds heard through the stethoscope.

On auscultation over normal lung substance a rustling or breezy sound is heard with inspiration and expiration; this is the normal pulmonary or vesicular murmur. The sound heard on auscultation of the trachea and larynx is quite different from that heard over normal lung tissue:

* For descriptions of the various forms of stethoscopes, and their modifications, see article on *Stethoscopes*.

it is a much harsher and more tubular sound, and is called laryngeal, tracheal, or tubular breathing.

Of the several theories as to the cause of the respiratory sounds, the following is the most satisfactory: A fluid, either liquid or gas, in this case air, passing with sufficient velocity through a narrow opening into a wider channel produces a sound. Such a condition obtains at two points in the respiratory system, the larynx and at the ends of the bronchioles, where they enter the alveoli of the lungs. At the larynx, the arrangement of the vocal cords is such that sounds are produced in both inspiration and expiration. At the bronchiole endings a sound is produced during inspiration, but not during expiration, as the air then is passing from a larger into a smaller space.

The laryngeal sounds, therefore, are of purely glottic origin, and may be distinctly heard over the larynx, the trachea, or the back of the neck.

The pulmonary murmur heard over the chest wall is a combination of the laryngeal sound, modified by transmission through the bronchi and lung tissue, and the sound produced in the bronchioles. The intensity of the laryngeal sound is greatly diminished by its transmission through the thin-walled smaller bronchi, which contain so many openings that the sound is much diffused. For this reason vesicular breathing is a very soft sound. The inspiratory portion is heard throughout the inspiratory act, and is composed of two elements, the glottic and the alveolar; the expiratory portion, consisting only of the glottic element, is a mere puff, oftentimes indeed it is inaudible. The fact that the expiratory sound is conducted to the ear of the examiner against the current of air producing the sound is another factor in causing the marked diminution in the intensity of the expiratory sound.

Respiratory sounds are studied by considering the quality, pitch, intensity, and duration of the sound, and also the rhythm. The inspiratory and expiratory sounds should be separately considered.

Pulmonary or Vesicular Breathing.—Normal vesicular inspiration has a breezy or rustling quality, low pitch, variable intensity, and the sound is heard throughout the inspiratory act; the quality of expiration is soft and blowing, low in pitch, and short in duration; the rhythm is unbroken, *i.e.*, there is no pause between inspiration and expiration. Expiratory sound is not always audible. Inspiratory sound is three or four times as long as expiratory. Pulmonary breathing is heard over the anterior, lateral, and posterior surfaces of the thorax.

Puerile or Supplementary Respiration.—On listening to the chests of children and also of adults, when the lungs are doing extra work, as after violent exercise or where a sound lung is doing the work for a diseased lobe in addition to its own, the normal vesicular breathing is heard much more distinctly than usual. The quality is the same as that of normal vesicular breathing, but the intensity is much increased or exaggerated. This is called "puerile," "supplementary," or "exaggerated" respiration.

Diminished Respiration.—In diminished respiration the quality is that of normal vesicular breathing, but the intensity is greatly diminished. This occurs whenever there is any interference with the circulation of the air in the lungs, or with the conduction of the sounds to the ear of the examiner.

The free entrance and exit of air may be prevented by the presence in the trachea or bronchi of secretions, diphtheritic membrane, or foreign bodies, by spasm of the bronchi, or by the pressure of tumors. Emphysema and tuberculosis, by diminishing the elasticity of the air vesicles, also restrict the free circulation of air in the lungs, and pain or great muscular weakness may so interfere with the respiratory movements that but little air enters and leaves the lungs.

The conduction of the breathing sounds to the ear may be obstructed by the presence of fluid in the pleural sac, or by thickened pleura or chest walls.

Suppressed Respiration.—Absence of respiration occurs when there is complete obstruction of a bronchus from any of the above-mentioned causes, no matter what the condition of the lung substance may be; also over fluid in the pleural sac, in pneumothorax, if the opening between the bronchus and the pleural sac is closed, and over cavities filled with fluid.

Prolonged Expiration.—At the right apex a slight prolongation of the expiration is not uncommon in normal chests. When heard in other situations, however, it is an abnormal sign and indicates a difficulty in expelling the air during expiration—in other words, an expiratory dyspnœa. In emphysema and asthma prolongation of expiration is heard all over the chest. It may also be heard in cases of bronchitis, in which the bronchi are partially occluded with mucus; and in tuberculosis, from the loss of elasticity of the lung substance due to the consolidation, it is one of the earliest physical signs.

Cogwheel or Interrupted Inspiration.—The inspiratory murmur may be interrupted or jerky in rhythm; this is sometimes heard when examining the chests of very nervous patients, and it is often one of the physical signs of early tuberculous consolidation. It occurs in this condition because, from the presence in the bronchi of deposits of tubercle, an obstruction is offered to the entrance of air into the lobules, which instead of being distended at the same time by the entering air are expanded at different times, thus producing the uneven or interrupted rhythm. Unless accompanied by other physical signs, it is of no value in diagnosis.

Laryngeal, Bronchial, or Tubular Breathing.—This breathing is normally heard over the larynx and trachea, and also may be heard over the back of the neck. The inspiration is tubular in quality, of high pitch, marked intensity, and the duration of the sound somewhat shorter than the inspiratory act. Expiration has the same tubular quality, but the pitch is higher, the intensity usually greater, and the duration as long as or even longer than that of inspiration. The rhythm is broken by an appreciable pause between the inspiratory and expiratory sounds.

When bronchial breathing is heard over those portions of the chest where normally vesicular breathing should be heard, it is a sign that the lung is in a condition of consolidation.

The occurrence of bronchial breathing over consolidated lung may be explained in this manner: The bronchial tubes are like speaking tubes, normally poor ones, as their walls are thin and interrupted by the numerous openings of the bronchioles; the laryngeal sounds in their transmission from the point of production to the chest wall through these poor conducting tubes are much diffused and changed in character. When the lung is consolidated, however, the thin walls of the bronchi are stiffened and supported by the surrounding consolidation, their resistance is increased, and the diffusion of the vibrations is diminished. In other words, consolidation makes good speaking tubes of the bronchi, and the laryngeal sounds are well conducted, with little change in their character, to the wall of the chest.

Consolidation may be due to pneumonia, phthisis, to new growths in the lung substance, to infarcts, and to compression of the lung by fluid or tumors.

Bronchial breathing is also heard over cavities which communicate freely with a bronchus, and also over dilated bronchi. In these conditions the laryngeal sounds are conducted through fairly large bronchi directly to the cavity or dilatation of the bronchus, and these bronchi are often quite close to the chest wall, and usually, in the case of a cavity, are surrounded by an area of consolidation. Should the bronchus conducting the sound vibrations to the consolidated area become occluded, no bronchial breathing will be heard. In pneumonia, for example, the bronchi may become filled with inflammatory products, and the conduction of the laryngeal sounds may be thus interrupted. If the patient be made to cough, the mucus will be expelled and the tubes cleared, then bronchial breathing will again be audible.

Broncho-Vesicular Breathing.—This, often called harsh or rude respiration, is a respiratory sound combining

characteristics of bronchial and vesicular breathing. The bronchial element may predominate or the vesicular may be the more marked. In inspiration the quality is broncho-vesicular; the pitch is high in comparison with that of normal pulmonary inspiration, intensity is more marked, and duration the full length of the inspiratory act. The quality of expiration is also broncho-vesicular, pitch higher than that of inspiration, intensity greater, and the duration as long as or longer than that of inspiration. The rhythm is not broken.

This breathing is heard in the normal chest in the infraclavicular region near the sternum, and in the upper part of the interscapular region, because the bronchi are large and near the chest wall in these localities, and the sounds produced in the larynx are therefore little diffused or modified in transmission to the observer's ear.

When heard over portions of the chest where normally vesicular breathing should be heard, it is an indication of smaller or larger areas of consolidation surrounded by normal lung tissue. Therefore we may have this variety of breathing in cases of phthisis in which the infiltration is slight, or when a deep-seated pneumonia is surrounded by normal lung tissue. This variety of breathing may be heard over the portion of the lung compressed by fluid in cases of pleurisy with effusion.

The greater the infiltration or consolidation, the more marked will be the bronchial element in the respiratory sounds; the less the amount of consolidated lung, the more will the vesicular element predominate in the breath sounds.

Cavernous Breathing.—This variety of the respiratory sounds is heard over cavities, and has a hollow, blowing character, from which the sound takes its name. The quality of inspiration is cavernous, pitch low, intensity variable, and duration full length of the inspiratory act. Of expiration the quality is the same as that of inspiration, pitch is lower, intensity variable, and the duration usually longer than that of inspiration. The rhythm is not broken. Cavities over which this breathing is heard must have free communication with a bronchus; otherwise there will be an absence of breath sounds.

If the cavity is surrounded by consolidated lung, there may be a decided bronchial character to the cavernous breathing, which is called broncho-cavernous breathing; and should the cavity lie in fairly normal lung substance, the vesicular element will be marked, and a vesiculo-cavernous respiratory murmur be heard.

Amphoric Respiration.—The peculiarity of this sound lies in the musical quality, which may be imitated by blowing over the mouth of an empty bottle. The inspiration is of amphoric quality, fairly low pitch, and of some duration. Expiration is like inspiration, except that the expiratory sound is much prolonged. This breathing is heard over cavities usually large with smooth walls, and in pneumothorax or hydropneumothorax. The cavity must have free communication with a bronchus or there will be no sound during respiration. The sound indicates a cavity containing air that is not expelled on expiration.

Sibilant and Sonorous Breathing.—In sibilant breathing the quality of the sound is whistling or wheezing, and the pitch high, with marked prolongation of the expiratory murmur. Of sonorous breathing the quality is snorting or snoring and the pitch low; expiration is also prolonged. The intensity is variable. These sounds are indicative of diminution of calibre of the larger and smaller bronchi. This narrowing may be due to the presence in the bronchial tubes of viscid mucus, the product of inflammatory processes, or to the spasmodic contraction of the muscle fibres within the bronchial walls. The former condition obtains in bronchitis, the latter in spasmodic asthma.

These sibilant and sonorous sounds, or rhonchi, are heard in inspiration, in expiration, or in both; they are not constant, and often disappear if the patient be made to cough. Occasionally the sounds are so loud that they may be heard without placing the ear on the chest wall: and sometimes a fremitus may be appreciated by the palpating hand, the so-called bronchial fremitus.

Signe de Sou or Bell Sound.—This sound is heard when the chest is percussed with two coins, one used as pleximeter and the other as percussor, and the ear is applied to the opposite side of the chest. The sound transmitted through healthy lung is of a wooden quality; that heard when fluid is present is of a metallic character; while the sound transmitted through air, in pneumothorax for example, is clear and ringing, like a bell.

Auscultation of the Voice and Whisper.—The voice sounds heard over the chest on auscultation are the sounds produced by the vibrations of the vocal cords, which are transmitted through the bronchial tubes to the alveoli of the lungs and the thoracic walls. Those conditions which in any way modify the breath sounds produced in the larynx will also change the character of the voice sounds, whether spoken or whispered. The patient should count "one, two, three," but not too rapidly and in a moderately loud voice.

Pulmonary voice or normal vocal resonance is heard over normal lung substance. The quality is pulmonary; pitch low, and the intensity feeble; it is an indistinct sound seemingly distant and diffused. In men the voice sound is usually much more marked than in women and children; the intensity varies with the quality of the voice; being more marked in deep voices than in high voices. The thickness of the chest wall also modifies the intensity of the sound. Pleuritic adhesions, much adipose and muscle, fluid in the pleural sac, as well as air, all diminish the intensity of the vocal resonance.

If the pleural effusion is large, and over consolidated lung, if the bronchi are occluded, the vocal resonance is absent.

In the infraclavicular regions the vocal resonance is usually increased; this is also true of the voice sounds heard in the interscapular space. In the early stages of pneumonia and in phthisis, in which the amount of consolidation is slight, the voice sounds are increased in intensity: also over cavities lying near the chest wall.

If the person examined be asked to whisper "one, two, three," the examiner hears during expiration the normal bronchial whisper. The sound resembles the normal expiratory sound; it is feeble and blowing in quality, and may oftentimes be inaudible.

When there is moderate consolidation the whispered voice is much more intense, and is not unlike the respiratory sound heard in broncho-vesicular breathing.

Laryngeal or Bronchial Voice.—Bronchophony. This may be normally heard over the larynx and trachea. The quality is laryngeal, the pitch high, intensity great, and the distinctness marked; the sound seems near, there is a marked thrill, and a sensation, like a shock or concussion, is conveyed to the ear. When the lung is consolidated or compressed, so that the bronchial tubes have been made good conductors of sound, bronchial voice is heard at those points of the chest wall which lie above the consolidated area. It may also be heard over cavities, and sometimes over fluid.

Ægophony, which is a modification of bronchophony, has the same intense character, but in addition has a bleating or tremulous quality, from which it derives its name, the quality being likened to the bleating of a goat. It is best brought out by having the patient repeat words like "brant" or "rant." It is significant of a small amount of fluid in the pleural sac, and is heard in pleurisy with effusion, where the effusion is not great and where a thin layer of fluid lies between the lung and the chest wall. It is not a common sign. The most usual location for this sign is at the angle of the scapula.

Pectoriloquy, another variety of bronchophony, is that voice sound where, in addition to the voice, the articulation of the words is distinctly appreciated. It can be heard best when the patient whispers, and is indicative of the presence of a cavity; it may also be heard over consolidated lung, where the consolidated area is in contact with a large bronchus.

Amphoric voice has the quality of amphoric breathing, and is heard when there is air in the pleural sac, or over large cavities; the same conditions of the lung

in which amphoric percussion note and breathing may be heard.

Metallic tinkle is the sound produced, during breathing and talking in cases of hydropneumothorax, by the dropping of fluid in the pleural sac. This sound is also heard when there is a large cavity in the lung, containing fluid.

When listening over a cavity, after the patient coughs, a suction-like sound may frequently be heard. This is caused, in all probability, by the sudden expansion of the cavity, after the violent expulsive effort of coughing, and the rush of air back into the cavity. It is a sign distinctive of the presence of a cavity in the lung substance, which is in free communication with a bronchus. Should the bronchus become occluded the sound would not be heard.

Râles.—Râles are adventitious sounds, which are never heard in the normal chest. They may be produced in the larynx, trachea, bronchi, alveoli, in the pleura or in cavities. The character of the râle depends entirely on the point at which the sound is produced.

Crepitant Râles.—The finest of all râles is the crepitant râle. This is a fine, dry, crackling sound, which is heard only at the end of inspiration and does not disappear when the patient is made to cough; coughing in fact often makes the sound more intense. The sound is likened to the crackling of burning salt, or of hair rubbed between the fingers. It is heard in puffs and seems close under the observer's ear.

There are two theories as to the production of the crepitant râle; one considers the sound a pure friction sound produced in the pleura by the rubbing of the roughened surfaces against one another; the other believes that the sound is caused by the separation of the adhering surfaces of the alveoli, when the air enters the alveoli during inspiration.

The first theory explains satisfactorily the production of the fine crepitations heard in dry pleurisy; whereas the latter seems the more satisfactory explanation of the crepitant râles heard in the early stages of pneumonia before consolidation is complete, and again in the later stages, when resolution is beginning. At both of these periods the walls of the air vesicles are held in contact by the products of inflammation, and are separated by the entrance of air at the end of inspiration.

Crepitant râles are heard in pneumonia, in phthisis, in dry pleurisy, and at times after a full inspiration at the bases of lungs of patients who breathe superficially and are confined to bed.

Subcrepitant râles are fine, moist, crackling or bubbling sounds heard with inspiration, expiration, or with both, and which disappear when the patient coughs. These sounds are probably produced by small bubbles of air breaking through the mucous or inflammatory exudate in the bronchioles. They are commonly heard in bronchitis, pneumonia, phthisis and œdema of the lungs.

Coarse, Mucous, or Bronchial Râles.—The cause of these sounds is the same as that of subcrepitant râles, but the point of production is in the larger bronchi, where more inflammatory exudate is collected, through which during respiration a larger volume of air must pass. The same pathological conditions are indicated by the presence of these sounds, viz., bronchitis, pneumonia, phthisis, etc.

In cavities containing fluid, when the bronchus communicating with the cavity opens below the level of the fluid, gurgling râles are produced by the entrance and exit of air; the quality of these sounds is moist and coarse, and is suggestive of large bubbles of air passing through fluid.

Friction Sounds.—When the surfaces of the pleura are inflamed and move during respiration upon one another, a rubbing or creaking sound is produced. These friction sounds may be fine and dry, like crepitant râles; they are heard with expiration as well as with inspiration, they may be moist and coarser and resemble subcrepitant râles, or they may be creaking and rubbing in quality. The sound is close under the ear, and may be intensified by making firm pressure with the stethoscope; also, in contradistinction to râles produced in the lung substance, they do not disappear when the patient coughs.

Dry pleurisy, pleurisy with effusion, when the fluid is absorbed, pneumonia and phthisis, all may cause the presence of friction sounds.

Succussion.—This is a splashing sound produced by shaking the patient in cases in which there are air and fluid in the pleural sac, or in which there is a large cavity containing air and fluid. It is not uncommonly heard over the normal stomach when it is partially filled with fluid.

Physical Examination of the Heart.

The same methods are employed in examining the heart that are used in examining the lungs; and thus the size of the heart, the character of its impulse, the rhythm, and the sounds (both normal and abnormal) may be determined.

Topographical Anatomy.—The heart is placed somewhat more to the left of the median line than to the right. The anterior surface, that which is in contact with the chest wall, is composed chiefly of the right auricle and ventricle, and of a narrow strip of the left ventricle. The base of the heart, formed by the right auricle, the great vessels, and the left auricular appendix, lies at the level of the upper border of the third costal cartilage, and extends nearly an inch to the right and left of the sternum (Fig. 1256).

The apex, the tip of the left ventricle, lies normally in the fifth intercostal space about one inch within the mid-clavicular line.

The right edge, which begins at the third costal cartilage on the right of the sternum and extends to the junction of the fifth costal cartilage with the sternum, is composed of the right auricle. The line of the right edge is somewhat curved with the convexity directed to the right.

The inferior edge is formed by the right ventricle and the apex of the left; it extends from the fifth costo-sternal junction to the apex of the heart.

The left edge of the heart is made up entirely of the left ventricular wall, and extends from the apex to the upper border of the third rib, about one inch to the left of the sternum. The groove which separates the right auricle from the right ventricle may be indicated by a line drawn on the surface of the chest from the third left to the sixth or seventh right costo-sternal junction. The ascending part of the aorta is in closest relation to the chest wall in the second right intercostal space, slightly beyond the edge of the sternum. The pulmonary artery is in the corresponding position to the left of the sternum (Fig. 1256).

The orifices of the heart are situated beneath the left half of the sternum, and near together. The aortic and pulmonary at the level of the third costal cartilage, the mitral and tricuspid at the level of the fourth and fifth respectively.

Inspection.—The location of the apex beat and its character—that is, whether the visible impulse is well defined, diffused, heaving, or wave-like—may be observed by inspection. Bulging or retraction in the præcordial region, pulsation of the vessels in the neck, and pulsation in the epigastrium may also be noted.

Normally the site of the apex beat is in the fifth space about one inch within the mid-clavicular line; it is well defined and localized (Fig. 1256). Often the apex beat is not visible on account of the thickness of the chest wall, the depth of the chest and consequently the distance the apex may be from the thoracic wall, or because the apex is separated from the chest wall by lung tissue as in emphysema.

Bulging of the præcordium may be caused by hypertrophy of the heart, by fluid in the pericardial sac, by aneurism (in which case the bulging is situated at the base of the heart), or by tumors. Retraction, usually in the third, fourth, and fifth left intercostal spaces, and occurring with the systole, may be due to adherent pericardium or to atmospheric pressure; this is the more common cause, and it occurs in hypertrophy or dilatation, in which conditions the volume of the heart is much