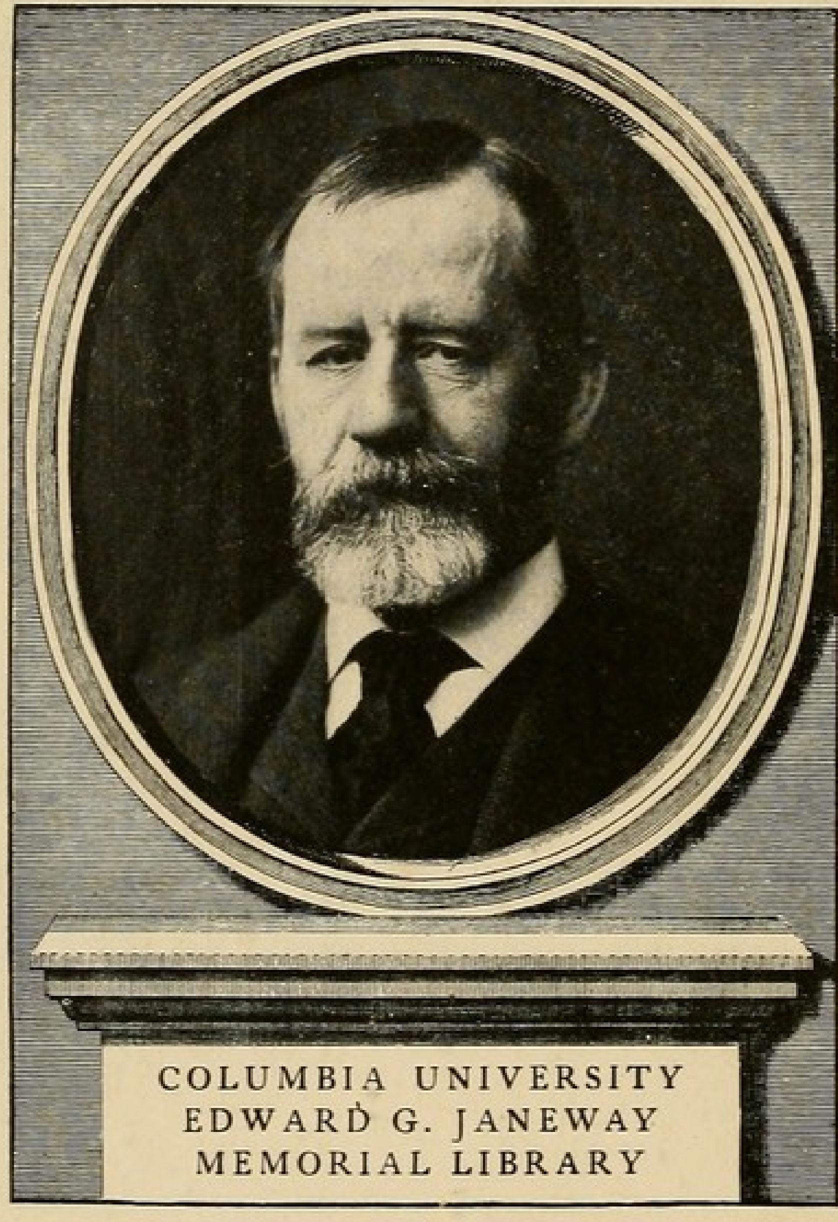
Physical Diagnosis

Tyson

THIRD EDITION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OF

PHYSICAL DIAGNOSIS.

TYSON.

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MANUAL

OF

PHYSICAL DIAGNOSIS

FOR THE USE OF

STUDENTS AND PHYSICANS.

BY

JAMES TYSON, M. D.,

PROFESSOR OF CLINICAL MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA AND PHYSICIAN TO THE UNIVERSITY HOSPITAL; PHYSICIAN TO THE PHILADELPHIA HOSPITAL; FELLOW OF THE COLLEGE OF PHYSICIANS OF PHILADELPHIA; MEMBER OF THE ASSOCIATION OF AMERICAN PHYSICIANS, ETC.

THIRD EDITION, REVISED AND ENLARGED,

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PREFACE TO THIRD EDITION.

Advantage has been taken of the opportunity afforded by the demand for another edition of this manual to improve it and extend it as far as consistent with the original purposes of the book. The section on the examination of blood has been enlarged, so as to meet more completely the requirements of a modern blood examination. The same may be said of the section on the chemical examination of gastric contents. A number of new illustrations have been introduced, together with other additions of a minor character, all intended to add to the accuracy and usefulness of this book. I am indebted to Prof. A. C. Abbott and Dr. Alfred Stengel for assistance in the technique of the blood and bacteriological examinations.

1506 Spruce Street,

June 1, 1898.

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MANUAL

OF

PHYSICAL DIAGNOSIS.

GENERAL CONSIDERATIONS.

The term physical diagnosis strictly defined would include the diagnosis or investigation of disease by the aid of all the special senses, but practically it is confined to eliciting such information as can be furnished by vision, touch, and hearing, whence come the terms *inspection*, *palpation*, and *auscultation*. The information acquired by hearing is further subdivided into: 1st. That gained by listening directly to the various normal sounds and their modifications as produced by morbid states, and to certain new sounds produced by such states. 2d. Information gained by striking or percussing the part to be investigated. Hence, too, the words auscultation and percussion are constantly used in association.

The information furnished by inspection is also rendered more accurate by measuring or *mensuration*, when this can be applied. Thus constituted, physical diagnosis is applied to any portion of the body, but it is more especially in the study of diseases of the thoracic and abdominal contents, and particularly the former, that it is useful. The phenomena thus learned are known as physical signs. The use of the term "physical" is based upon the fact that it is through alterations in the physical properties of the tissue or organ investigated that information is obtained, such as the shape, density, transparency. On the other hand, in its usual application there is a limitation inconsistent with strict accuracy. Thus there is no more accurate means of recognizing physical states than by thermometry, yet thermometry is not one of the measures included under physical diagnosis.

It is very true that a knowledge of physical signs cannot be acquired from books and must be learned at the bedside; but we may record their import and significance in the recognition of disease and render somewhat easier their study. To this end is indispensable a familiarity with the physical condition of the organs of the body in a state of health. This, too, can only be learned on the living subject by giving the student an opportunity to listen until he is thoroughly familiar with the normal breathing- and heart-sounds, to observe the normal shape and configuration of the body, and to learn the percussion note characteristic of different regions over important organs, as the heart, lungs, and various abdominal viscera. Such a study of the situation of internal organs in relation to external parts, for the purposes of the physician, constitutes *medical anatomy*.

The attainment of the objects of physical diagnosis is greatly facilitated by mapping out the body into certain spaces or areas, of which we consider first the

REGIONS OR SPACES OF THE CHEST.

Starting with the **clavicle** and **sternum** as landmarks in physical examination, above each clavicle, in health, is usually a slight depression known as the **supraclavicular fossa**, and above the sternum another known as the **suprasternal notch.** Below each clavicle is the **infraclavicular space,** which is somewhat arbitrarily bounded below by the upper edge of the 3d rib and adjacent cartilage, internally by the edge of the sternum, and externally by the base of the shoulder or a line drawn vertically from the inner end of the outer fourth of the clavicle. Below the clavicle, as well as above, in health, is usually a slight depression. All these depressions or spaces are liable to become deeper in emaciation, and are less conspicuous in fat persons. Below the upper edge of the 3d rib is the **mammary region,** bounded internally by the edge of the sternum, externally by the above described vertical line, and below by the upper margin of the 6th rib. Nearly in the centre of the mammary region is the nipple, which in males and young girls is just below the 4th rib. A line drawn vertically through it is known as the **mammillary line.** The **mid-cla-**

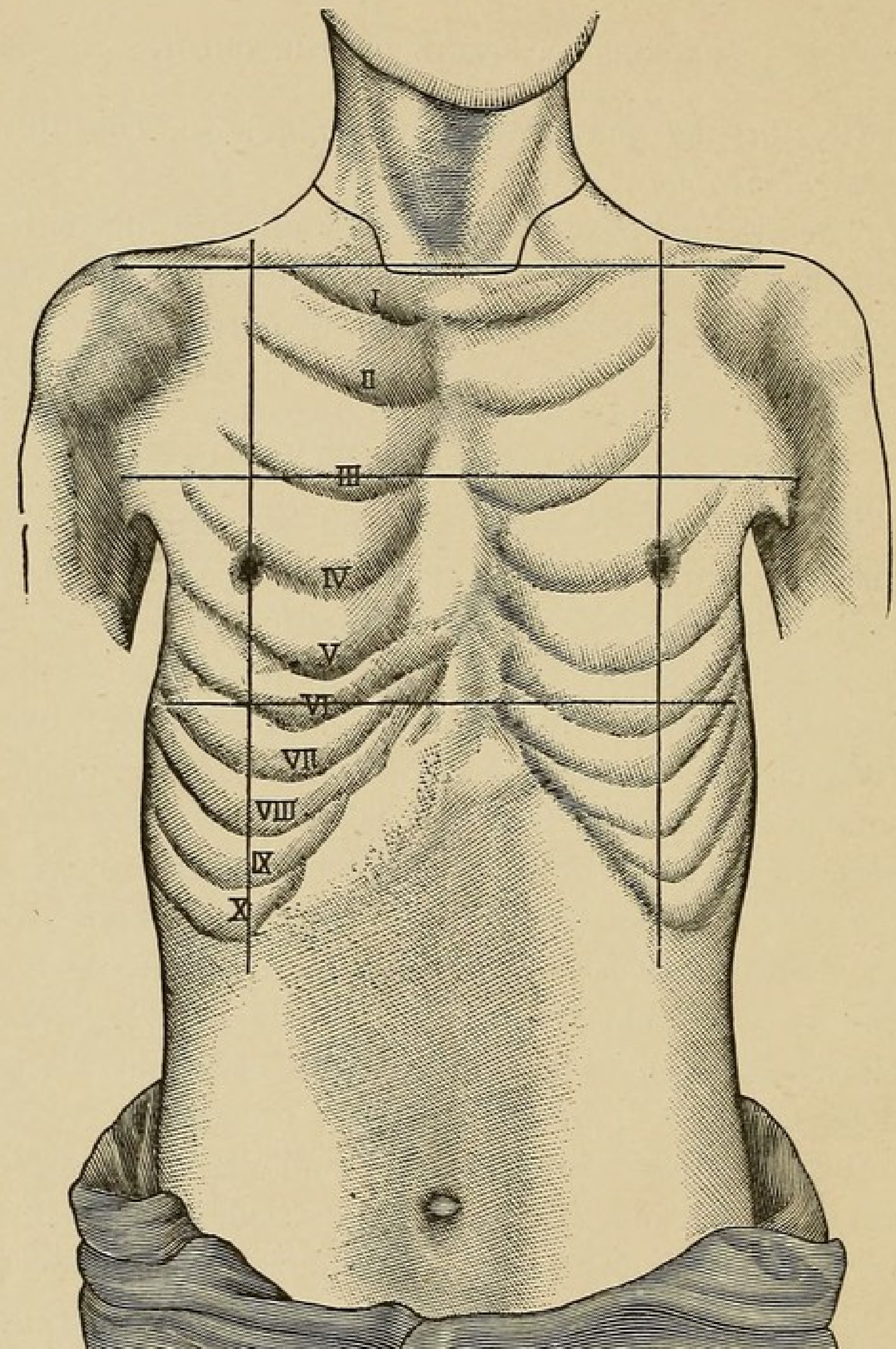

Fig. 1.—Regions of the Thorax, Anterior Aspect.

The figure is taken from a photograph of a living subject on which the ribs were made more distinct by chalk. While the chest is fairly typical, the distance between the end of the ensiform cartilage and the umbilicus, which varies in different individuals, is perhaps longer than the average in this case.

vicular line coincides with the mammillary line when the nipple is in its typical situation, and is therefore a better term. Below the mammary region, as far as the edge of the thorax, is the **inframammary region.** In the centre of the thorax anteriorly is the **sternum,** bounded by its notch above and the end of the ensiform cartilage below. It is divided into the **upper sternal region,** extending as far as a line drawn along the upper edge of the 3d cartilage, and the **lower sternal,** including the remainder of the bone. Laterally are the **axillary** and the **infra-axillary** regions, the former above and the latter below a line continuous transversely with the lower border of the mammary region (6th rib); bounded in front by the external border of the mammary and inframammary regions, and behind by a line drawn vertically downward from the insertion of the posterior fold of the axilla. The infra-axillary region extends downward to the edge of the thorax.

Posteriorly are the **scapular regions,** including the **supraspinous fossa** and the **infraspinous fossa** of each scapula, sufficiently indicated by their names; the **interscapular** region, and the **subscapular** or infrascapular regions. The interscapular region is included between the scapulæ posteriorly and bounded below by a line drawn through the angles of these bones in the position assumed by them when the arms are hanging at the side. Such line usually crosses the 7th rib. The infrascapular regions are bounded above by the line just described, below by the edge of the thorax,

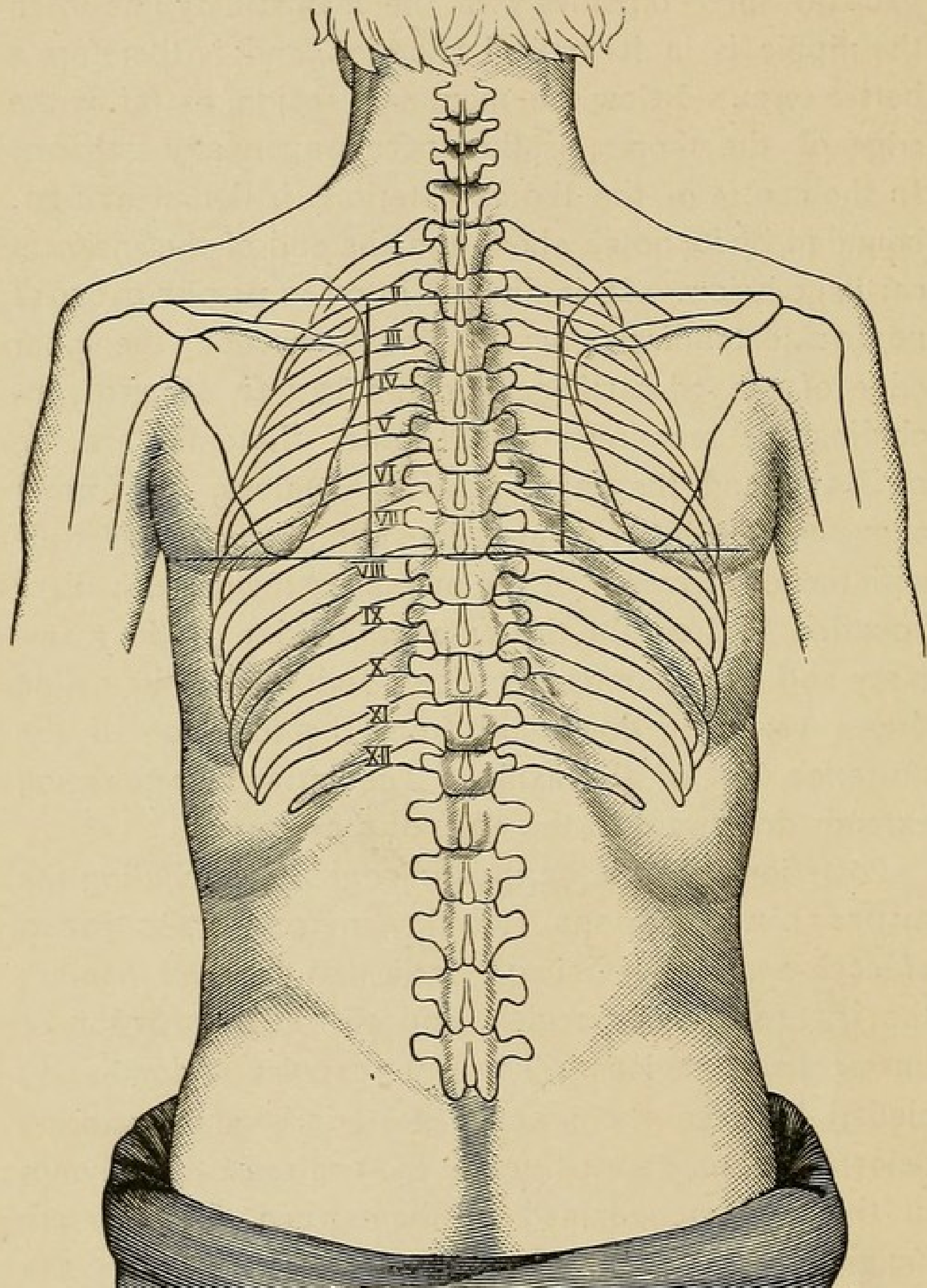

FIG. 2.—REGIONS OF THE CHEST, POSTERIOR ASPECT.

and extend from the median line to the posterior axillary line on each side.

In addition to the mammillary line, are lines drawn vertically down the middle of the axilla and through the angle of the scapula behind, called the **mid-axillary** and **mid-scapular** lines—also landmarks useful in description. The **parasternal** line, frequently used, is a vertical line drawn midway between the edge of the sternum and the mammillary line.

MEDICAL ANATOMY OF THE THORAX.

For the intelligent study of the physical diagnosis of the chest, it is important that the student should know what viscera or parts of viscera are contained in the areas just mapped out. (See Figs. 3 and 4.)

1. In the *supraclavicular* region is contained the apex of the lung (4, 10, Fig. 3), which rises above the upper border of the clavicle to the extent of ½ inch to 1½ inches and even two inches, varying in different persons. It is rather toward the inner end of the clavicle. One or the other apex is usually a little higher than its fellow, the left more frequently. The apex of the lung is crossed by the subclavian vessels in the first part of their course. In the subclavicular fossa near the outer border of the sternomastoid muscle, and about one inch above the clavicle, the beating of the subclavian artery can be felt. In this hollow, too, is the termination of the external jugular vein.

2. Behind the clavicle, in the *clavicular region*, is

also found the lung, but the 1st and 2d ribs are interposed between the clavicle and the lung, so that no typical lung note on percussion can be expected in that situation. Behind the inner end of the clavicle is the commencement of the innominate vein; behind this, on the left side, the common carotid; to the outside of this the left subclavian artery; and on the right side behind the sternoclavicular joint, the bifurcation of the innominate.

3. The *infraclavicular regions* are occupied almost purely by lung structure. The superior cava extends slightly beyond the right edge of the sternum in this region, the pulmonary artery somewhat more to the left of the left edge of the sternum. The left auricle is in the 2d intercostal space and extends to the left parasternal line, being covered by the edge of the lung.

4. The structures occupying the *mammary regions* differ considerably on the two sides. The *right* side is the simpler. It is occupied mainly by lung. At least

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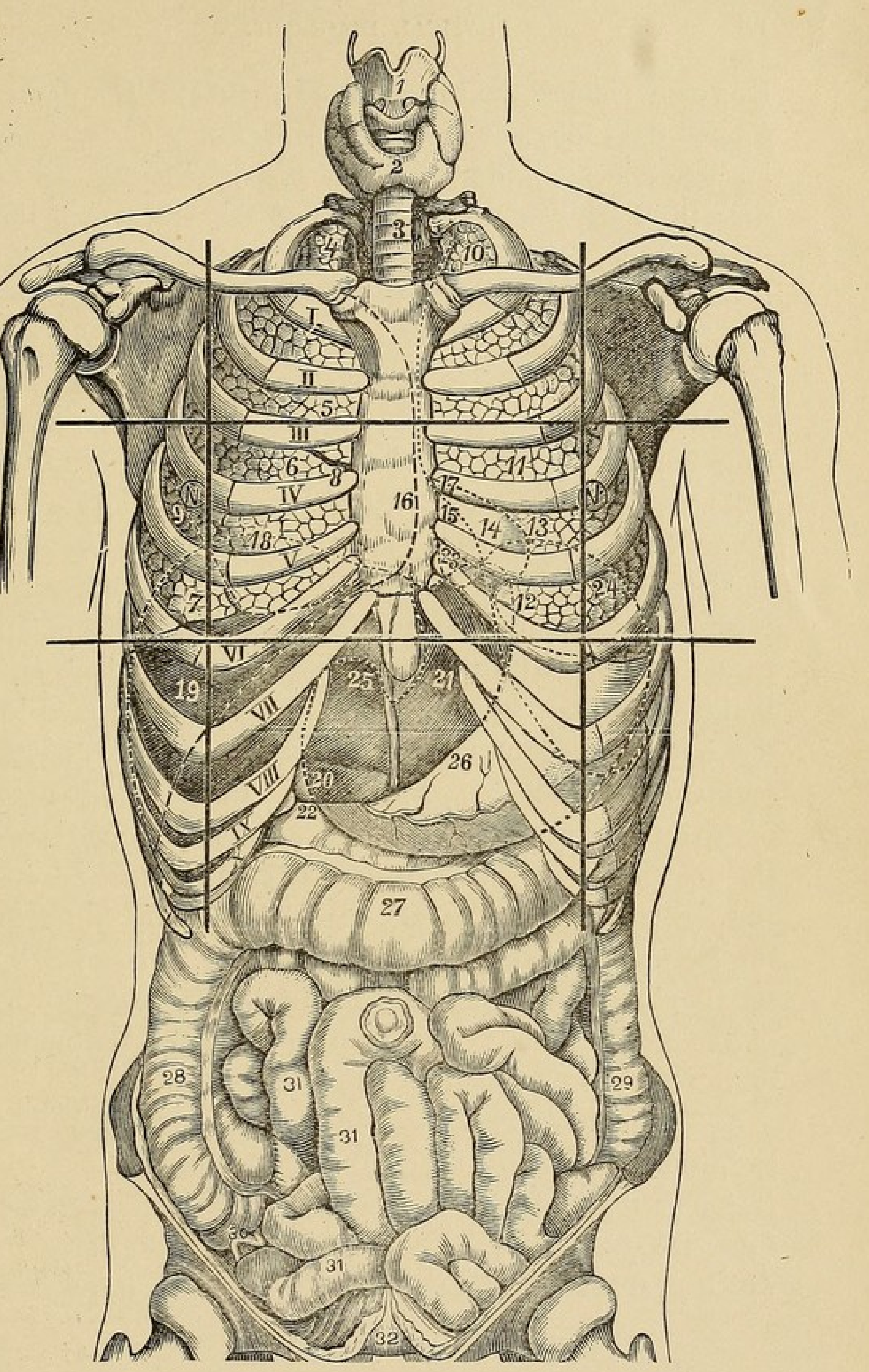
FIG. 3.—ANTERIOR VIEW OF THE ORGANS OF THE CHEST AND ABDOMINAL CAVITY WITH REFERENCE TO THEIR RELATIONS TO THE SKELETON AND THE BOUNDARIES OF THE STOMACH.

1. Larynx. 2. Thyroid gland. 3. Trachea. 4. Right lung-apex. 5. Upper lobe. 6. Middle lobe. 7. Lower lobe, of right lung. 8. Upper, 9. Lower interlobular boundary of the right lung. 10. Apex, 11. Upper lobe, 12. Lingual process of the left lung. 13. Cardiac boundary of the anterior border of the left lung. 14. Portion of the anterior aspect of the pericardium covered by the cardiac pleura. 15. Portion of same uncovered by diaphragm. Site for paracentesis. 16. Anterior border of the right mediastinum. 17. Anterior border of the left mediastinum. 18. Upper or true border of the liver partially covered by lung. 19. Right lobe of the liver. 20. Quadrate lobe of the liver. 21. Left lobe of the liver. 22. Gall bladder. 23. Cardiac end of the stomach. 24. Stomach cul-de-sac partially covered by lung. 25. Pyloric end of the stomach. 26. Larger curvature of the stomach (right gastro-epiploic artery). 27. Transverse colon. 28. Ascending colon. 29. Descending colon. 30. Vermiform appendix. 31. Small intestine. 32. Bladder.—(*After Luschka*, slightly modified.)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lung only reaches the surface in this space. The dome-shaped right lobe of the liver projects into a corresponding space in the under surface of the right lung as far as the 4th interspace. To the right of the sternum is the right auricle, behind the 3d costal cartilage, the 3d interspace, the 4th costal cartilage, and 4th interspace, and extending almost to the right parasternal line, but covered by lung. The right ventricle extends very slightly, if at all, by the outer inferior angle of its base, from behind the sternum into the 6th interspace.

The *left mammary* region is occupied almost as far as the mid-clavicular line by the heart, including portions of the right and left ventricle. The cardiac line is an oblique one beginning at or near the junction of the left parasternal line with the lower border of the 2d rib and thence downward and outward to the apex formed by the left ventricle in the 5th interspace an inch below and within the nipple. The upper portion of this area is covered by lung, leaving only a tongue-shaped portion of the heart uncovered between the 4th and 6th ribs. Between the 4th and 5th ribs (at 15, Fig. 3), near the sternum, is a spot of the pericardium uncovered by the diaphragm, which is the usual site for paracentesis of the pericardium. The remainder of the left mammary region is occupied by lung.

5. The *inframammary regions* differ even more on the two sides in the structures comprehended in them. This region on the *right* side mainly covers the liver separated from the chest-wall by the diaphragm, the dome of which reaches its highest point in the 4th interspace

within the mammillary line. The lung extends down to the 6th rib. The lower border of the liver in health just reaches the edge of the ribs at the mid-clavicular line, and then extends obliquely upward toward the left, crossing the median line usually at one-third the distance between the ensiform cartilage and the umbilicus, and reaching the left border of the thorax at or near the left parasternal line. The lower edge of the liver varies somewhat in healthy individuals, and descends below the ribs with deep inspiration.

The *left inframammary* region includes the anterior part of the lower lobe of the left lung, the left lobe of the liver, the cardiac end of the stomach, varying degrees of distension of the latter organ producing considerable variation in the percussion boundaries of these organs.

Between the inframammary regions is the *epigastrium* in abdominal topography. In the right half of the epigastrium is the quadrate lobe of the liver, the gall bladder, the pyloric end of the stomach at a point mid-way between the ensiform cartilage and the parasternal line, behind the liver and adjacent to the gall bladder. The fundus of the gall bladder can sometimes be felt at the edge of the liver. In the left half of the epigastrium is the left lobe of the liver and lower median part of the stomach.

6. The *suprasternal notch* is solely occupied by the trachea in health, but is often encroached upon by a dilated aorta, or aorta pushed up by a hypertrophied heart.

7. The *upper sternal region* under the manubrium is occupied by the trachea, which bifurcates at the junction of the 1st and 2d bone, by a part of the superior cava, the arch of the aorta, the left innominate vein, which joins its fellow to form the superior cava just below the cartilage of the 1st rib, close to the right edge of the sternum; also by a part of the pulmonary artery. The upper and central part of this region is uncovered by lung.

8. The *lower sternal region* contains a part of the aorta, a portion of the right auricle, much of the right ventricle, beginning opposite the 4th cartilages, and behind this the left ventricle. The edges of the two lungs unite through the upper part of this region in the middle line, the left diverging at the 4th rib where the uncovered tongue-shaped piece of the heart commences. The primary bronchi are found diverging at the upper part of this region, where they penetrate the lung. The right, larger and shorter, passes downward on the level of the 4th dorsal vertebra; the left, longer and smaller, downward and outward to the level of the 5th dorsal vertebra.

9. The *scapular regions* cover the lung, the incisure between the upper and lower lobes passing obliquely downward under the bone from the upper edge of the 5th rib behind, to between the 5th and 6th ribs laterally.

10. The *interscapular region* in its central portion is occupied by dorsal vertebræ, in front of which is the trachea, bifurcating at the 4th, whence its primary bronchi extend downward and outward surrounded by lung structure.

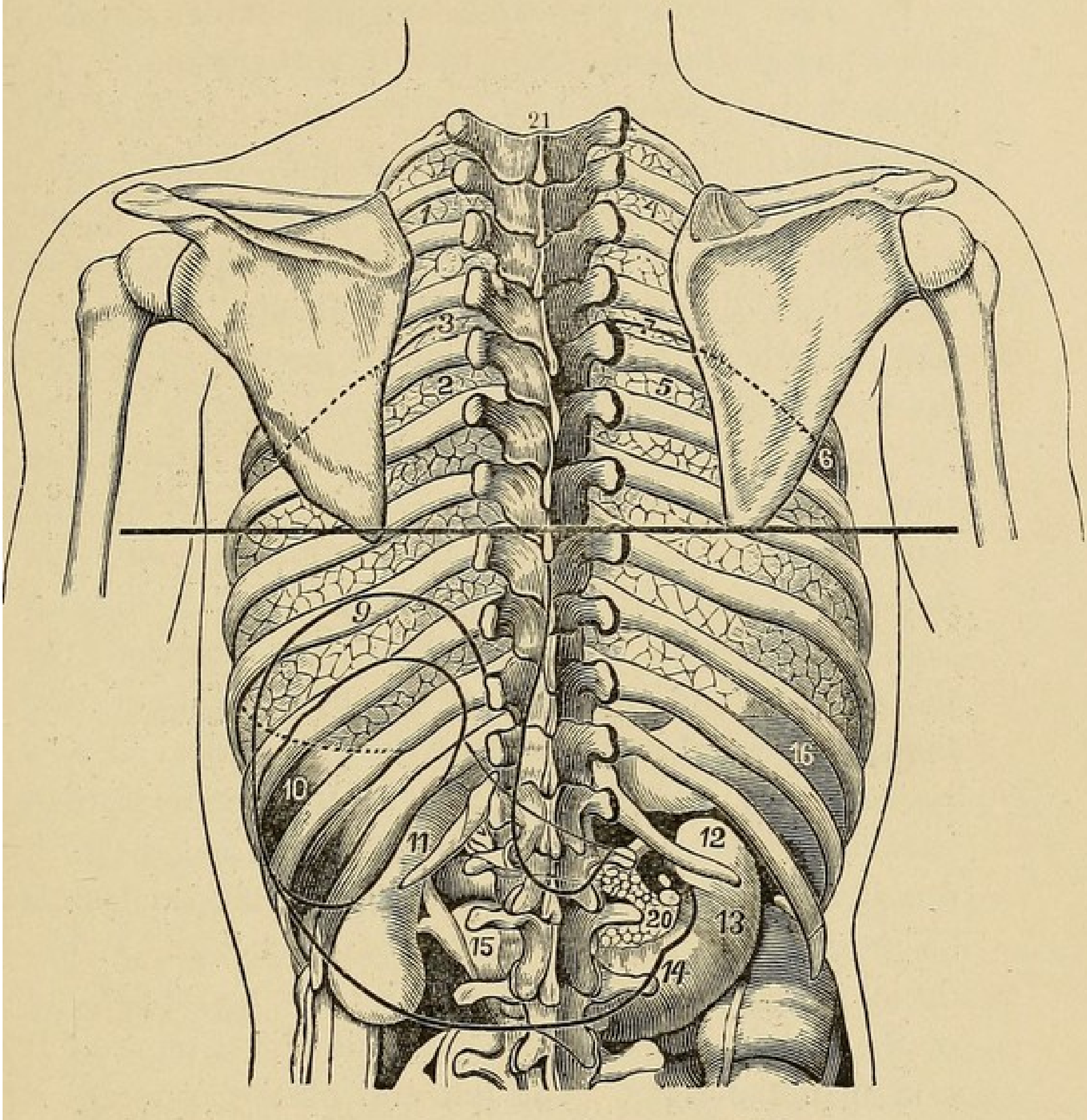


FIG. 4.—POSTERIOR VIEW OF THE ORGANS OF THE CHEST AND ABDOMINAL CAVITY.

1. Upper lobe. 2. Lower lobe of left lung. 3. Interlobular boundary between them. 4. Upper lobe of right lung. 6. Middle lobe of the right lung. 7. Line between upper and middle lobes of the right lung. 9. Stomach demarked by a dark line. 10. Spleen in its relation to the lung in expiration, with the kidney showing behind and below it. 11. Left kidney. 12. Horizontal upper part of the duodenum. 13. Descending portion of the duodenum. 14. Horizontal lower part of the duodenum. 15. Duodeno-jejunal flexure. 16. Liver. 20 Pancreas. 21. First dorsal vertebra.—(*After Luschka.*)

11. The *infra-* or *subscapular regions*, extending from the angles of the scapulæ to the edge of the thorax, include on the *right* side lung as far as the 10th rib in the mid-scapular line. Below this is the complemental pleural space (see p. 24) filled by lung only in deep inspiration, as far as the 11th rib, where the lower border of the liver is met. The thick lumbar muscles separate the integuments to the right of the vertebræ from the upper end of the right kidney, forward of which is the pyloric orifice of the stomach. The upper end of the right kidney is covered by the 11th interspace and the short 12th rib. On the *left* side there is pure lung tissue as far as the 10th rib, whence it dips down in deep inspiration into the complemental pleural space between the thoracic wall and that part of the diaphragm covering the spleen, which extends from the 9th to the 11th ribs inclusive. A small portion of lung tissue is interposed between the posterior edge of the spleen and the 10th dorsal vertebra. The cardiac orifice of the stomach is on the left side about opposite to the body of the 9th dorsal vertebra. Beneath the 11th rib is the upper end of the kidney, which extends a little higher on the left side than the right. The left end of the pancreas is close to the spinal column in the 11th interspace and under the root of the 12th rib.

12. The *axillary regions* on both sides are occupied with lung structure, a part of the upper lobe of each lung.

13. The *infra-axillary* regions are again more complex in the structures they cover. On the right side

there is lung as far as the 9th rib in the mid-axillary line; below this is liver to the 11th rib, or edge of the thorax in this line.

On the left side there is lung as far as the 9th rib in the mid-axillary line. Below this is the spleen, which extends to the 11th rib inclusive, or edge of the thorax at this situation. The cardiac end of the stomach, especially when dilated, is apt to protrude into the infra-axillary region and to influence the percussion note.

The Borders of the Lungs.—It is to be remembered that the anatomical outlines just described are of themselves rather approximate, and, furthermore, that they do not necessarily coincide with the percussion boundaries of the same organ, as in many situations portions of lung protrude between the organs and the surface and produce a modification of the note peculiar to such organs, which modification is the relative or deep-seated dulness of the organs. It is therefore useful also to know the correct anatomical boundaries of the lungs as a whole in relation to the landmarks given:

In front the lungs extend above the clavicles from ½ inch to 1½ inches or more; behind as far as a line drawn through the apex of the spinous process of the 7th cervical vertebra. Downward and adjacent to the sternum, the right lung extends to the neighborhood of the 6th cartilage, the left to the 4th; in the mid-axillary line both extend to the lower border of the 7th rib, in the mid-scapular line to the 10th rib, and near the spinal column to the 11th rib. On the left side at the inner end of the 4th cartilage the lung diverges from under the breast bone obliquely behind the 4th cartilage through the 4th intercostal space and again turns toward the sternum behind the 5th costal cartilage, but at the 6th cartilage again turns outward. By this divergence is formed the tongue-shaped indentation of the lung border, by which a portion of the heart is uncovered. Behind the sternum, from the 2d to the 4th cartilage, the edges of the two lungs approach each other very closely.

The summit of the dome of the liver in front reaches as far as the 4th interspace on the right side, but it is covered with a wedge-shaped extension of the lungs as far as the 6th rib, where what is known as the *absolute* dulness of the liver begins, the lesser impairment of resonance appearing at about the 5th rib being called *relative* dulness.

It is to be remembered that in quiet breathing, during which the boundaries above traced are supposed to be maintained, the anterior edge of the left lung and the inferior edges of both lungs do not reach the extreme limit of the pleural space, so that between the edges of the lungs and the limit of the pleural sac there remains a space which is only filled at the time of deep inspiration. At other times the costal and diaphragmatic pleuræ below the lower edge of both lungs are in contact, as are also the costal and pericardial pleuræ toward the median line at the anterior order of the left lung. The spaces thus formed are called **complemental spaces.**

Above the level of the 4th cartilages the anterior edges of the lungs closely approximate and fill the pleural space, but below this the edge of the left lung deviates from the pleural border to form the tongue-shaped cardiac indentation referred to. The inferior border of the left lung extends a little lower than that of the right, more particularly between the parasternal and the mammillary line, where it extends half an inch lower.

It is less important to know the interlobular boundaries of the lung. The two principal fissures begin posteriorly nearly on a line with the spines of the scapulæ. The left incisure starts under the dorsal end of the 4th rib, passes downward and outward, intersecting the 5th rib in the mid-axillary line terminating at the lower edge of the lung at its junction with the right parasternal line and the 6th rib. The right incisure divides at about two or 2½ inches above the angle of the scapula into two branches, an upper and a lower, which separate the upper lobe from the middle, and the middle from the lower lobe of the lung. The upper branch passes nearly transversely forward to terminate in the edges of the lung at about the level of the 4th cartilage. The inferior branch passes sharply downward and slightly forward at the level of the 6th rib in the neighborhood of the mammillary line, and out at the lower edge of the lung. Hence it is that on the *posterior aspect the lower lobe on each side makes up the larger part of the lungs exposed to percussion ; on the left, in front, only the upper lobe, on the right the upper and middle lobes. Laterally, on the left side the upper and* *lower lobe, and on the right side the upper, middle, and lower lobes approach the surface.*

The **bifurcation of the trachea** corresponds anteriorly with the lower end of the manubrium, posteriorly with the cartilaginous disc between the 4th and 5th dorsal vertebræ.

INSPECTION AND MENSURATION.

The appearances of the regions described, during and independent of the motions of breathing, are objects of **inspection** but these are best described in connection with the conditions which modify them. In inspecting the chest from the front or behind, the patient should stand erect with the hands at his side; during lateral inspection the hands should be raised alongside of the head, or they may grasp opposite shoulders. Such relations to light should be chosen as will obviate shadows as much as possible. It will be remembered that during breathing a woman exhibits more motion in the upper part of the chest, while in men abdominal motion is marked.

Mensuration is for the most part practised by an ordinary tape measure, and thus the circumference of the chest at different situations is determined; aiso differences in the circumference at the end of inspiration and of expiration, and differences in the semi-circumference as the result of abnormal states. It is to be borne in mind that in right-handed persons the semi-circumference of the right side is often ¼ inch to one inch greater than that of the left, owing to the greater muscular development of that side. The reverse obtains to a less degree in left-handed individuals. The transverse and antero-posterior diameters of the chest may be determined by a pair of calipers; any deviations in the shape of the chest by the cyrtometer, a simple form of which may be made out of strips of sheet lead, moulded to the chest-walls, and the outline thus produced is drawn on a large sheet of paper. More perfect appliances for chest measurement are the stethometer of Quain, the stetho-goniometer of Allison, the cyrtometer of Woillez, and others, but they are not needed for the usual measurements.

THE SHAPES OF THE CHEST.

By inspection and mensuration we learn the shape of the chest.

1. The **normal shape** of the infant's chest at birth is nearly cylindrical, but as development proceeds it asquires an **oval shape** well established by the time the child has cut its milk teeth. This increases slowly until development is complete, when the outline shown in Fig. 5 is attained.

During maturity the chest retains this shape, but with the wane of life and the effect of disease incident to it there come changes which cause the chest again to approach the cylindrical shape of infancy.

The effect of various diseases on the shape of the chest will be considered in connection with the diseases themselves, but there are several types presented by those in apparent health which are important, in that they favor tendencies to special diseases or are the result of weakness in childhood

2. Thus we have the alar or pterygoid chest, which is one of the forms of the so-called phthisical chest, because supposed to favor the development of this disease.

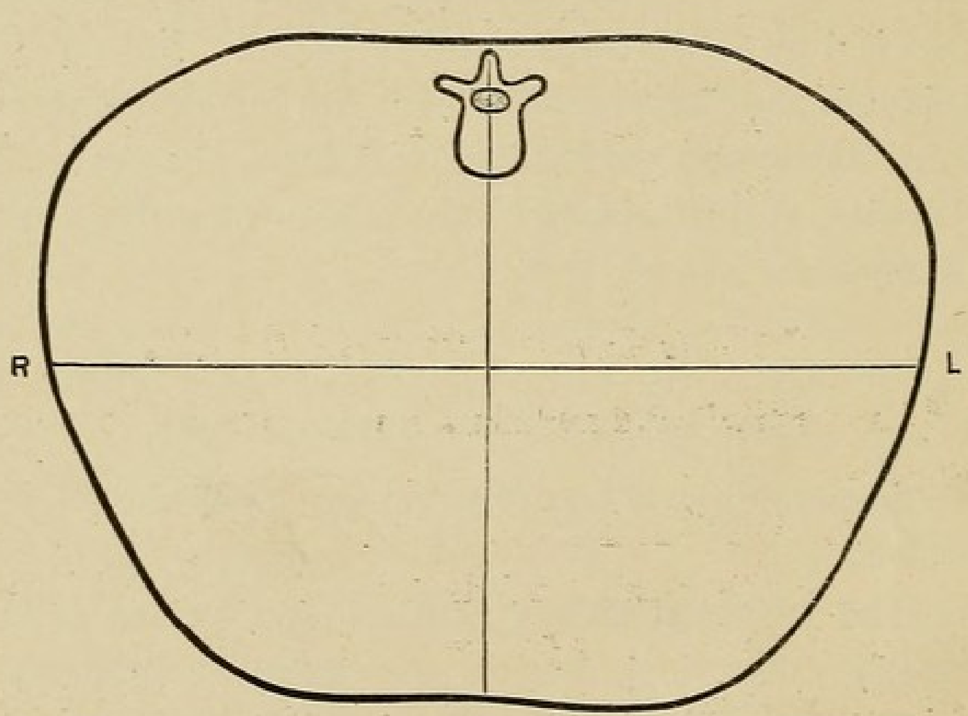


FIG. 5.—TRANSVERSE SECTION OF HEALTHY ADULT CHEST AT LEVEL OF STERNO-XIPHOID ARTICULATION.—(*After Gee.*)

Such a chest is small; the angles of the scapulæ project so as to give the appearance of wings. It is narrow, shallow, and long; but the ratio between the antero-posterior and transverse diameters is not necessarily changed. The ribs droop or are unduly oblique. The throat is prominent, the neck long and the head bent forward.

3. Then there is the **flat chest**, also phthisical, wherein the antero-posterior diameter is disproportionately short, owing to the loss of convexity in the cartilages, which are even sometimes turned in so that the sternum is depressed between the cartilages, producing a form of chest which on section is kidney-shaped.

In this form of chest there is not the obliquity of the ribs characteristic of the alar chest. Both the flat and alar chests are known as *phthinoid* chests.

4. The **transversely constricted** chest is charac-

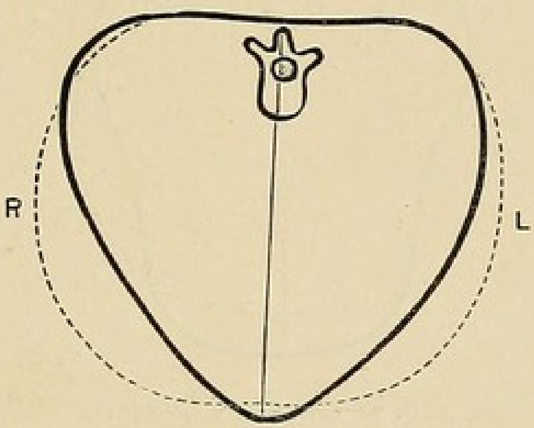


FIG. 6.—PIGEON BREAST, CHILD OF SEVEN YEARS.
(Dotted line indicates natural shape at same age.—(*After Gee.*)

terized by a depression of varying depth known as **Harrison's sulcus**. It passes outward and slightly downward on a level with the xiphoid cartilage and as far as the mid axillary line. It is produced in childhood by some obstruction to the entrance of air, usually a bronchial catarrh, as the result of which the upper part of the chest is not expanded, while the lower part is held upward by the abdominal viscera. It is especially frequent in rickets.

5. The **pigeon breast** is the result of higher degrees of obstruction than are produced by simple catarrhal conditions. Whooping-cough, with its prolonged paroxysms, is probably the most frequent cause, but any chronic pulmonary catarrh may do it, as may also enlarged tonsils. In it the shape of the transverse section of the chest is more or less triangular, the result of a straightening of the ribs and forward protrusion of the

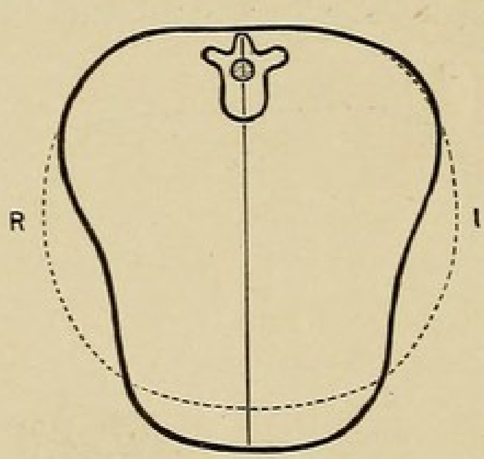


FIG. 7.—RICKETY CHEST.
Dotted line indicates the shape of the chest of an infant about the same age.—(*After Gee.*)

sternum, which takes place while the ribs are plastic and yielding. The pigeon breast is usually associated with the transverse constriction above described, both being the result of different degrees of the same cause.

6. The **rickety chest** is characterized by a shallow longitudinal groove on each side of the chest, parallel and a little external to the sternum. It is due to external atmospheric pressure upon soft, rickety ribs before the lungs are sufficiently filled to occupy the space ren-

dered vacant by the descent of the diaphragm. The groove takes the position it does because the softest parts of the ribs are about the costo-chondral articulations.

In addition to the shapes of chest described, inspection recognizes local **bulgings**, and **shrinking** or **depression**, **deficient expansion**, the **breathing rate**, and change of **rhythm.**

Litten's Sign – The Diaphragm Phenomenon.—Inspection also recognizes Litten's sign, a wave-like retraction during inspiration of the intercostal spaces on the frontal, lateral, and dorsal aspects of the thorax. It is ascribed to the peeling off of the diaphragm from its thoracic contact, coincident with the descent of the lungs, in the act of inspiration.

It is seemingly the direct result of external atmospheric pressure anticipating the balance of pressure subsequently restored by the complete expansion of the lung. It is said to occur in all healthy individuals, but is plainer in those who are thin. Its lower limit in health corresponds with the lower border of the lung. It is said to be absent in large pleural effusions and emphysema of the lung, diminished in small effusions. The effect of the latter is to lower the line at which it begins, which is usually the 6th interspace.

PALPATION.

After inspection and mensuration of the chest, palpation is usually practised. This is done by applying the palm of the hand or the fingers, as may best serve the purpose, to the chest-wall. The chief value of palpation lies in the fact that when the hand is thus closely applied, and the person "touched" speaks, a peculiar vibrating or trembling sensation is conveyed to the hand. This is known as **vocal fremitus** or **tactile fremitus.** This fremitus or thrill, representing the vibrations communicated to the air by the vocal cords, is conveyed to the walls of the air passages, from the larger to the smaller, until the ultimate structure of the lung is reached, whence it is conveyed to the chest-wall and hands. In health it is felt everywhere over the chest where lung-tissue reaches, but is more distinct where the chest-walls are thinnest, and especially in the infraclavicular spaces. It is further often more plainly felt below the right clavicle than below the left, an important fact to be remembered in recognizing delicate shades of difference. This is usually explained by the fact that the right bronchus is shorter, larger, and enters the lung higher up and more horizontally than the left, whence a larger volume of air is contained in the right lung, especially in its upper portion, and stronger vibrations are produced in speaking. For the same reason vocal fremitus is sometimes slightly more distinct posteriorly in the right half of the interscapular space and even below the angle of the right scapula. In the axillæ the same difference may exist to a less degree. Tactile fremitus is, of course, more marked in persons with thin chest-walls than in those with thick muscular walls, or walls covered with fat, while it is feebler but still easily appreciable in women. It is also greatly influenced by the pitch or tone of the voice used, being more marked in a deep, low-toned speech than in a high one. It is further influenced by words selected for utterance. My favorites are "ninety nine," as producing a longer vibration than words like "sixty-six," for instance. But "one, two, three," or "twenty-one," "twenty-two," and "twenty-three," and the like, are useful also to bring out vocal fremitus.

Vocal fremitus is increased in abnormal states producing consolidation of the lung, as in pneumonia and tubercular deposit, and is diminished by conditions which separate the lungs from the chest-wall, as pleuritic effusions, plastic pleuritic thickening, and even solid tumors.

Fremitus is also produced by the action of coughing, when it is called **tussile**, as distinguished from vocal; by râles, dry or moist, if the tubes are of sufficient calibre, when it is called **rhonchal**; also by pleural and pericardial **friction.**

By palpation is also recognized the **resistance** due to increased density of an organ.

Palpation co operates with inspection in recognizing the relative **excursion of breathing movement** on the two sides of the chest, slight degrees of difference in which being often difficult to discover.

Cardiac and **vascular thrills** are also felt in diseases of the heart and blood-vessels.

PERCUSSION.

Percussion naturally succeeds palpation, and consists in striking a part with a view to eliciting sound. In its simplest form it is probably as old as diagnosis itself, but Leopold Auenbrugger, of Vienna, was the first to publish, in 1761, results obtained from its application. Percussion is called **immediate** or **mediate**, accord-

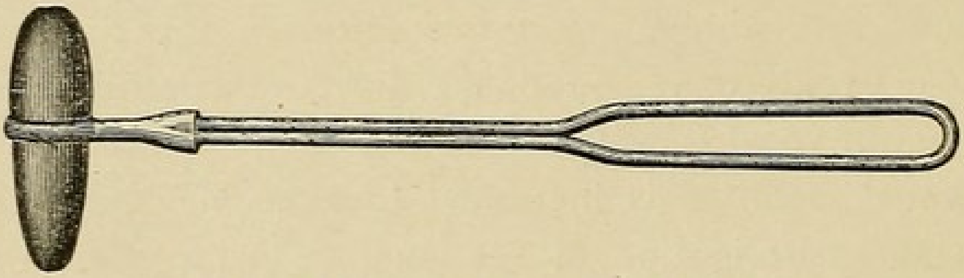
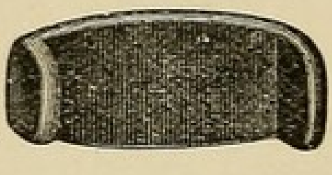


FIG. 8.—PERCUSSION HAMMER OR PLEXOR.



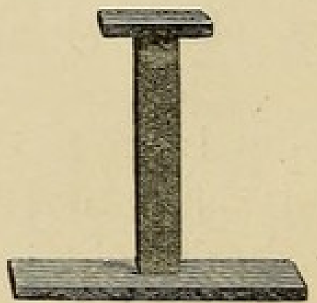


FIG. 9.—IVORY PLEXIMETER. FIG. 10.—SANSOM'S PLEXIMETER.

ing as the blow is struck directly upon the part or upon some interposed medium. Immediate percussion is of limited application, but it is still sometimes very useful, and I much like to percuss the clavicular region by striking directly the bone rather than upon some interposed substance. The hammer or agent by which the stroke is practised is the **plexor**, and the interposed material is the **pleximeter.** By far the most common plexor, and usually the best, is the middle or index finger, or both of these, while one or the other of the same fingers of the other hand becomes the pleximeter. It is often useful, however, to have a specialized hammer, like that shown in Fig. 8, while more useful and even more indispensable at times becomes a pleximeter (Figs. 9 and 10), in situations which the fingers cannot conveniently reach, or where there is much percussing to do, when the fingers sometimes become sore and tender from the constant pounding. By far the most satisfactory pleximeter, in my experience, is the little hard-rubber pleximeter suggested by Sansom. (See Fig. 10.) Either the larger or smaller end may be applied to the chest, and the stroke given to the other, with equal efficiency.

The pleximeter was invented and first used by Piorry, of Paris, in 1828, and the hammer by Wintrich, in 1841.

The essential conditions of successful percussion are, first, the close application of the pleximeter, whether it be the finger or an artificial pleximeter, to the chest, so that it will form a part, as it were, of the area to be percussed; and, as the two sides of the thorax are commonly compared, precisely corresponding points should be selected. Then care should be taken to strike with equal force on each side. When the fingers are used as plexors, the stroke should be made from the wrist, and vertically on the pleximeter, while the hand should be raised quickly, and one, two, three, or more blows given until the proper sound of the part is elicited. To this end the force of the stroke should be regulated, being made lighter on thin-walled chests and more forcible over thicker walls. When the proper note is brought out it should be remembered and compared with the sound elicited under the same conditions at the corresponding point on the opposite side. Practice with attention to these conditions can alone make perfect.

The sound produced by percussing the chest is a mixed one, made up of the vibrations of the pleximeter, those of the thoracic wall, and those of the air in the lungs. The first, when the finger is used as a pleximeter, is scarcely noticeable, but when a pleximeter of ivory or hard rubber is used this element may be recognized, especially when the pleximeter is accidentally struck by the nail of the finger used as a plexor. In like manner the vibrations of the thoracic wall are insignificant and unnoticeable under ordinary circumstances, in comparison with the vibrations of the air in the lungs, which are responsible for most of the sound produced in percussing the normal chest. These vibrations are set up by the blow, and it is the sound thus produced, variously modified in health and disease, which we are to study. Where the chest-wall is very thick, however, the note of its percussion becomes more predominant and that of the lungs less.

Auscultatory or **stethoscopic percussion** is a term applied to a method introduced by Cammann and Clark, which consists in listening, with a stethoscope applied to the chest- walls, to the sounds obtained by percussion. Such sounds are much intensified when thus conveyed to the ear. The boundaries of organs may, therefore, be thus marked out with greater precision because of the more sudden change of note when they are passed. So long as both plexor and stethoscope are placed over the same organ the intensity continues, but as soon as either passes the limits of the organ the percussion note becomes feeble and diffused. This form of percussion is scarcely enough appreciated, as information obtained by percussion is rendered more precise, while boundaries may be thus recognized which are not obvious to ordinary percussion, as that between the lower border of the heart and the liver, and that between lobes of the lungs. It is not necessary to tap with the plexor,—

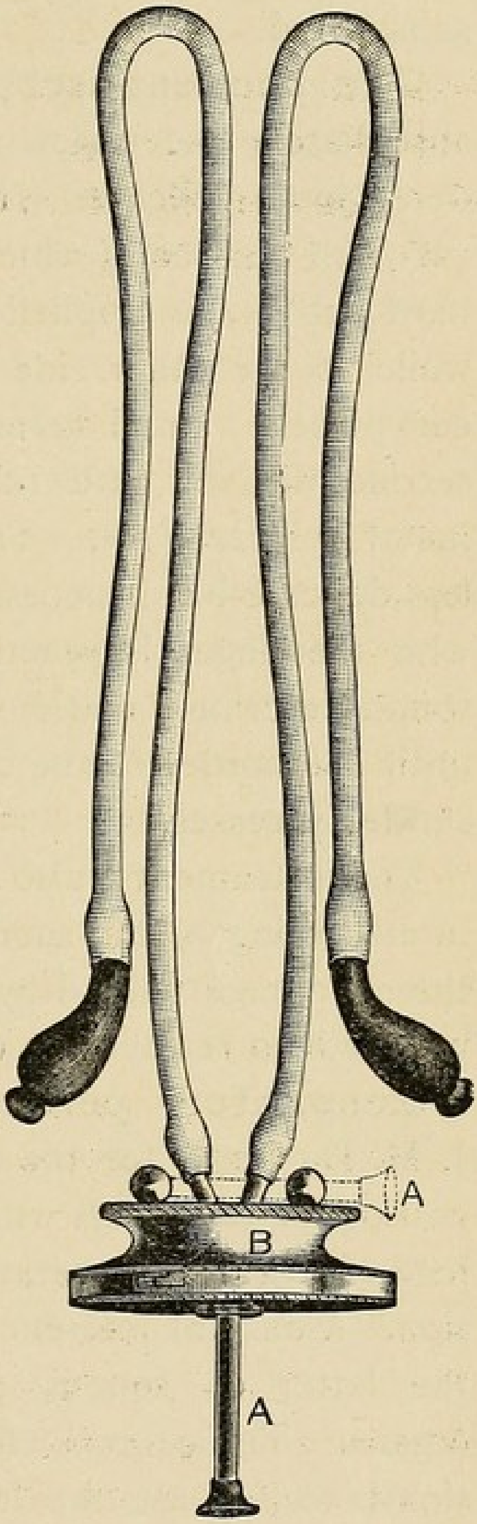


FIG. 11. — THE PHONENDOSCOPE. DESIGNED BY DRS. BAZZI AND BIANCHI.

scraping or scratching by the finger or a pencil may be substituted.

The phonendoscope is an instrument by which auscultatory percussion as well as auscultation is rendered more delicate. It consists of a drum or cylinder (B), one surface of which, covered with a thin sheet of hard rubber, is applied to the part to be examined, while to the other side are attached rubber tubes and ear pieces. Small areas are reached by means of a second disc of hard rubber, into which is screwed a metal cylinder (A). The instrument thus arranged is less delicate but is necessary over small areas. Scraping with the finger is practised, and the same intensity of sound described under stethoscopic percussion is heard until the border of the organ is passed, when the sound suddenly ceases.

The instrument is also used in securing greater delicacy in ausculting breath-sounds and cardiac murmurs; but the advantage gained by its use is scarcely sufficient to permit it to replace the ordinary stethoscope.

Respiratory percussion is a term proposed by J. M. Da Costa for the study of a note made by percussion of the lungs while the breath of the patient is held after a deep inspiration or after a prolonged expiration. Constant reference will be made to the effect of the latter on sounds elicited by percussing normal organs. The general effect of a full breath on percussion is to increase the lung resonance, make the sound fuller and raise the pitch. The effect is more marked on the right side. The effect of a complete expiration is the opposite.

ATTRIBUTES OF PERCUSSION SOUNDS.

Percussion sounds have attributes of **quality**, **intensity** or **loudness**, **pitch**, and **duration**. No one of these attributes can, strictly speaking, be so described as to enable it to be recognized by the ear. Practice and illustration must be associated with the description in order that an adequate idea may be obtained.

Quality is the easiest indicated of the attributes of sound. Although the late Dr. Austin Flint truly said that "to attempt to describe the quality of sounds to one who has never heard them would be like describing colors to one who is blind," illustration happily comes to our assistance and helps greatly. Thus it is not difficult for any one who has heard it to recognize the note of a tuning-fork, violin, or piano, and to name the instrument producing it. The attribute of sound by which such recognition is made is quality, and each quality is produced by certain conditions peculiar to the instrument producing the sound. It varies therefore with those conditions.

Now, the qualities of sound produced by percussing the normal lung are mainly two: First, *the normal vesicular resonance or clear sound;* second, *the dull sound or dulness*. There are modifications of both of these. A third quality, not strictly speaking a normal thoracic sound, but so conspicuous in adjacent organs in health as often to influence the thoracic sounds, will also be described in this connection. I allude to *tympany*. Each of these is produced by conditions peculiar to itself.

Vesicular resonance, or lung-clearness, as applied to the healthy chest, is produced by percussion over normal air-distended lung tissue, a structure containing air in minutely divided spaces. Such structure is its condition, and the sound produced is as much *sui generis* as is the violin's sound. It is of the nature of a reverberation, and is reverberation modified by minute subdivision of air spaces. It was compared by Auenbrugger to the sound of a drum covered with a thick woolen fabric, and not inaptly by Flint to the sound produced by percussing a loaf of bread over which a towel has been spread, the upper crust of the bread corresponding to the chest-wall; but it does not do to take this illustration too literally. Normal lung resonance differs in different parts of the chest of the same individual and in different individuals. Its typical quality may always be found in the left infraclavicular space or below the angle of either scapula in healthy persons with chest-walls of moderate thickness.

The chief cause which operates to produce the differences alluded to in health is the varying thickness of the chest-walls and the intervention of bone, as a rib, the clavicle, or sternum. But the state of tension of the air in the air vesicles has to do with it, as has also the position of adjacent viscera and the mode of percussion, according as it is forcibly or lightly practised, according as it is well or faultily done. The differences themselves consist in variations in the other three attributes named —intensity, pitch, and duration.

Intensity means simply loudness and increases *pari* *passu* with the thinness of the chest-wall and the force of the percussion blow. The effects of the attributes of pitch and duration are best studied after the other qualities mentioned, dulness and tympany, are considered.

Dulness in general may be defined as diminished resonance, but the term is not used by all authors with a single meaning. I do not think Da Costa's description can be improved upon. He says,* "a dull sound denotes the absence of air. It is the sound both of fluids and solids. It is, thus, the sound sent forth by the airless viscera; from the liver, spleen, and heart." The term flatness is essentially synonymous, although also used to indicate a higher degree of dulness. To retain the word flatness for the sound produced by percussing an absolutely airless organ or fluid, and dulness for resonance diminished in positive degree, gives a desirable latitude in the use of terms, further increased by the application of the adjective terms slight, moderate, considerable, or marked. I shall therefore use the term in this sense. Dulness and flatness are both associated with increased resistance to the percussing finger, a sign also more or less valuable in diagnosis.

Tympany or **tympanitic resonance** is the sound elicited by percussing over a large cavity filled with air —a cavity whose walls are rather thin, and neither very tense nor very yielding. The stomach and intestines furnish such a cavity, and it is in this region that we

* "Medical Diagnosis," 7th ed., 1890, p. 264.

seek the tympanitic quality of resonance. Tympany also has variations in pitch due to variations in the size of cavities, which will be better understood after this attribute of sound is considered.

Pitch and Duration.—We are now ready to discuss and illustrate the attributes of pitch and duration, neither of which are so easily described as quality and intensity. They can, indeed, only be learned by practice and with varying facility by different ears, the musical ear having a decided advantage. Perseverance, however, will enable any one to appreciate them sufficiently for practical purposes.

First as to **pitch**. We speak of it as high or low and of intermediate degree. Pitch is higher the more rapid is the succession of the vibrations of the sounding body and of the sound waves which emanate from it, while intensity depends on the amplitude of the vibrations.* Shrillness is the acme of pitch, loudness of intensity. The higher the tension of a percussed cavity containing air the more numerous the vibrations and the higher the pitch, but the shorter the amplitude of the vibrations and therefore the less the intensity. *Vice versâ*, a high-pitched tympanitic resonance would indicate a smaller cavity with tenser walls than low-pitched tympany. The normal vesicular resonance is characterized

* Amplitude is the length of the excursion of the particles which at any time form the sonorous wave, and the motion of the particles or their width of swing must not be confounded with the motion of the sonorous wave itself.

by its low pitch, because the air vesicles are not in a state of high tension. If, however, the lungs be forcibly dilated, the air vesicles are placed in a state of higher tension and of diminished elasticity, a situation akin to that of a distended stomach, and if percussion be now practised over such areas the pitch will be raised, but there will be added not only a higher pitch, but also a tympanitic quality, and a note will be produced which was named by Dr. Flint **vesiculo–tympanitic resonance.** It is a mixed note, therefore, and its conditions are produced by any cause which over-distends the air vesicles, as prolonged crying in a child. It is also the note of the over-distended air vesicles in emphysema of the lung or of portions of a lung, supplementally active in consequence of impairment of function in other parts.

Tympanitic sounds, although generally high-pitched, also vary in pitch, the latter increasing inversely as the size of the cavity and directly with the degree of tension. Thus the stomach, being a large cavity, gives to percussion a lower pitch than the small intestine distended to an equal degree. On the other hand, tension may be made so great by forcible distension, say of the stomach, that the tympanitic sound may be destroyed.

When a bladder or stomach is so forcibly distended that its percussion produces a dull sound instead of a tympanitic one,—and such distension is only possible when the air space is tightly closed on all sides,—it is as though the air space were surrounded by unyielding walls. Percussion under these circumstances—a thoroughly closed cavity and firm walls—produces no tympany. The observer hears, for the most part, only the sound produced by the vibrations of the bladder wall, influenced in part by the convex shape of the bladder, and in part by the condensed air within it. The pressure of this air resists the inward vibration of the bladder wall, and by shortening the amplitude of the air vibrations diminishes the intensity and resonance of the sound. In a word, it is shorter, duller, non-tympanitic. If, however, the mass of air thus surrounded by a tense wall communicates with the exterior by an opening, the tympanitic note responds to percussion.

Dull and flat percussion are high pitched in their note, and the pitch increases with the dulness and the area of the dulness, while the first suggestion of impaired resonance is a slight heightening of pitch which the practised ear readily recognizes, and attaches to it great importance. The suggestion of a higher pitched note just below the right clavicle in health as compared with the note of the corresponding region on the left, is also to be remembered in weighing slight differences in the percussion note of the two sides. It is associated with the tendency to increased vocal fremitus in the same situation, already referred to.

The explanations of this tendency to a slightly higher pitched note and slight dulness at the right apex are not uniform, and best considered in a footnote.*

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* One explanation of this slight impairment of the resonance is based on the different arrangement of the bronchial tubes on the

Duration is the attribute of least importance, or at least comes little into play in the percussion of the human body. It varies inversely with the pitch, that is, the higher the pitch the shorter the duration, and *vice versâ*.

We are now ready to study the percussion sounds as heard in the different regions of the chest as already mapped out.

PERCUSSION OF THE NORMAL CHEST—TOPOGRAPHICAL PERCUSSION.

First, in the **supraclavicular spaces.**

Satisfactory percussion here is difficult and results are

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right side as compared with the left. The former are larger, extend higher up than the latter, and thus give more tubular tissue, including a larger proportion of connective and muscular tissue to deal with in percussing, which would cause slightly less resonance.

A second explanation, which certainly must be allowed to apply in some instances, is the greater muscular development of the right side of the body, and in consequence greater thickness of the pectoral muscles of that side. This would also cause a slightly higher pitch. The opposite state of affairs in left-handed persons would go far to confirm this, but I am not aware of any systematic observations intended to settle this question.

Still another explanation of this difference is based on the fact that the right lung rests, through the diaphragm, upon the right lobe of the liver, which is a dense organ, and percussion of the lung would be modified, by such relation, toward a slight impairment of resonance. It is not impossible that any one or more of the first three causes might operate to produce the difference on the two sides, the last cause more particularly in explaining any slightly raised pitch in the lower lobe as compared with the left.

not to be too much relied upon. The nearest approach to normal clear percussion or vesicular resonance is found above the centre of the clavicles where the lungs rise from ½ inch to 1½ or even two inches above the clavicle, being usually higher in women than in men. Toward the inner end of the clavicle the percussion may acquire a more tympanitic quality, on account of the proximity of the trachea, while toward the outer end a duller note obtains.

On the **clavicles** themselves the percussion note is clear, almost typically so, over the middle of the bone, but becomes duller as the outer end is approached, while on the inner end it may be higher pitched—osteal.

The **infraclavicular spaces** furnish in health the typical clear lung note or vesicular resonance throughout these spaces. On the right side is to be looked for the shadowy higher pitch, less clearness, and shorter duration, so that the left subclavicular may be selected as affording typically normal lung resonance. This difference is not invariable, but the fact is to be remembered in weighing shades of difference with a view to diagnosis.

In the **mammary region** percussing down the *right* mammillary line, the clearness continues, possibly a trifle less on account of the greater thickness of the pectoral muscle, until the 4th interspace or the 5th rib is reached, when there is a raised pitch and diminished intensity, which passes at the 6th rib into a positive dulness which continues in health to the edge of the ribs. This impairment of the resonance on the right side is due to the liver, the lesser degree being known as the deep or *relative* dulness, and below this the *absolute dulness*. The upper border of the absolute dulness corresponds with the lower edge of the right lung. Close to the sternum on the right side there may be slight impairment of resonance from the 3d to the 5th rib, due to the relative dulness of the right auricle, passing at the 5th rib into the relative dulness of the liver, and at the 6th into the flatness of that organ. On forced inspiration the liver is pushed downward an inch or more, and on forced expiration there is a corresponding rise.

On the *left* side, close to the sternum, normal vesicular resonance begins to lessen at the 3d interspace, owing to the deep or relative dulness of the heart, and at the 4th costal cartilage is replaced by the absolute dulness of this organ, which continues down along the left edge of the sternum until it passes into the left lobe of the liver, from which it cannot be demarked; but in general terms the absolute cardiac dulness may be said to extend from the 4th to the 6th rib along the left edge of the sternum; and from the sternum to a curved line extending a short distance along the 4th cartilage and thence down within the nipple line to the seat of the apex-beat, the line of relative dulness being a short distance outside of this. (See Fig. 12.) The cardiac area of dulness is also diminished on deep inspiration, because the organ becomes more fully covered by the distended lungs. External to the nipple on both sides there is, in health, resonance to the anterior axillary line, slightly lessened by the mammary gland and pectoral muscle.

The **inframammary** region on the right side is wholly occupied by the liver and furnishes flat percussion, beginning in the mammillary line at the 6th rib, rising with this rib as the sternum is approached. In the mammillary line it extends to the edge of the thorax. The extent of the area of absolute dulness of the liver is three to four inches.

On the left side the percussion in the inframammary region varies greatly in different persons and in the same person at different times. Near the tip of the sternum and a short distance below, the left lobe of the liver for the most part maintains its dulness, but even this is sometimes replaced by the tympany of a gas-distended stomach, while to the outside of this the stomach as normally distended with gases quite frequently imparts a tympanitic note. On the other hand, the presence of solids and fluids in the stomach contributes dulness in various degrees. A spleen of normal size does not extend into the inframammary region. In this connection it may be mentioned that the lower edge of the liver generally corresponds to a line drawn from the left 6th rib within the mammillary line obliquely across the epigastrium to the junction of the right mammillary line with the edge of the thorax.

In the **suprasternal notch**, also difficult to percuss, tracheal tympany may be brought out by vertical percussion on a suitably placed pleximeter. Over the **upper sternum**, as far as the 3d rib, the percussion is

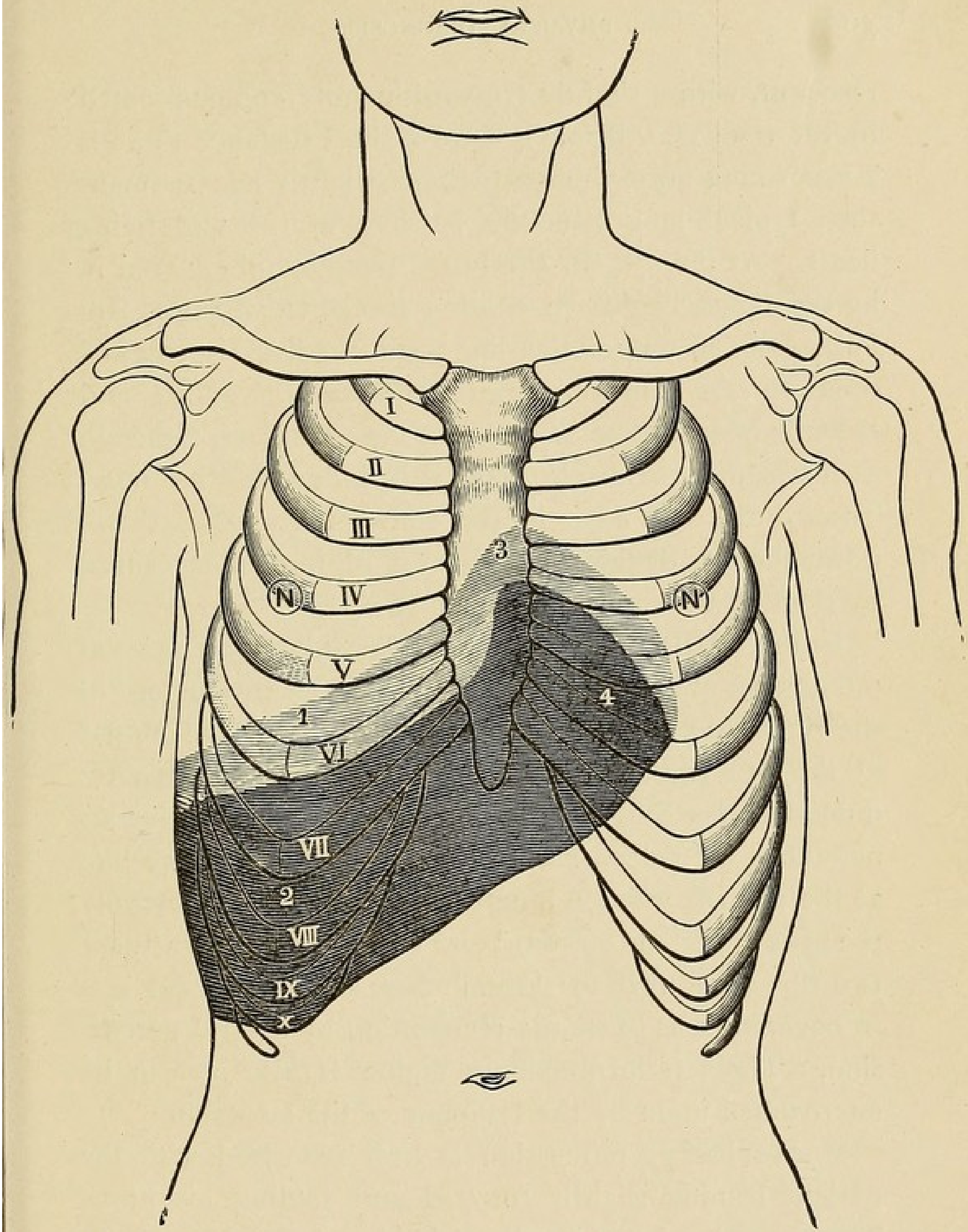

Fig. 12.—Showing Absolute and Relative Percussion Dulness of Liver and Heart.

1. Relative dulness of liver. 2. Absolute dulness. 3. Relative dulness of heart. 4. Absolute dulness.

resonant, with a slightly tympanitic note communicated by the trachea. Below this for a short distance there is a purer lung note, though perhaps slightly less resonant than typical lung structure because of the underlying heart. At the 4th rib the heart, though still covered in by the lungs, begins to deaden the note, which is still fairly clear in the median line until the liver is reached opposite the 6th rib, where dulness is absolute and extends one-third to half-way to the umbilicus, although a tympanitic stomach may also influence the note. Toward the left edge of the sternum from the 4th rib down there is decided impairment of resonance caused by the heart immediately under it.

In the **axillary spaces** on both sides there is good pulmonary resonance. In the infra-axillary region of the right side, the relative dulness of the liver is noted at the 8th rib in the mid-axillary line and the absolute dulness at the 9th. On the left side there is also clearness until the spleen is reached in the mid-axillary line at the 9th rib, whence it extends to the 11th. Laterally the **spleen** extends upward and backward between these two ribs from two to three inches, and sometimes it is so covered in as to escape recognition by careful percussion. The left infra-axillary region is also apt to be encroached upon by the tympany of the stomach.

Posteriorly, percussion is best practised with the patient leaning slightly forward and folding his arms. The upper border of the lungs behind is on a level with the spinous process of the 7th cervical vertebra.

In the **supraspinous fossa** the percussion resonance is markedly less than typical, because of the bone and the thick muscles overlying it, and the same may be said of the infraspinous region. At the same time percussion here is important because differences on the two sides are usually easily recognizable.

In the **interscapular** region there is again better resonance than over the scapulæ themselves, but still less intense than below the angles of the scapulæ, on account of the tolerably thick muscles and the spinal column. In the upper portion the tympany of the trachea may influence the note.

In the **infrascapular** regions we have the nearest approach behind to the typical resonance as represented by the left infraclavicular space. The information obtained here by percussion is most valuable, only equaled in importance by that obtained by percussing below the clavicles, and in consequence of this it is important to remember the inferior border of the normal resonance. The lower border of the lung in the line of the angle of the scapula corresponds on both sides to the 10th rib, where, on the right side, the absolute dulness of the liver is found, while the relative dulness on strong percussion is found a rib higher. On the left side resonance extends in the line of the angle of the scapula fully to the 10th rib, though sometimes a tympanitic quality may be imparted by a dilated stomach or the colon, or a slightly dull sound if the spleen extends a little further back than usual. Here as elsewhere on the thorax there may be slightly less intensity and slightly higher pitch on the right side, on account of the greater muscular development in right-handed persons; and the effect of a deep inspiration in lowering the line of resonance, and in expiration of raising it an inch or more, is also to be remembered. In ordinary breathing the normal resonance posteriorly passes at the 10th rib into the absolute flatness of the lumbar region.

The upper border of the **kidney** below the 11th rib, the left being a little higher than the right, cannot ordinarily be separated by percussion from the dulness of the spleen and liver, nor can the inner border be separated from the spinal column. The outer edge can, however, be defined by percussion from the colon on the right and the stomach and colon on the left by percussing outward from the median line behind. The outer border of the kidney is three or four inches beyond the median line. The lower border can sometimes be defined by a line of tympany just above the crest of the ilium, produced in the colon. Forcible percussion is required, and it is desirable to place a pillow under the abdomen of the patient lying prone upon his face.

ABNORMAL LUNG SOUNDS ELICITED BY PERCUSSION.

It goes without saying that a sound which is normal in one situation becomes abnormal when heard in a position unnatural to it in health, as dulness or tympany below the clavicles or below the angles of the scapulæ, where vesicular resonance is ordinarily found. But in addition there are certain positive modifications of normal sounds not heard anywhere in health, or at least under such exceptional conditions as do not permit them to be included among normal sounds.

These are **vesiculo-tympanitic resonance, amphoric resonance**, and **cracked-pot sound.**

Vesiculo-tympanitic Resonance.—The vesiculo-tympanitic resonance of Flint has already been alluded to, but requires to be further considered because it is not generally recognized by either American, English, or German authors as something distinct and different from tympany, and it requires to be conformed to their treatment of conditions supposed to cause it. In the language of its describer, "the resonance increased in intensity; the quality a combination of the vesicular with a tympanitic, and the pitch higher in proportion as the tympanitic quality predominates over the vesicular." According to him, also, the morbid condition which especially illustrates this form of resonance is the over dilatation of the air vesicles which constitutes vesicular emphysema of the lungs, but he includes also interstitial or interlobular emphysema. It occurs also over the upper lobe of a lung when the lower lobe is solidified in the second stage of pneumonia, and over the lower lobe when the upper is solidified. So, also, if the lower part of a pleural sac contains fluid, even though the volume of the lung is diminished, the upper part of the same lung may give the same vesiculo-tympanitic note. Attention was first called to this by Skoda, and it is known as **Skoda's resonance**. Too much of the intrathoracic space must not be occupied by fluid, because the lung is thus compressed and rendered airless. The resonance remains vesiculo-tympanitic above the liquid when the latter is sufficient to fill a third, a half, or even two-thirds of the intrathoracic space.

Now, these are essentially the conditions named by Da Costa, Paul Niemeyer, and Graham Brown as producing *tympanitic* resonance of lung tissue. It is well described by Brown*: "Just as when the lung is removed from the body and allowed to collapse it gives a tympanitic note, so when a similar retraction and relaxation of the pulmonic tissue takes place within the thorax, that variety of percussion note may be heard. This is best marked in cases of pleuritic effusion, which, gravitating to the lower portion of the cavity, floats up the lung and causes relaxation of the upper portion. When the effusion is small in amount the tympanitic note can only be detected over that portion of the lung which lies immediately above the upper limit of the fluid, but when the effusion is considerable the whole upper lobe may be tympanitic on percussion. This is also called tympany by mediate relaxation. Similarly, effusion into the alveoli in pneumonia or œdema may produce a like result." † This is tympany by imme-

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* "Medical Diagnosis," 3d edition, Edinburgh, 1887, page 207.

† This can occur only in the first and third stages of pneumonia when the air vesicles contain air, the second stage being one of absolute airlessness and dulness.

diate relaxation. Niemeyer* adds, occasionally gangrene and infarct, also disseminated tubercular infiltration, emphysema, and nervous asthma, and that portion of the lung not inflamed but immediately adjacent to a hepatized part,—another instance of mediate relaxation. In like manner phthisical consolidations of the apices may also occasion an obscurely tympanitic note over neighboring portions of the lung by mediate relaxation. Finally, Da Costa, who with Flint may be regarded as representing the American School, says: "But generally a tympanitic sound over the seat of the lungs is expressive of emphysema or of pneumothorax, or sometimes of a cavity or of œdema of the lungs. Again, as Skoda has taught us, it occurs in moderate pleuritic effusions above the level of the liquid." †

It has seemed to me important to contrast these statements, both in order to give a better idea of what Flint intends to convey by vesiculo-tympanitic resonance and to avoid confusion in the minds of those who might with reason be confused by statements apparently so diverse.

Pure Tympanitic Resonance.—Tympanitic resonance is found in normal thoracic states only over the larynx and trachea and in the left infra-axillary region from encroachment of a tympanitic stomach. Elsewhere it becomes a sign of an abnormal state.

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* "*Grundriss der Percussion und Auscultation.*" *Zweite Auflage. Erlangen*, 1873, pages 38, 39.

† "Medical Diagnosis," 7th edition, 1890, page 265.

The fundamental principle to be remembered in connection with tympanitic sounds is that their pitch depends inversely on the volume of circumscribed air and the transverse section of an opening communicating with the exterior. In the chest, tympany is produced by percussing over air-containing cavities in the lung tissue, sufficiently near the surface and sufficiently large, and whose walls are not too tense. Bearing in mind the above principle, approximate estimates as to size and shape of cavities may be made even by observations as to pitch. Thus a cavity of small size will give a higher-pitched tympanitic note than one of a large size.

As these cavities usually communicate with a bronchus they are further characterized by differences in the pitch when percussed with the mouth open or closed. Thus is produced **Wintrich's change of note**, according to which percussion over a given cavity gives a higher-pitched tympanitic sound with the mouth open than when it is closed. This may be illustrated by percussing over the thyroid cartilage under the two conditions, when the difference will be very evident. It occurs in connection with the superficially-placed cavities in communication with a bronchus. If this change of sound is observed on lying down, but is not on sitting up, or *vice versâ*, it means that the bronchus leading to the cavity is obstructed in the position in which the Wintrich change of note does not occur. This is the interrupted change of note of Wintrich.

By what is known as **Gerhardt's change of note** we learn something about the shape of cavities. Cavities which have unequal diameters, or are oval in shape and are partially filled with fluid, alter their note on changing the position of the patient from sitting to horizontal. Thus suppose A to represent an oval cavity in the vertical position with the contained fluid at the line *c d*. If the patient lies down the long diameter

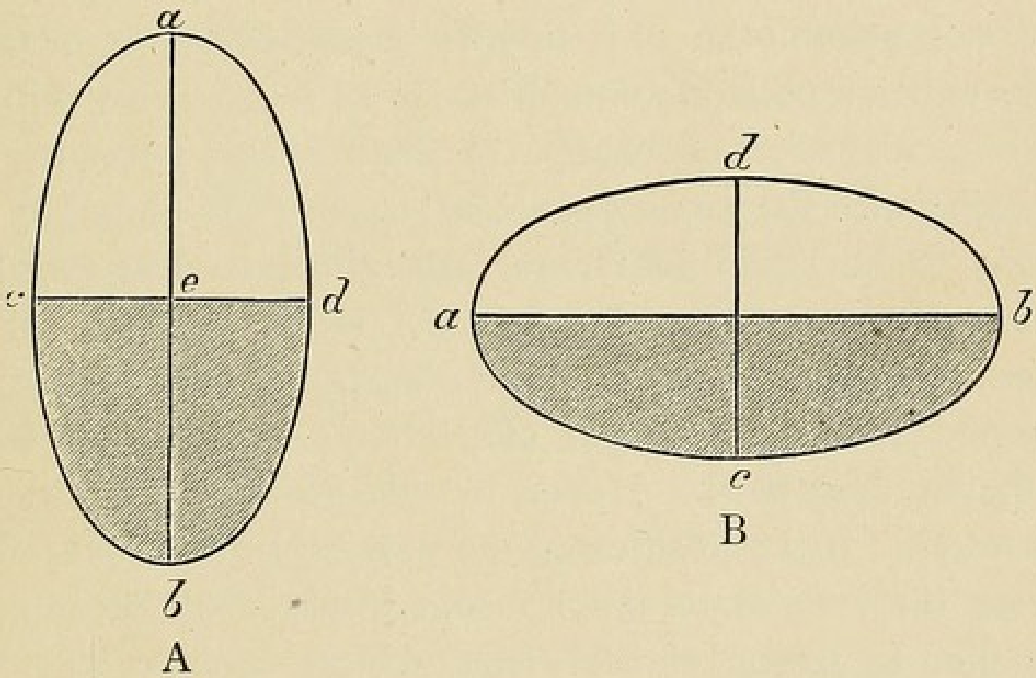

FIG. 13.—TO ILLUSTRATE GERHARDT'S CHANGE OF NOTE.

will become horizontal, as in B, and the level of the fluid will fall to *a b*. The percussion note is lower when the longer diameter is horizontal, higher when it is vertical. If, therefore, the percussion note changes in thus altering the position of the patient, the cavity is oval.

Every cavity does not, of course, furnish the conditions of tympanitic percussion. Recent experiments also shed some doubt as to the correctness of the law originally announced by Gerhardt, that the pitch of oval cavities partially filled with fluid depends on the direction of the greater diameter, while other conditions, too, have been suggested as capable of explaining the differences of pitch observed in cavities whose relations have been altered by changes in the patients' position.

Second, pure tympanitic resonance is also characteristic of pneumothorax if the distension is not too great. There being no free communication of such a space with a bronchial tube, no change of pitch occurs when percussing with the mouh open and closed. If there happens to be liquid in the sac, **Biermer's change of note** may be produced as follows: In the vertical position of a pneumothorax containing fluid the cavity is larger because the weight of the fluid pushes the diaphragm downward. Hence in this position the pitch is lower. If the position of the patient is now changed from the vertical to the horizontal, the cavity becomes smaller by reason of the changed position of the fluid and the pitch becomes higher.

Third, a pure tympanitic resonance may be produced in pneumonia when the portion of the lung lying between the trachea or primary bronchi and the surface becomes hepatized. This is sometimes called *Williams's tracheal resonance*, and is most frequently found in the first or second intercostal space near the sternum. A pleuritic effusion may compress the lung into a like position, at which a like note may be produced.

Amphoric Resonance.—Amphoric resonance, a variety of tympanitic resonance, is a high-pitched metallic resonance, so called from its resemblance to the sound produced by striking the side of a jar, either empty or containing a small quantity of fluid. It may also be imitated by filliping the cheeks when the mouth is distended with air. It has an echoing sound, the waves being reflected from side to side of the closed vessel, as is speech in a vaulted chamber. A modification or variety of amphoric resonance is the **coin-clinking** test of Gairdner, or **Bell tympany** or **bell-metal** sound, in which a coin of sufficient size used as a pleximeter is percussed by another on the anterior surface of the chest, while the auscultator listens posteriorly or *vice versâ*. The sound thus elicited usually resembles that produced by striking with a hammer on an anvil; more rarely it is softer and more musical. It is especially characteristic of pneumothorax.

Amphoric resonance is not very often met; the conditions of its production in the human body are an air-filled cavity of considerable size, with firm and *smooth* walls, completely closed or communicating with the air by a small opening only. When thus communicating it is louder when the mouth is kept open. These conditions are fulfilled by certain phthisical cavities, and especially by pneumothorax or pyopneumothorax, sometimes also by a distended stomach. If with a pyopneumothorax the body be shaken, a splashing or **succussion** occurs, which will sometimes have the same ringing character. The same conditions are sometimes fulfilled by a distended stomach containing fluid.

The Cracked-pot Sound.—This sound is well named because it quite resembles that produced by tapping a cracked jar, and is therefore one of the most distinctive and easily recognized of the abnormal percussion sounds. It is, too, a modification of tympany, and is caused by the explosion of air from a cavity through a small opening by a sudden forcible blow. It is also imitated in mechanism as well as character by suddenly striking the back of the two palm-apposed hands against the knee, after the method used by boys to imitate the clinking of coins.

It may also be made by striking the pleximeter when the latter is not closely applied to the skin, an accident favored by a hairy skin. The cracked-pot sound may also sometimes be produced in the normal chest by percussing it sharply while the patient is in the act of speaking or crying out, the narrow glottis affording the condition of a small opening. This may more readily be done under these conditions in children who have thin, elastic chest-walls.

The cracked-pot sound is produced in disease by percussing over a cavity which affords the conditions named, *viz.*, a somewhat superficial position, sufficiently yielding walls, and communication by a small opening with a bronchial tube and thence with the outside air. It is the most infallible sign of a cavity known. In producing it, the mouth of the patient is kept open and a sudden forcible blow of the plexor given. Often it cannot be heard unless the ear is attentively turned near the chest to catch the sound. The same conditions exist in a pneumothorax with a thoracic fistula into the lung, and under these circumstances a cracked-pot sound may be produced by percussing such a chest in the manner described.

AUSCULTATION.

Auscultation is the act of listening to sounds, more particularly those produced in the chest by breathing or speaking, or by the heart's action, or in the blood-vessels; to these sounds as modified by disease and to certain new sounds produced by disease. In so doing the ear is applied either directly to the chest or on an instrument known as a stethoscope. According as this instrument is employed or not, the auscultation is **mediate** or **immediate.** Both have their advantages. When it is desired to isolate or circumscribe a sound, especially in the study of the heart, the stethoscope helps us greatly, while in the study of more diffuse sounds, as many of those produced in the lungs, the direct application of the ear to the chest is generally to be preferred. The stethoscope becomes also desirable in the examination of patients not especially clean. In inexperienced hands, on the other hand, the patient is often rendered uncomfortable by undue pressure by the head on the instrument.

The stethoscope was invented and used by Laennec, of Paris, in 1816, in its single shape. Through the labors of Laennec, by the aid of the stethoscope the diagnosis of diseases of the chest developed in a comparatively short space of time to an accuracy scarcely equaled in the case of any other set of organs. The binaural instrument was devised by Cammann, of New York city, in 1840. There can be no doubt that, with the latter, sounds are more loudly heard. On the other hands, all noises, as that of the rubbing of linen or clothing, are so much exaggerated that the beginner is often confused. The double instrument is becoming more popular of late, but preference depends on training. A man who has been brought up to use the double stethoscope soon grows to prefer it, while he who is trained to the single instrument would not have the double. When either form of the instrnment is used, better results are obtained when the chest-end is applied directly to the bare skin, whereas in immediate auscultation it is desirable that there should be a thin, soft towel, or some thin garment, interposed between the ear and the skin.

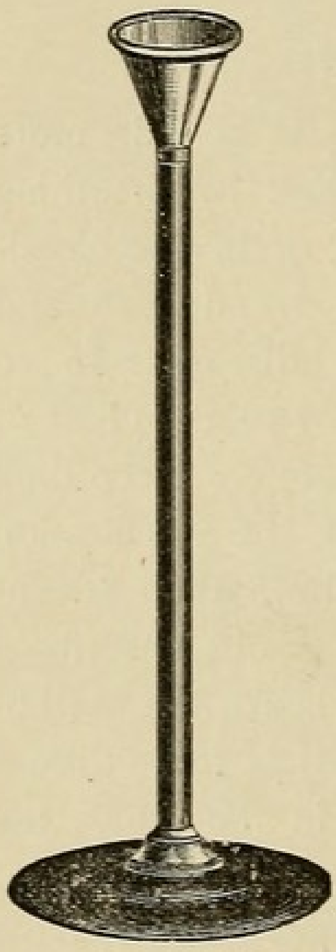

FIG. 14. — HAWKSLEY'S STETHOSCOPE.

The ear or stethoscope should also be applied closely to the chest-wall, so as to become a part of it or continuous with it; and yet, as stated, the stethoscope may be applied too strongly, so as to give pain to the patient. Successful auscultation requires that the attention should be closely concentrated on the matter in hand.

The single stethoscope is made of wood or metal. That originally made by Hawksley, of London, out of gun-metal, and provided with a detachable hard rubber

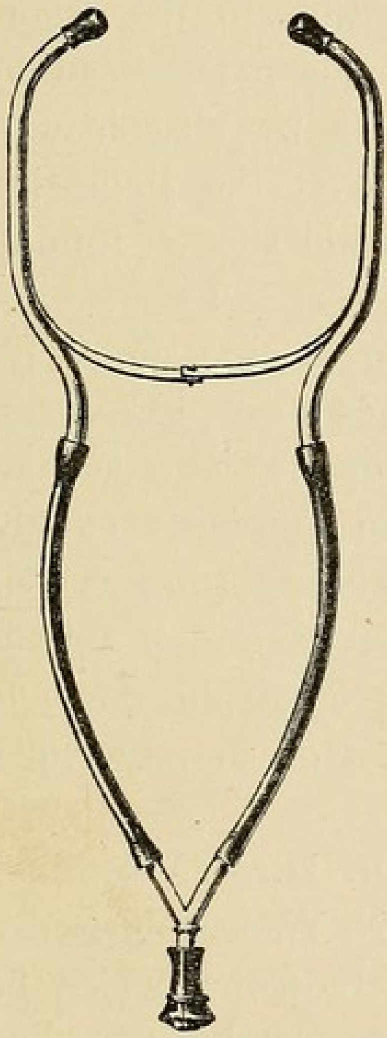

Fig. 15.—Sansom's Binaural Stethoscope.

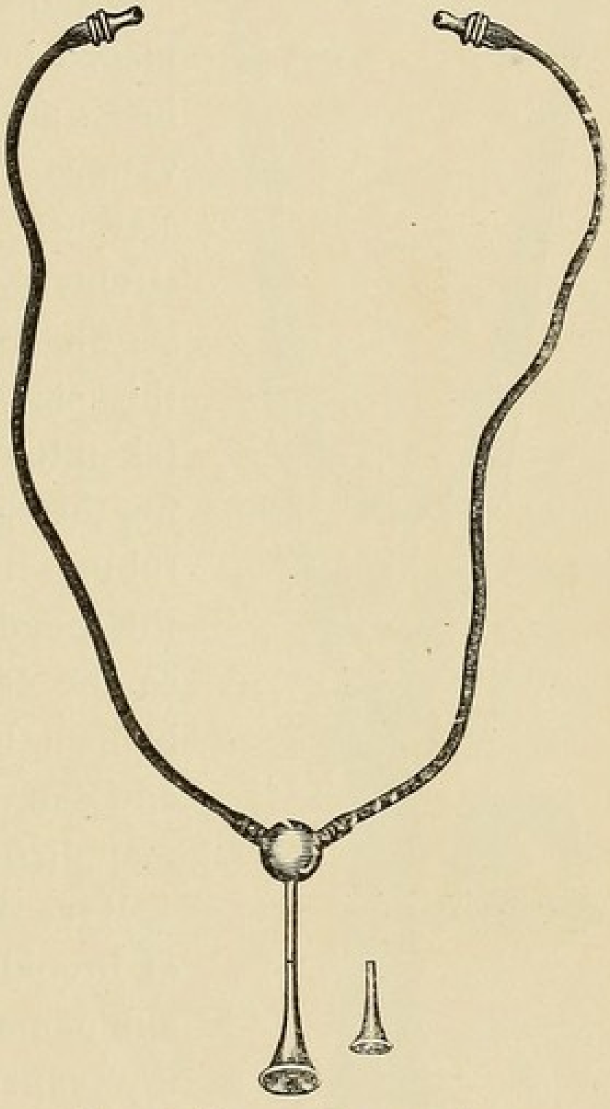

Fig. 16.—Simpler Form of Sansom's Binaural Stethoscope.

ear piece, shown in Fig. 14, is the most convenient and neatest. A large variety of double stethoscopes has been suggested. The double instrument, Fig. 15 in the text, partly metal and partly rubber tubing, was devised by Sansom, and is very conveniently carried when folded at the joint. It is especially suitable when the patient is inaccessibly placed in relation to the examiner, an advantage possessed in various degrees by all binaural stethoscopes over the single instrument. A still simpler form is shown in Fig. 16. In selecting this shape, great care should be taken to secure an ear-piece which fits the ear properly; also, that the rubber tubing embraces closely the metallic chest-portion as well as the ear pieces, and if tubing happen to become split, the split end can be cut off and the tube reapplied.

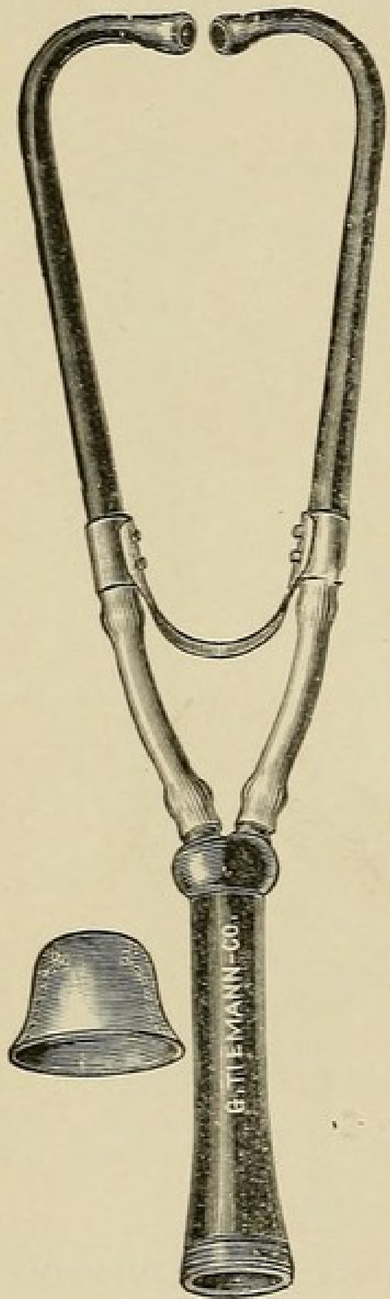

Fig. 17.—Valentine's Binaural Stethoscope.

Recently Dr. H. K. Valentine, of Brooklyn, N. Y., has devised * a binaural stethoscope, which in my experience conducts stethoscopic sounds more loudly to the ear than any other I have used. The instrument (Fig. 17) is composed of hard rubber, the chest- and ear- pieces

* *N. Y. Med. Record*, July 16, 1892.

being united by two pieces of ordinary soft-rubber tubing, each about 3½ inches in length, and being flexible the instrument may be folded and carried in the pocket. The bell consists of two parts, the lower a tube 4½ inches long, having ⅞ inch at the mouth and ⅝ inch at the upper end, where it is screwed into the upper section. This top section is ⅝ inch long and has two canals, each ¼ inch in diameter, diverging from it, separated at their origin by a septum of hard rubber. The ear-pieces are straight up to where they are curved to enter the ear, having a bore of ¼ inch at the lower end, tapering to ⅛ at the ear ends. These are retained in the ear by a flat steel spring. When the instrument is in use, the waves of sound pass upward through the long bell, divided at the top by the sharp rubber septum, and thence through the ear-pieces into the ears of the operator. The efficiency of the instrument depends largely on the smooth finish of the interior of the hard-rubber tubing throughout its entire length. It is provided with one or two accessory soft-rubber bells, also figured, which intensify the sounds, but the instrument is, for the most part, best used without them.

When the interior of the bell becomes very dusty, it may be easily cleaned by allowing cold water to run through it.

AUSCULTATION OF THE NORMAL LUNG.

The breathing sounds in health are separable into two distinct orders: first, the **bronchial breathing**;

second, **vesicular murmur** or **respiratory murmur.** Both are normal sounds, constantly produced in the act of breathing, but in certain parts of the chest one is heard more or less to the exclusion of the other. Thus the vesicular breathing is heard in its most typical character under the left clavicle, where it is best studied by immediate auscultation.

Bronchial respiration is the easiest of description. It is blowing or tubal in quality, both in inspiration and expiration, and the two parts are nearly equal in length, the expiratory being often slightly the longer. It is heard in its purest form over the larynx and trachea, but also quite pronouncedly between the scapulæ at the root of the lungs, where, however, it is more or less admixed with vesicular breathing. The pitch is high in both in- and out-breathing, and somewhat higher in the latter. It is caused primarily in the glottis by vibrations produced in the column of air as it passes the vocal cords in inspiration and expiration. It is conducted downward from the larynx partly along the solid walls of the trachea and bronchi and partly by air, the latter being chief conductor. It is modified as the tubes gradually reduce their calibre.

Vesicular murmur is the breathing sound heard when listening over the vesicular tissue of the lung. It is also divided into two portions—the inspiratory and expiratory, the **in**- and **out**-murmur, the former being much the longer. Perhaps no language can give a correct notion of the vesicular murmur, but it is a soft, low-pitched sound, said to resemble the sighing of a gentle breeze through the leaves of a tree. It is the blowing sound primarily produced in the glottis, subdued and muffled by distance and the spongy structure of the lung. When typical the inspiratory murmur is much longer than the expiratory. The ratio is, however, not fixed. The expiration may be one-fourth as long, or it may be a mere whiff, as it were. It represents the recoil of the air vesicles and the backward movement of the air. The question why the expiratory murmur is less loud and shorter than the inspiratory is a natural one. It is probably because sound is better conducted in the direction of the movement of the vibrating column from the point at which the vibration is caused, *i. e.*, in this instance at the glottis. During inspiration the sound is conducted toward the periphery and during expiration toward the glottis.

The vesicular murmur is not everywhere the same, even in health. As a rule, it is slightly louder, more purely vesicular below the left clavicle, and, assuming it to be typical in this situation, is nearest maintained in the axillæ and below the scapulæ. Under the right clavicle the slightest rise in pitch and a distinct prolongation of the expiratory portion is often noted, and to be remembered as of great importance in diagnosis in doubtful cases. This is usually ascribed to an admixture of the bronchial element due to the larger size of the right bronchus, and of its branches sent up toward the right clavicle. Over the scapular regions posteriorly the vesicular murmur is less intense, because of the thickness of the bone and muscles, but the same difference between the two sides may sometimes be noted in the supraspinous fossæ, as below the clavicles in front. For the same reason it is less intense in the mammary regions, and in all fat and muscular persons as compared with the thin and emaciated. Between the angles of the scapulæ still more of the bronchial element is added than below the right clavicle, and the sound is decidedly more blowing and the expiration longer. It is to be remembered that both vesicular and bronchial breathing are being constantly produced in the lungs, but that in certain situations one overshadows the other, partly because of its proximity immediately under the point where the ear is applied, and partly because the normal lung is a poor conductor of sounds.

ABNORMAL MODIFICATIONS OF BREATHING SOUNDS.

Changes in the Vesicular Murmur.—The vesicular murmur is modified by diseased states as follows:

1. It is jerking or interrupted.
2. It is increased in intensity or loudness.
3. It is diminished in intensity, feeble, more indistinct.
4. It is altogether absent.
5. It is commingled with bronchial breathing, by which a harsher sound is produced, and of altered rhythm.
6. It is substituted by bronchial breathing.

1. **Interrupted** or **jerking** or **cogwheel** breathing is the least important of the alterations in the vesicular murmur, being generally of no significance.

Such is its value in persons who are nervous or slightly alarmed during examination. The interruption affects most frequently the inspiratory act, but it may occur in either or both, and the act may be broken into two or three parts. More serious is its cause when it occurs in connection with severe pleurisy or pleurodynia, where the pain of the act of breathing causes the latter to be interrupted. Finally, it may be present in incipient tuberculosis or emphysema, but even here its diagnostic value is merely confirmatory, and that only when it persists.

2. Vesicular breathing is **exaggerated** or **supplemental,** or increased in intensity by any cause which compels the lung or a part of it to assume increased function. This happens in one lung or a part when the other or the remainder is deprived of its use by compression or destruction. In this change both the inspiratory and expiratory factors are proportionally increased in loudness and in length. Its pitch is unaltered. From the resemblance of this exaggerated breathing, as it is also called, to the louder normal breathing in children it is often called **puerile** breathing.

3. The vesicular murmur is **feeble** or diminished in intensity by various causes. The quieter the breathing the less loud its sounds, and diminished loudness may be due to feebleness in the inspiratory act from debility, or to obstruction in the bronchus leading to the ausculted area. More commonly, in actual practice, the feebleness is due to the interposition of a liquid or a solid medium between the lungs and the ear, such as a

pleuritic effusion or the plastic exudation of a pleurisy. Or it is due to the filling up of the air vesicles by an exudate, as in pneumonia, or tubercular infiltration in phthisis. More frequently it is obliterated by these causes.

4. The vesicular murmur is **absent** or altogether removed by the higher degrees of the last-named conditions, viz., pleuritic effusion, pneumonic and tubercular infiltrations.

5. The vesicular murmur is altered by the addition of a bronchial element, the first effect of which is to lengthen the expiratory factor of the breathing sound, to alter, in a word, its rhythm. Coincidently with, or immediately succeeding upon this, is a roughening of both inspiration and expiration, at first slight and then positive. As long as this degree is maintained there is still a vesicular factor in the breathing, whence it was named by Flint **broncho-vesicular breathing.** It has also been called indeterminate breathing. Expressive terms are also, harsh respiration, *rude respiration*, or *rough* respiration. Such modifications of normal breathing are brought about by an infiltration of a certain number of air vesicles with solid material, while others still maintain their function. The effect of this is also to improve the conducting power of the portion of the lung involved, so that it becomes a better conductor of the bronchial sounds elsewhere produced, which are thus brought to the ear. It means, therefore, that a certain small extent of consolidation has taken place.

How shall we distinguish between puerile breathing *and broncho-vesicular breathing*, a most important requirement, since they indicate opposite conditions? Yet there is a certain similarity between them which inexperienced observers may mistake for identity, and which even an experienced man may sometimes have occasion to dwell on before deciding. Both are louder and rougher as to inspiration, but vastly different is the manner in which expiration is influenced. In puerile breathing it may be slightly longer and more distinct than in health, but it maintains its ratio to the length of the inspiratory murmur. Not so is it with rude respiration. Here the expiratory sound is roughened and prolonged out of all proportion to the inspiratory. And in catching slight degrees of difference the attention must be concentrated on the expiratory murmur. If it is greatly prolonged in proportion to the inspiratory, so as to nearly or quite equal it, and at the same time harsher than in health, not simply ~~louder~~, then we have broncho-vesicular breathing and the conditions which produce it. And if to this is added a slight rise of pitch on percussion, a slight dulness, the condition is confirmed. Sometimes, however, these conditions do not go entirely *pari passu*. Then we must wait and watch. We must not forget, too, the physiological differences on the two sides, that there is the slightest higher pitch on the right in both percussion note and breathing sound, and that the expiratory murmur is slightly longer on the right. The difficulties are increased by the physiological variations in the vesicular murmur, which are not to be overlooked.

6. The **expiratory vesicular** murmur is *prolonged* in emphysema because of the loss of elasticity of the air vesicles resulting in a slowing of the expiratory act.

7. Finally, the vesicular murmur may be altogether *substituted by* **bronchial breathing.** This means that a considerable area of lung has become obliterated as to its vesicular structure, and has thus also become an excellent conductor of the distant normal bronchial breathing, which is heard with a blowing tubal quality as though produced directly under the ear. Again, it is to be remembered, that there is no more bronchial breathing produced under these circumstances than there was before the consolidation took place. It is simply that the vesicular murmur has altogether vanished for the reason named, and therefore cannot longer mask the bronchial breathing, while the latter also is better conducted to the ear. Acute croupous pneumonia furnishes the most characteristic bronchial breathing. Between this and broncho-vesicular breathing there is every degree, depending upon the degree of destruction of vesicular tissue and the extent of consolidation. When the consolidation is very intense the bronchial breathing is rendered more intense, more metallic even than the tracheal breathing sound, which may be regarded as the type of bronchial breathing in disease, the latter resembling more the tracheal sound as heard in health than the sound heard over the bronchial tubes.

Varieties of Bronchial Breathing.—Bronchial breathing is low pitched or high pitched according as the tubes whence the sound is conveyed by the consolidated lung are large or small.

Low-pitched bronchial breathing is also heard over cavities of moderate size, when it is called **cavernous breathing.** The expiration in cavernous breathing is also commonly lower pitched than the inspiration, reversing, in this respect, the bronchial breathing, although this is not constant enough to be made a rule of difference. The conditions of its production are a cavity with yielding and resilient walis, by the collapse of which the air can be forced out, since the sound depends upon the entrance and exit of air. It is also often associated with gurgling, or may alternate with it. It may disappear to reappear after copious expectoration. Cavities at the apex of the lung in tubercular consumption are the most common causes, but whatever produces an excavation of the kind may cause it. A dilated bronchus, an abscess, and even gangrene of the lung may be such a cause.

High-pitched bronchial breathing is heard when the lung about smaller bronchial tubes is consolidated, as often occurs in pneumonia, which affords the most frequent site of bronchial breathing. The term *tubular breathing* is reserved by some for such high-pitched breathing, while others use the terms bronchial and tubular as synonymous.

Amphoric Breathing.—Amphoric breathing is more easily recognized from its ringing metallic character, like that of the amphoric percussion note, resembling also the sound produced by blowing upon the mouth of a bottle. It is produced by the same conditions, a cavity with firm walls—a large cavity. It is likewise a blowing sound, of high or low pitch, inspiratory or expiratory, or both. It is an echoing sound. Clinically its presence most frequently means pneumothorax, but a phthisical cavity may rarely furnish the same conditions. Every case of pneumothorax does not, however, produce it, since there must be a perforation of the pleura above the level of the fluid and free communication with a bronchial tube.

There are other modifications of bronchial breathing more or less accidental and therefore of less importance. Thus it sometimes happens that either the inspiratory or the expiratory portion is absent, when the peculiar breathing may be still recognized by the pitch and quality of the portion remaining cavernous. Again, we may have a vesicular inspiration with a cavernous expiration (*vesiculo-cavernous respiration*), or there may be an admixture of cavernous and pure bronchial breathing (*broncho-cavernous*). In the latter, the sound of expiration is bronchial, high pitched, and is said to indicate a cavity situated near consolidated lung. In the *vesiculo-cavernous* breathing the cavity is surrounded by a comparatively intact pulmonary tissue which produces an admixture of sound.

Another variety of modification is the **Seitz-metamorphosing respiration,** in which the inspiratory sound is heard for about one-third of its time as harsh tubal and the remainder is of ordinary blowing, cavernous, or amphoric quality. It is said to be caused by air entering a cavity through a narrow opening.

AUSCULTATION OF THE NORMAL VOICE.

Normal Vocal Resonance.—When the ear is applied below the clavicle of a person speaking, a confused monotonous humming sound is produced, of slight intensity and low pitch. In the aged, it is apt to be tremulous or somewhat bleating. This is normal vocal resonance. It varies, however, in intensity and pitch in different persons, being almost inaudible in some. It depends also somewhat upon the manner in which the person speaks and the words he utters. It is increased not so much by loud speaking as speaking "from the chest." It is better noted also if the patient counts "one, two, three," or speaks the word "ninety-nine." It is also feebler in women than in men. It is accompanied by a fremitus which is the same as that described under palpation. It is a tactile fremitus in which the ear is the touching part instead of the palm of the hand.

Vocal resonance varies in different parts of the chest, being more marked where the walls are thin. Hence below the clavicles it is relatively loud, and more so below the right, just as is tactile fremitus, an important fact to be remembered in diagnosis, as well as that everywhere on the right side it may be more marked. Toward the sternal portion of the clavicular region it is louder, the tracheal voice influencing it. Below the clavicles it diminishes with the greater thickness of the chest-walls of the mammary region, it is again more marked in the axillæ, less intense over the scapulæ and louder below them. Between the scapulæ it is also intense.

The **whispering voice** also requires some allusion. It being borne in mind that whispering in most persons is an act of expiration, if the ear is applied to a thin-walled portion of the chest, as that below the clavicle, and the patient is asked to count in a whisper, there is heard a feeble, low-pitched blowing sound, *unaccompanied by fremitus*, with a pitch and quality the same as those of the expiratory vesicular sound in breathing. All that has been said of vocal resonance, as to its audibleness and the degree thereof in different persons and on the different parts of the chest, is true of the "normal bronchial whisper," as it is called by Flint, because "the conduction of the sound produced by the whispered voice must be chiefly by the air contained in the bronchial tubes."

Normal Bronchophony.—When the stethoscope is placed over the thyroid cartilage of the larynx of a person speaking, a much louder resounding sound is heard directly under the ear, accompanied also by a thrill or fremitus conveyed to the ear. But it is still confused and no articulate words are heard. It corresponds to bronchial respiration, as normal vocal resonance accords with vesicular breathing.

If the person thus auscultated over the larynx or trachea whispers instead of speaks audibly, a high-pitch tubal sound accompanied by feeble fremitus is heard. It is, in fact, the expiratory breathing sound, as heard in these air tubes, interrupted by the act of speech.

Abnormal Modifications of the Ausculted Voice.—The association of a corresponding degree of vocal resonance with normal vesicular breathing and of bronchophony at the seat of normal bronchial breathing has been referred to. The same relation exists in pathological conditions. Thus any increase in the intensity of the normal vocal resonance implies a corresponding condensation of lung tissue, culminating in typical bronchophony when the consolidation is complete, just as the normal vesicular breathing passing through bronchovesicular terminates in bronchial breathing. *Pari passu* with increased vocal resonance and bronchovesicular breathing goes increased bronchial whisper.

Pectoriloquy.—In addition there are certain special modifications of the normal vocal resonance corresponding more or less to certain morbid states. Thus there is the cavernous voice or pectoriloquy, in which articulate speech is heard as though coming directly from the chest into the ear. While this is commonly the sign of a cavity of some size, it is not always so, the voice being similary transmitted by solidified or collapsed lung, a tumor of the lung, and over the upper lobe of a lung whose lower lobe is compressed by a pleuritic effusion. Whispering pectoriloquy, in which whispered articulate speech is conveyed to the ear, is a much more reliable sign of a cavity.

Amphoric voice is ringing and metallic, echoing like the other amphoric sounds, and like them indicates the same conditions—a large cavity with firm walls.

Ægophony is another very distinctive modification of bronchophony. It is admirably likened to the bleating of a goat, and is produced during speech when there is a thin layer of liquid between the chest-wall and the lung, in pleuritic effusions, or when there is liquid in the chest cavity from other causes. It is most frequently heard behind at about the angle of the scapula or somewhat anterior to this. It is said to be produced in flattened air tubes of moderate size whose calibre is constantly changing in size during speech. It is not confined to the condition just named, but may occur over any superficial area of collapsed lung, whether caused by effusion or false membrane.

Diminished Vocal Resonance.—Finally, speech sounds may be diminished in intensity by the same causes which diminish the tactile fremitus; pleuritic effusions, pleuritic thickening, separation of the lung by fluid or air, and by over-distension of the lung.

NEW OR ADVENTITIOUS SOUNDS.

These sounds are not a modification of preëxisting sounds, but something altogether new or additional. They include **râles**, or **rhonchi**, the **friction sound**, and **metallic tinkling**.

Râles are new sounds produced in the trachea, bronchial tubes, or in cavities, concurrent with the movement of air inward or outward in the act of breathing. They are the direct result of some partial obstruction to the onward movement of the air, for the most part within the tube, but the narrowing may also be the result of extra-tubal pressure. They are divided into moist or dry râles, according as the obstructing substance is liquid or the reverse. Both are influenced by coughing and may often be completely removed, for the time being, by this act. When not thus influenced by coughing they are probably due to pressure from without.

Dry Râles are sounds engendered in the air of the air passages by any causes which narrow their lumen. These are commonly adherent mucus or the swollen mucous membrane of the bronchi. Sounds produced in the tubes of large lumen, like the trachea, are musical, low pitched, and are called **sonorous** râles. Those produced in the small tubes are high pitched and hissing, and therefore called **sibilant** râles.

Moist râles are caused by the passage of air through liquid, which may be blood, mucus, or serum. They are therefore of the nature of bubbling sounds and are spoken of as large and small bubbling sounds, according as the bubbles are large or small, and as large bubbles can only form in tubes of large size or cavities, they indicate these conditions, while the small râles indicate smaller tubes. Moist râles, except the crepitant, are heard in inspiration or expiration, or both. The bubbling sounds are further subdivided, according to size, into gurgling, mucous, submucous, subcrepitant, and crepitant râles, and crackling.

Gurgling is a term applied to the largest bubbling sounds, and is produced in cavities containing fluid. It is also known as the cavernous râle, and has sometimes a metallic character when it becomes associated with the other metallic physical signs already mentioned as characteristic of a cavity with firm walls.

The mucous râle is a bubbling sound smaller than the cavernous, but still of large size, produced in the trachea and larger bronchi. The death-rattle is a tracheal mucous râle. The **submucous** râle is a smaller bubbling sound produced in tubes of smaller size and the **subcrepitant** in still smaller. The **crepitant** râle is formed in tubes of smallest size and in the air vesicles. It may be a true bubbling sound, or it may be due to the separation of agglutinated air vesicles by entering air. From its extreme importance in the diagnosis of pneumonia, although it occurs also in œdema and collapse of the lungs, it requires some further illustration. It is aptly compared to the crackling produced by throwing salt on the fire, or rolling the hair between the fingers alongside of the ear; also to the noise made by separating near the ear the moistened thumb and index finger. The first appears to me the best imitation. It is heard only in inspiration and is thus distinguished from the subcrepitant râle, which is heard in expiration as well. It is sometimes heard throughout the whole of the inspiratory act, more frequently only toward the end of it.

Crackling literally means the same as crepitation, and, in fact, the mechanism of the two signs is nearly the same. Both are inspiratory sounds, and both may be small bubbles. The main difference is really in the number of crackles which go to make up the râle, the crepitant consisting of several of these, while the crackling consists of but one, two, or three. "Crackling" is heard at the apices of the lungs, and the crepitant râle for the most part at the base. The interpretation of crackling is almost invariably tubercular consumption, and it means that the tubercle is beginning to break down. Yet we may have pneumonia of the apex. What is known as "moist crackling" is a little larger râle than crackling, a pure bubbling sound produced in the smallest bronchial tubes, and is really a subcrepitation. It is essentially a subcrepitant râle.

Friction sound is a noise produced by the rubbing of two slightly roughened serous surfaces upon each other. The pulmonary and costal pleuræ and the cardiac and pericardiac serous membranes move over each other smoothly and noiselessly in health, but let them be roughened in any way by an inflammatory exudate, an eruption of the tubercles, or other morbid growth, and at once the friction sound is produced. In its simplest and most frequent form, representing the first stage of pleurisy, it also resembles somewhat the crepitant râle and it is sometimes not easy to distinguish from it. In addition, however, to being more superficial in situation, the friction sound is not influenced by coughing, while the crepitant râle is. The friction sound is heard more loudly if the stethoscope is pressed closely to the chest wall and is localized, while the crepitant râle is heard over a large area of lung. It is also often a to-and-fro sound, being heard with expiration as well as with inspiration, while the crepitant râle is confined to inspiration. The friction sound disappears with pleuritic or pericardial effusion, to return for a time with the subsidence of the effusion.

In addition to its typical crepitant like character, as heard in pleurisy, the friction sound assumes also at times greater roughness, which is more conspicuous in pericardial friction. Where organization has taken place in an exudate there is sometimes a leather like creaking produced under the same circumstances as the friction sound, and it is regarded as a friction sound. It is sometimes so loud as to be heard by the patient himself, and may also be recognized by palpation. Pleural friction may be found anywhere in the chest, but is more frequent in a circumscribed area in one side of the chest, especially below the nipple toward infra-axillary region or below the angle of the scapula.

Metallic tinkling is the last of the adventitious sounds to be considered. It is another one of the amphoric sounds, requiring a space with firm, tense walls as its condition. A pneumothorax will furnish such condition, as also do certain pulmonary cavities. Under these circumstances a drop of liquid falling into such a space will produce metallic tinkling. This sometimes happens in a pneumothorax when a drop of secretion will sometimes fall from a bronchial tube into a cavity. Such resonance also is contributed to râles in a bronchus communicating with a pneumothorax or cavity.

Allied to the metallic tinkling is the **Hippocratic succussion** produced in pyopneumothorax, and very rarely in a cavity when the patient is shaken.

PHYSICAL SIGNS OF ABNORMAL STATES OR DISEASES OF THE LUNGS.

ACUTE BRONCHITIS.

Acute bronchitis of the larger tubes is essentially a symmetrical disease, the bronchi of both lungs being generally more or less equally invaded. There may be absolutely no physical signs; inspection, palpation, percussion, and auscultation being alike negative. In other cases *inspection* may discover increased frequency of respiratory movement, and possibly increased frequency in the cardiac apex-beat if there be fever. *Palpation* may appreciate a rhonchal fremitus if there be sufficient narrowing of the breathing tubes. It may be found anywhere or on either side and may be very transient. *Percussion* continues invariably clear so long as the bronchitis is uncomplicated.

Auscultation furnishes the most distinctive and constant physical sign, the presence of dry râles, the sonorous and sibilant, which may invade either or both lungs, and may also be transient. To these may be added harshness of breath sounds. In the resolution of bronchitis, bubbling râles may substitute the sonorous and sibilant, in consequence of the presence of liquid secretion.

Other symptoms are pain or a sense of oppression behind the sternum, some shortness of breath, and annoying cough.

Capillary bronchitis, catarrhal or **broncho-pneumonia,** involves the finer and finest tubules and adjacent air vesicles, into whch it generally extends from the larger bronchi. The frequent breathing is more evident and constant; so is the frequent heart beat with fever. *Percussion* elicits circumscribed areas of dulness. *Auscultation* recognizes first the signs of an ordinary acute bronchitis, followed by more or less distinct bronchial breathing, very soon by small bubbling râles, subcrepitant and crepitant, but dry râles are often absent at the outset. These signs are most frequent in the bases of the lungs posteriorly, but may be found anywhere all over.

CHRONIC BRONCHITIS.

Physical signs attend chronic bronchitis more constantly than acute, yet they afford no unchanging picture. To *inspection* there is often nothing apparent, except the corresponding motion of more frequent breathing. Even this is sometimes absent. To *palpation* there may be rhonchus with normal tactile fremitus, unchanged or slightly increased or as much diminished. To *percussion* there may be no change or, unless in the vicinity of a superficial dilated bronchus filled with secretion, where there may be impairment of resonance. If such a dilated bronchus be emptied of its contents by expectoration, the percussion signs of a cavity may be present, but in the middle or lower part of a lung instead of the apex. Vesiculotympanitic or even tympanitic resonance may be present from relaxation of lung tissue, especially in the lower posterior part of the lungs.

Auscultation may also be negative, but much more frequently recognizes an alternation or combination of harsh and feeble breathing, sonorous and sibilant râles, with moist râles of all sizes, variously modified by different distances from the ear and varying consistence of the secretion.

Other symptoms are cough and expectoration, usually copious, of muco-purulent sputum, little or no pain but marked shortness of breath.

If the frequently associated complication of emphysema of the lungs is present, the signs and symptoms of that condition are superadded as detailed below.

EMPHYSEMA OF THE LUNGS.

This condition, an over-distension and destruction of air vesicles with a like destruction of their covering of capillaries, is most frequently the result of bronchitis and a complication of it. It may also be produced from forced straining efforts, as in heavy lifting or carrying heavy loads. It also commonly affects both lungs at the same time, but involves different lungs and different parts of the same lung unequally.

The physical signs are more or less distinctive. *Inspection* discovers a rounded chest anteriorly and posteriorly, with increased circumference and wide intercostal spaces, the highest degree of which is known as the "barrel-shaped chest" (Fig. 18). But the emphysema may be so circumscribed as to produce local bulgings, by preference in the upper lobe of the right

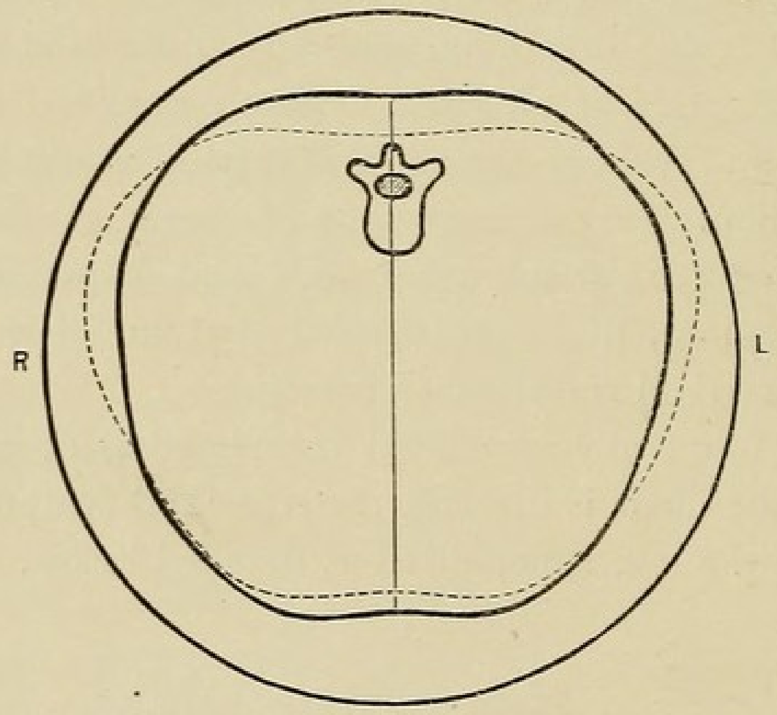

FIG. 18.—BILATERAL ENLARGEMENT IN EMPHYSEMA.—(*After Gee.*)

and lower lobe of the left lung. The excursion of expansion of the chest-walls is diminished, while the scaleni and sterno-cleido-mastoid muscles stand out distinctly. The rate of the movements is increased. The apex of the heart is displaced downward and to the right, but it is often difficult to find, because covered up by the enlarged lung. To *palpation* vocal fremitus is diminished, while the natural resiliency of the chest-walls is substituted by increased resistance.

Percussion recognizes resonance exaggerated in various degrees, sometimes amounting almost to tympany, the vesiculotympany of Flint. The cardiac dulness is extended to the right and downward, partly from displacement by the distended lungs and partly from hypertrophy of the right ventricle. At the same time the cardiac area is more thoroughly covered by the lungs, and pretty strong percussion is often necessary to bring it out. The hepatic area of dulness is also lowered by reason of the encroachment of the lungs, and often diminished from the same cause.

The distinctive *auscultatory* sign of the emphysematous area is the feeble inspiratory murmur due to the fact that the air vesicles are already distended with air, and current conduction is impaired. The prolonged expiratory murmur is the result of the lost elasticity of the air vesicles, in consequence of which they recoil but slowly on their contents. Vocal resonance is diminished because of the diminished motion in the air columns. Crackling is sometimes heard. If bronchitis be present its sounds are associated and often obscure all else. The pulmonary second sound at the second left interspace is accentuated on account of the hypertrophy of the right ventricle, but the heart sounds are usually obscured by the extra covering of the lung. With dilation of the right ventricle, which sooner or later succeeds, the increased accentuation disappears.

Of **other symptoms** the most invariable is shortness of breath, but there is often a good deal of cough.

Interlobular emphysema is a condition in which the connective tissue between the lobules is infiltrated with air as the result of rupture of air vesicles due to violent acts of coughing or to wounds of the lung.

The physical signs, except to inspection, are the same as those of vesicular emphysema, except that the crackling sound referred to is more common. The configuration of the chest in such cases is not usually altered. Suddenness of onset is characteristic of this form of emphysema, and it is apt to be associated with a similar infiltration of the tissues of the neck, which gives rise to a very distinctive crepitation on palpation.

BRONCHIAL OR SPASMODIC ASTHMA.

The physical signs of this peculiar neurosis reveal themselves to all the methods of physical diagnosis employed. There is a spasm of the muscles of the smaller bronchi. *Inspection* observes the most labored effort in breathing, while the chest moves but slightly, because the lungs cannot be inflated. The spaces above and below the clavicle and above the sternum, the intercostal spaces, and the pit of the stomach, are drawn in, for the same cause,—that is, the thoracic cavity not being filled from within, the external atmospheric pressure forces the yielding portions inward.

Rhonchal fremitus is recognized by *palpation*, while vocal fremitus, obscured by the rhonchus, is otherwise diminished by a frequently associated emphysema.

Percussion is negative in uncomplicated asthma, but if asthma is associated with emphysema it may produce abnormal resonance.

Auscultation discovers the most striking and easiest recognized of the physical signs. All over the chest are heard sonorous and sibilant râles, inspiratory and expiratory, but more commonly the latter. In fact, for the most part they do not require the ear to be placed close to the chest for recognition. The vesicular murmur, on the other hand, is inaudible.

It is to be remembered that chronic bronchitis, emphysema, and asthma may also complicate each other, and render correspondingly complex the physical signs.

Other symptoms include little else than the labored breathing until the spasm breaks up and secretion is established, when there is cough and scanty sputum containing small lumps in which Curschmann's spirals and Charcot-Leyden crystals are found.

PULMONARY TUBERCULOSIS, OR CONSUMPTION.

Accepting the modern doctrine that all phthisis is tubercular, there are three ways in which it invades the lungs:

1. As catarrhal or bronchopneumatic phthisis.
2. As fibroid phthisis.
3. As miliary tuberculosis of the lungs.

Catarrhal Phthisis.—This, the most common form of consumption, presents two varieties, differing mainly in the rapidity of their course,—whence acute and chronic phthisis. The former is also known as *phthisis florida* or galloping consumption. Perhaps there should be added, as a distinctive feature of the latter, the diffuseness as well as the rapidity of the process.

Catarrhal phthisis resolves itself, with more or less definiteness, into three separate stages, of which the physical signs, commonly sought at the apices of the lungs, are also more or less distinctive:

1. The incipient stage, or beginning deposit *
2. Stage of complete consolidation.
3. Stage of softening and cavity formation.

1. *Inspection*, in the *incipient stage*, is as often negative as not. A slight impairment of motion in the infra-clavicular space may be present, and more rarely a slight flattening of the same region. The clavicle becomes correspondingly conspicuous. The body may continue well nourished or slightly emaciated, or the heart beat in the normal position may be somewhat accelerated, while the respirations are likely to be more frequent than in health.

Palpation recognizes increased vocal fremitus in the same situation, although this may not always be noticeable in the first stage, while the physiological difference in favor of the right side is to be remembered. Percussion in this stage gives slightly higher pitch and impair-

* This subdivision does not seem to me as satisfactory nor based on as well-defined clinical features as another which makes the *first stage that of consolidation*; the *second that of softening*; *third, that of cavity formation*; but for the sake of uniformity with other writers I retain it for the present.

ment of resonance, which may be noted above, on, or below the clavicle. Dulness may sometimes be brought out by directing the patient to hold his mouth open during percussion, or to hold his breath at expiration.

To *auscultation* above or below the clavicle, we have the first evidence of abnormality in a prolongation of the expiratory murmur and harshness in the inspiratory sound—the bronchovesicular breathing described. Theoretically, this should be preceded by a diminished intensity in the inspiratory sound, owing to the interference of the newly deposited tubercles with the conduction of sound into the air vesicles, but practically this is scarcely encountered, and if encountered, is of such indistinctive significance as to be of little value.

Increased vocal resonance is a constant accompaniment of these modifications in the normal breathing sounds, but it, as well as the vocal fremitus, may be masked by a pleuritic thickening, and the physiological difference so often referred to must be remembered. Da Costa also calls attention to the fact that in a certain number of cases, at this stage, there is a blowing sound in the subclavian or pulmonary artery, and that a murmur is sometimes present in the subclavian or pulmonary artery before any other physical sign is present. There are frequently concurrent with these signs those of a bronchitis more or less acute.

2. In the *second stage* the changes discoverable by *inspection* are more easily recognized. There is evident loss of flesh, depression of surface, and impaired range of respiratory movement on the side affected. The

hectic flush is intermittingly present. *Palpation* may also discover an increased warmth of skin. The increased vocal fremitus should be plainly recognized unless obscured by a thickened pleural membrane. Dulness on *percussion* is positive.

To *auscultation* there is increased vocal resonance. The bronchial factor in the breathing now becomes conspicuous, showing itself by the harshness and relative shortening of the inspiratory element, with the decidedly rough and blowing expiration; also a gradual diminution of the vesicular factor, until the latter disappears entirely, when we have the typical bronchial breathing of extended areas of tubercular infiltration. This sign will now be found in the supraspinous fossa as well. The high degree of vocal resonance, known as *bronchophony*, is also superadded as a valuable confirmation of the presence of complete consolidation. The auscultation signs of a concurrent bronchitis may also be present in this and the next stage. The heart sounds are sometimes conducted with great intensity by an adjacent consolidated area.

3. In the *third stage* the information furnished by *inspection* is still more decided. Emaciation is extreme, and breathing and the pulse are rapid, the face often flushed. There is flattening over the affected area, and the excursion of respiratory movement is still more limited. In this stage the superficial veins over the involved area may be prominent, partly from emaciation and partly from obstructed circulation.

To *palpation* the vocal fremitus is still more marked, and even remains distinct over cavities, because of the consolidation around them, unless there be some obstruction to the entrance of air in the bronchus leading to the involved area. Rhonchal fremitus may be added if adventitious sounds are present. The skin is hot and dry, unless succeeding one of the sweats which characterize this stage, when it may be moist and clammy.

Dulness on *percussion* is always to be found in the third stage, but to it is constantly added some one of the varieties of tympanitic note referred to, viz., pure tympany, the "cracked-pot" sound, or amphoric resonance, due to cavities. These require sufficient size and superficial situation on the part of the cavity, and the other conditions described on pages 55, 56, 57, and 58. On the other hand, resonance may even be normal over a cavity some distance from the surface, especially if the percussion be lightly made.

Auscultation in this stage may continue to recognize the bronchial breathing of the second, but to it may be superadded the distinctive signs of a cavity, which may also supplant those of the bronchial breathing. These signs are cavernous breathing, cavernous voice, or pectoriloquy, either when whispering or speaking with the ordinary voice, amphoric breathing, and amphoric voice, the full import and conditions of all of which have been described. To these are often added the large bubbling sounds known as gurgling, caused by the air bubbling through the fluid in a cavity. Metallic tinkling may be added to these phenomena, caused by the bursting of bubbles in a cavity with the amphoric conditions.

The heart sounds are often heard with great intensity and even with amphoric note over neighboring cavities.

Fibroid Phthisis, or Cirrhosis of the Lung.—Fibroid phthisis does not admit of the same sharp division into stages which characterizes catarrhal phthisis. Frequently traceable in its initial symptoms to the inhalation of irritating substances, and much more chronic in its course even than the chronic form of catarrhal phthisis, the general clinical history is of great value in distinguishing it from the latter. It is constantly associated in its beginning with pleurisy, and it may be a sequel of it.

The degree of retraction as noted by *inspection* is greater and more easily recognized, and not confined to the apices of the lungs. The heart is frequently dislocated and its apex correspondingly displaced, sometimes to an extreme degree. If on the left side, owing to the retraction of the lung, there is sometimes noted a distinct cardiac pulsation in the 3d, 4th, and 5th interspaces. The intercostal spaces are often narrowed and the diaphragm may be drawn up. The modifications of vocal fremitus as revealed to *palpation* are not nearly as constant, being masked by the retraction and pleuritic complications, and may be absent. There is usually little or no elevation of temperature.

Percussion is more constant in its results, there being marked dulness and a wooden-like resistance. There is sometimes hypertrophy of the right ventricle due to the extra effort of the right heart to propel the blood through the obstructed lung areas. *Auscultation* most frequently notes bronchial breathing and exaggerated voice, but both of these may be lessened in intensity by thickened pleuræ.

A dilated bronchus is a frequent result, furnishing the signs of a cavity, which may be in the middle or even at the base of the lung, and furnishes a copious expectoration characterized by a peculiar fetor, in which the microscope sometimes discovers fat-crystals.

To the signs of the fibroid state in one part of a lung are frequently added those of emphysema in the remainder or in the other lung, or there may be a similar involvement of that lung.

The rarity with which the bacillus tuberculosis is found in the sputum in this condition is not regarded as sufficient evidence to exclude it from the category of tubercular diseases.

Acute **miliary tuberculosis** is not accompanied by any distinctive physical signs, and the diagnosis is made from the clinical and hereditary history rather than from such signs. The temperature is high and exceedingly fluctuating. A tympanitic or hyperresonant *percussion* note is sometimes present throughout the lung in disseminated miliary tuberculosis due to the relaxed state of the air vesicles which such an infiltration favors.

Not every case of tuberculosis of the lungs begins in the apex, nor even when it does thus begin are the physical signs always first discovered anteriorly. Examination of every case should therefore include the posterior portion of the lung, and especially the supraspinous fossæ. Tuberculosis not very rarely succeeds upon a pneumonia as well as upon a pleurisy, and especially a catarrhal pneumonia, when the signs first make their appearance in the area which has been made vulnerable by the previous state. Indeed, many cases supposed from the physical signs to be pneumonia are tubercular from the beginning.

PNEUMONIA.

Acute croupous or **lobar pneumonia,** more common in the right lower lobe, presents three easily separated sets of physical signs corresponding to as many stages in the morbid process itself.

The FIRST, OF STAGE OF CONGESTION, in which the air vesicles are still open, is of short duration, terminating within the first twenty-four hours, and may therefore be overlooked. *Inspection* notes the face flushed, increased frequency of respiration, with restricted movement upon the involved side and exaggerated motion on the sound side. The patient lies by preference on the affected side because of the greater comfort it gives him. This posture not only diminishes the pain by hindering the motion of the affected side, but also lessens the dyspnœa by permitting unrestrained expansion of the other side which is doing the work.

Palpation at first may even find vocal fremitus diminished on account of the relaxation of the air vesicles, but vocal fremitus becomes decidedly increased as the air vesicles fill up. The skin is hot and the pulse is frequent. *Percussion* obtains but slight if any impairment of resonance. In fact, tympany or the vesiculotympany of Flint is frequently present in this stage as the result of the relaxation of the partially filled air vesicles, giving resonance by immediate relaxation. (See p. 54.)

Auscultation in the very earliest stage may find the vesicular murmur feeble, but very soon is heard the distinctive physical sign of pneumonia, the crepitant râle at the end of inspiration, or if there be coincident pleurisy—pleuropneumonia—the closely simulating friction sound may be added. Morison * calls attention to a jerky expiration over a limited area as the first physical sign, heard soon if not immediately after the rigor, before dulness or crepitation appears. The sign is said to be more distinct in children, but has been noted in adults. Over the normal part of the lung there is exaggerated vesicular breathing.

But all of these physical signs, even if carefully sought for, may be wanting if the pneumonia is deep-seated, as is not infrequently the case. They appear as the surface is reached, or they may not be recognized at all if it remains central.

The SECOND STAGE, OR STAGE OF RED HEPATIZATION, or solidification, lasting four or five days, furnishes unmistakable signs. All the signs pneumonia reveals to *inspection* in the first stage are intensified in the second, and the breathing is markedly abdominal. To *palpa-*

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* *Medical News*, Dec. 16, 1893, p. 683, from *Lancet*, No. 3656, p. 746.

tion, vocal fremitus is now intense, the skin is hot and dry, and the pulse continues frequent.

Percussion gives absolute flatness over the solidified area, with high pitch and short duration, except in those very rare instances alluded to on p. 58, where the extreme consolidation throws the column of air in the trachea and bronchi into vibration, producing tympany. This explanation is perhaps the only one when it occurs in the upper lobe. In a lower lobe, tympany may result in the same way, from the proximity of a dilated stomach. Over the adjacent normal areas, also, resonance is exaggerated in consequence of the supplemental action of these parts. Here there may even be tympany or vesiculotympany due to the relaxation of the adjacent air vesicles, an instance of resonance by *mediate* relaxation. Even cracked-pot sound may be produced by percussion over the solidified lung as the result of the sudden expulsion of air from a large bronchus leading to the solidified area.

Auscultation discerns high-pitched bronchial breathing over the solidified lung. Indeed, these are the circumstances which give the typical bronchial or tubal breathing. The air vesicles are obliterated, and the resulting excellent conducting medium brings the tracheobronchial blowing to the ear. The auscultated voice gives us typical bronchophony and occasionally even pectoriloquy, as well as whispering bronchophony and pectoriloquy. The heart sounds are also heard with great distinctness over the consolidated lung, owing to the improved conduction, while the sounds of a concurrent bronchitis are similarly intensified. A lingering crepitant râle may also be heard.

The THIRD STAGE, OR STAGE OF GRAY HEPATIZATION or resolution, occupies six to ten days. It repeats largely, to inspection, palpation, and auscultation, the phenomena of the first. Resonance continues impaired for some time. The normal manner of breathing gradually returns, the temperature of the skin is noticeably less, the crepitant râle returns, technically known as the "crepitans redux," and is finally replaced by the normal vesicular breathing sound, by which time the dulness has disappeared.

Croupous pneumonia may rarely terminate in abscess or gangrene, when the signs of the second stage continue, the temperature does not fall, in a word, the crisis does not occur. The signs of a cavity which might naturally be expected are rarely present, and it is rather the general symptoms, the failure to recover, the continued high temperature, the expectoration of pus, and, in the case of gangrene, the intensely disagreeable odor, that informs us of the issue. These issues probably represent on a large scale what takes place in every instance in minute areas in the third stage of all pneumonias which terminate favorably. The occasional termination in tubercular phthisis exhibits a similar arrest of the resolving process in the second stage, and the phenomena of the catarrhal or fibroid phthisis supervene.

The obscuring effect of a thickened pleura upon all of these signs is to be remembered, and too much stress cannot be laid upon the fact that we may have a central deep-seated pneumonia which may give no physical signs, also that in old persons the physical signs of a pneumonia are very apt to be delayed from one to three days.

Other symptoms are sudden onset with chills, dull pain, cough with rusty, rather scanty tenacious expectoration, flushed cheeks, frequent breathing, and high continuous fever. The sputum contains pneumococci.

Catarrhal or Lobular Pneumonia or Bronchopneumonia.—The physical signs of this form of pneumonia are not nearly so distinctive as those of croupous. A circumscribed affection involving a few lobules, the physical signs are necessarily more obscure. Occurring most frequently in the course of a bronchitis in children and in old persons, as well as *de novo* in the former, the physician should be on the watch for it under these circumstances. It also occurs in adults, though more rarely, especially in those suffering from tuberculosis, as the result of insufflation of broken-down tubercular matter, which produces by inoculation and irritation a tubercular bronchopneumonia. When superadded to a bronchitis under any of these conditions, there ensue increase of fever, embarrassed breathing, and associated increased inspiratory effort. *Palpation* should recognize increased vocal fremitus if the area involved be sufficiently large, *percussion* should reveal dulness and *tympanicity* of *adjacent supplementally acting areas. Auscultation* will also discover in the inflamed area the crepitant râle, the bronchial breathing, increased vocal resonance, and bronchophony, in addition to the physical signs of the concurrent bronchitis.

Embolic Pneumonia and Hemorrhagic Infarct.—Pulmonary Apoplexy.—The effect of the lodgment of an *embolus* from any source in a branch of the pulmonary artery is to produce an extravasation of blood in the conical area formerly supplied by the vessel. Such an extravasation is called a *hemorrhagic infarct.* It is, in fact, a circumscribed apoplexy, but the term apoplexy of the lung is better retained for such extravasations of blood, circumscribed or diffuse, as are due to rupture of branches of the pulmonary artery from other causes than embolism. Such is over-distension of blood-vessels in valvular disease of the heart, disease of the blood-vessel wall, or traumatism.

Small infarcts of the lungs may give rise to no symptoms whatever. When large enough they cause sudden pain and embarrassed breathing, rusty expectoration, and circumscribed dulness, all of which increase with the size of the infarcted areas. *Palpation* reveals increased vocal fremitus, and *auscultation* crepitant and subcrepitant râles, bronchial breathing, and bronchophony. These are the signs of a croupous pneumonia, which is indeed present, the consequence of the infarct, which acts as an irritant. The circumscribed area covered by these signs would exclude an ordinary croupous lobar pneumonia, while the absence of fever, the suddenness of onset, and the presence of cardiac disease aid in the diagnosis.

Similar symptoms may be caused by *massive hemor-*

rhage into the lungs, or *pulmonary apoplexy*, caused by the rupture of a large branch of the pulmonary artery, whose wall is weakened by tuberculous infiltration or the engorgement due to valvular heart disease. Such a vessel may suffer a further strain in consequence of some transitory congestion, and rupture occurs. A great mass of blood is poured out, which, besides entering the bronchial tubes and producing hæmoptysis and mucous râles, also infiltrates the lungs, coagulates, and produces consolidation. If the patient lives, the blood in the bronchi may be insufflated into the vessels and there act as an irritant, producing intense inflammation followed by gangrene or abscess.

Pulmonary œdema furnishes many of the signs of the first stage of croupous pneumonia, and is sometimes accompanied by a frothy, pinkish expectoration; but the absence of fever, and the presence of dropsy elsewhere, or its causes, account for the condition.

Collapse of the Lung.—In the course of a capillary bronchitis there sometimes occurs a collapse of a portion of the lung, owing to a valvular plugging of a bronchus, as the result of which air may pass out during expiration but cannot enter with inspiration, or it may occur as the result of a want of strength to fill the air cells. The area of collapse often corresponds in size with that of lobular pneumonia.

When such collapse occurs there is sudden difficult breathing noticed on *inspection*, but *palpation* gives no information. *Percussion* reveals dulness, but it is much less marked than in lobular pneumonia, while *ausculta-*

tion finds no bronchial breathing, or if present it is very feeble; no bronchophony, but rather diminished intensity of breathing sounds and diminished voice. Collapse of the lung is apt to be symmetrical.

Compressed lung, most frequently due to pleural effusion, generally furnishes flattening, increased vocal fremitus, impaired resonance, increased vocal resonance, and bronchial or bronchovesicular breathing.

Cancer of the lung furnishes signs of consolidation very similar to those of the second stage of tubercular consumption. Flattening, increased fremitus, dulness, increased vocal resonance, bronchial breathing, all except elevation of temperature, may be present, and it is the history of the case and special symptoms that determine the diagnosis rather than the physical signs. History of heredity, cancer elsewhere, cachexia, more constant and severe pain, are symptoms of importance in the diagnosis. A peculiar currant-jelly-like sputum is much mentioned as characteristic.

PLEURISY.

Acute pleurisy is also resolvable into three stages, each of which is characterized by physical signs more or less distinctive. They include a **dry stage**, a stage of **effusion**, and a stage of **resolution** or **absorption**.

The FIRST OR DRY STAGE is characterized anatomically by the presence of the so-called lymph or exudate on the pleural surfaces. During this is revealed to *inspection* a restrained expansion of the affected side, often thrown into jerks or catches because of the pain suffered in a continuous inspiration. The expansion on the opposite side, on the other hand, is full and unhampered. The patient is apt to lie on the affected side. Very rarely *palpation* recognizes a fremitus corresponding to the friction of the two pleural surfaces. *Percussion* in this stage is negative as to modified note, but often causes decided pain. *Auscultation* recognizes the friction sound already described. It may be at a single spot in the inframammary or infra-axillary space, and hence be overlooked. At other times it may be noted over a considerable area.

The inflammatory process may stop here and resolution take place, or it may continue into the SECOND OR STAGE OF EFFUSION. The signs of this stage vary with the amount of liquid in the sac. With a small amount the lungs are slightly floated up, and there may be no signs unless there be a vesiculotympany above the line of the fluid, a *Skodaic resonance* by mediate relaxation of the air vesicles.

The effusion, however, rarely remains so trifling, but commonly rises to the mid-chest. In the upright position of the patient, *inspection* discovers in a spare person shallowness and perhaps obliteration of the lower intercostal spaces. The motion of the chest-wall is lessened both in the vertical and transverse directions.

To *palpation* vocal fremitus is diminished over the area of effusion, but may be increased in the lung above it. To *percussion* there is absolute flatness over the area of effusion, but the line of demarcation is not everywhere at the same level, being higher behind than in front. The late Dr. Calvin Ellis first called attention to an S-like curve in the line of demarcation which is said to be characteristic. Very important in the diagnosis is the fact that the fluid changes its level, and with it the line of dulness, when the position of the patient is changed. There is also an abnormal sense of resistance to the finger in percussing over the area of effusion. Above the effusion, especially anteriorly, there is again Skodaic resonance by mediate relaxation, and even sometimes a cracked-pot sound. Tympany may also be present, due to the proximity of a distended stomach.

To *auscultation*, the breathing sounds are inaudible or very feeble, as compared to the corresponding portion of the opposite side, but vocal resonance, though diminished, is still well heard where the collection of fluid is moderate. Above the line of dulness there is occasionally a friction sound, and close to the root of the lung bronchial breathing may be heard. This is, however, more apt to be the case when the effusion is larger and the lung is further compressed. Œgophony is also sometimes heard.

When the effusion is larger, filling up two-thirds or three-fourths of the pleural sac, the effects described are increased, while new ones are added. *Inspection* notes that respiratory movement is still more hampered, the intercostal spaces are widened and even bulging, while fluctuation may sometimes be recognized through them. The heart is displaced by the accumulated fluid, and if it be in the left sac, the apex is often found far over to the right of the median line, and if on the right, the apex is pushed further to the left. Its sounds are not, however, altered further than to be heard more intensely in the situation where they are not usually so heard, because sound is transmitted more readily through a single uniform medium than through two or more of different densities. On the opposite side the breathing movements are supplementally increased. There is complete absence of vocal fremitus on the affected side.

In pleural effusion the line at which the movement in Litten's sign, or the diaphragm phenomenon, begins, is lowered from the 6th interspace, while if the effusion is large it is entirely obliterated.

Percussion is absolutely flat all over the effusion, and Skodaic resonance is not now obtainable, because the lung is too thoroughly compressed up into the apex of the sac. Resistance to pressure is marked. On *auscultation* bronchial breathing may be heard at the upper part of the lung posteriorly, because the large tubes are still pervious to air, and the compressed lung intensifies the sound. Sometimes bronchial breathing is heard in more peripheral parts of the chest, probably conducted hither along a band of adhesion or along a rib. Elsewhere there is absence of breath sounds. Vocal resonance and whispering voice are alike absent, or the former is very feeble. *Diminished vocal resonance and diminished tactile fremitus are the distinctive features which distinguish a bronchial breathing of pleurisy from that of pneumonia.* In certain situations, too, high up, where there is but a thin film between the chest-wall and the lung, there may be œgophony, but this is more apt to be present as the fluid is being absorbed.

By massive effusion on the right side the liver is depressed.

In the THIRD STAGE, if resolution takes place with a gradual retrocession of the fluid and the reëxpansion of the lung, we have a return to normal physical signs. There may be, too, a **friction redux.** A considerable time is, however, required for absorption, and it is often many days before the normal breathing sounds are heard with their usual intensity or the natural fremitus is felt. Often resolution is not complete, and there then remain the symptoms and sequelæ of chronic pleurisy.

Other symptoms of acute pleurisy are sharp pain in the side, short, rapid breathing, and suppressed, dry cough.

Chronic Pleurisy.—Its symptoms and sequelæ are not uniform. The simplest and most harmless expression is a *thickened pleural membrane.* In this there is no adhesion between the opposite pleural surfaces, and the motion of the lung is not interfered with. There is, however, a general interference with the conduction of sound, and all the normal physical signs—including vocal fremitus, vocal resonance, normal percussion sounds, and normal breathing sounds—are diminished in intensity. For the same reason many abnormal physical signs, as already more than once instanced, are also less plainly heard.

The serious symptoms of chronic pleurisy are more frequently manifested in the *results of delayed absorption of effusion*, and in a change of its character from serous to purulent. The resulting accumulation of fluid in the pleural cavity is not always a continuation of acute disease. A chronic pleurisy may originate *de novo*, and often without the consciousness of the patient, although a careful analysis of the case will not fail to find symptoms of ill health which are explained by the state of affairs ultimately found. Such pleurisies are known as **latent.** With the discovery of the effusion, which may depend more or less on the acumen of the physician, the latency disappears.

Such fluid furnishes the physical signs detailed on page 104 and following pages. Its further effects vary very much according as it is serum or pus. In either event its speedy removal is desirable, because the longer it remains compressing the lung, the longer will the latter be in returning to its natural state. Hence, it is better done by aspiration than by the slower method of medication. If the fluid be **serous,** and if it has not been too long retained, the lung gradually resumes its normal state, and a thickened pleura is all that remains, with the physical signs referred to as associated with it. Not infrequently, however, the two pleural surfaces, costal and pulmonary, remain permanently agglutinated, and then, although the lung slowly resumes its natural function, there still remains some flattening over the lower part of the thorax, while the signs of a compressed lung may be found at the apex.

If the liquid be pus, we have an **empyema,** and the consequences are much more serious. The occurrence of a chill and continued high temperature will suggest a purulent collection. Baccelli's test may be tried. *

Medical treatment almost never removes an empyema, and aspiration is as invariably followed by reaccumulation. Hence, permanent measures, as the introduction of a drainage tube with or without exsection of a rib, must be used. If the drainage tube be inserted early, the lung may resume its natural office, and there may be no more permanent damage than the agglutination referred to, and subsequently a retracted thorax. More frequently, however, we have to do with a lung partly bound by adhesions into its new and unnatural position, while the pleural surface may be looked upon as an extensive ulcer. The restrained lung is unable to expand to refill its naural space, while the huge ulcer referred to must heal slowly with a resulting cicatrix. This cicatrix has the property of all cicatricial tissue. It must contract, and with this contraction drags with irresistible force whatever is attached to it, including the ribs and even the spinal column, which is sometimes drawn out of line. Thus there results distortion, in various degrees, of the shape of the thorax, associated with a

* Baccelli, of Rome, in 1875, suggested a method of distinguishing purulent accumulations from serous. He found that the whispered voice was often audible over these serous accumulations, while it was inaudible over pus collections. Douglas Powell ("Transactions of International Medical Congress," 1881) failed to confirm this observation. I have sometimes noted the sign under the circumstances described by Baccelli, but not always.

shortness of breath which is permanent, but which may, nevertheless, grow less as time rolls on.

A form of empyema which remains to be alluded to is a **circumscribed empyema** wherein the pus is circumscribed in two or more separate or communicating spaces. It is not always easy to recognize such a state of affairs. Most frequently it is ascertained by the attempt at the removal by tapping, the withdrawal of a certain amount of fluid giving partial relief and leaving other areas with physical signs unchanged. Da Costa gives us from Jaccoud * some points to assist toward such recognition. Given, in the area of dulness, a zone along which vocal vibrations are preserved, as from the spinal column toward the sternum, a separation between two portions of fluid probably exists along such line. When the diaphragm is adherent to the chest wall the normal movements at the epigastrium and hypochondrium are reversed, and the inspiration is accompanied by depression in the lower intercostal spaces instead of a filling out.

One other feature must be pointed out as associated with such collections, and that is pulsation sometimes communicated to them by the heart. Hence the term **pulsating empyema.** In one such under my care situated below the left clavicle, the pulsation was so striking that I hesitated to puncture it lest it be a pulsating auricle or an aneurism. The knowledge that there

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* Da Costa, op. cit, p. 366, from *Bulletin de l'Académie de Médecine*, 1879.

was pus elsewhere in the pleural sac, the elevation of temperature, and the absence of sound or murmur or thrill, seemed to justify operation, and a large quantity of fetid pus was drawn through a communication made with a pus cavity lower down. The tumor and pulsation and fever disappeared, and the patient, who was a girl, recovered. This situation, the upper præcordial region, is a favorite one.

Other Symptoms of Chronic Pleurisy.—A fever which is septic is almost invariably associated with empyema, causing emaciation. Shortness of breath is also constant. Chronic serous effusions are not commonly attended by fever, but breathing more frequent than normal is present.

PNEUMOTHORAX.

This comparatively frequent complication of tubercular consumption commonly results from the rupture into the pleural sac of a cavity in the lung, an accident usually brought about by a fit of coughing. Sixty to eighty per cent. of cases are said to be due to tuberculosis. After this comes emphysema, while other possible causes are gangrene and rupture of subpleural abscess. The perforation is followed by a rapid filling of the pleural cavity with air, which is soon followed by an effusion of liquid, at first seropurulet, but sooner or later becoming purulent. The result is a distended air sac, occupied to a certain height with liquid, compressing somewhat the lung and displacing the heart, while the physical conditions are those of a resounding cavity.

The effect on the physical signs is as follows: To *inspection* a bulging chest, a filling out of the intercostal spaces. The thoracic wall on the affected side diminishes its excursion of respiratory movement, or it appears at a standstill. *Palpation* appreciates no vocal fremitus. *Percussion* furnishes over most of the half of the thorax involved the most striking of the percussion notes, the ringing, amphoric resonance, which contrasts strongly with the absolute dulness due to the fluid below. When the patient lies on his back, the portion of the lung floated up in front gives good Skodiac resonance, while a striking sign is the marked lowering of the dulness in the recumbent position, a lowering far exceeding that noticed in a simple pleuritic effusion, and amounting to three and four inches. *Bell tympany* may also be elicited. If the pneumothorax is on the left side the heart may be pushed over to the right, and if on the right the liver may be lowered. To *auscultation* the normal breathing sounds are distant and feeble, the expiratory sound continuing short. Along with this may be heard amphoric breathing at the apex. The voice is ringing, amphoric, and an unmistakable tinkling sound attends the dropping of fluid from the perforation into the fluid below, or a similar metallic character may be given to râles in the adjacent tubes. A sudden shaking of the body produces a splashing sound similarly intensified by the reëchoing to which it is subjected,—the Hippocratic succussion splash.

PHYSICAL EXAMINATION OF THE HEART.

Anatomical Relations of the Heart.—The actual boundaries of the heart in the chest cavity demand some notice. The base of the heart is held fast by the great vessels coming from it, but the remainder of the organ has a certain freedom of motion, chiefly rotary but slightly also of elongation, but limited by the pericardial sac attached to the diaphragm and pleuræ. The heart lies with its *right ventricle upon the central tendon of the diaphragm*. The *auricles* are nearly transversely placed, on a level with the 2d interspaces and the 3d costal cartilages, both extending slightly beyond the corresponding borders of the sternum. The *ventricles* are obliquely placed, the right being in front and directly under the sternum, extending by its lowermost right-hand corner a trifle only to the right of the sternum at the 5th interspace, and considerably to the left. The right ventricle is on a level below with the 6th cartilage. A much smaller portion of the left ventricle is turned to the front when the heart is *in situ*, and it is altogether within the line of the nipple, the apex corresponding to a point between the 5th and 6th cartilages and an inch to 1½ inches below and within the nipple. The base of the heart corresponds behind with the 5th and 6th dorsal vertebræ, between which and it lie the aorta and œsophagus. The heart, surrounded with its pericardial sac, is covered very largely by the lungs, the right extending to the middle of the sternum, the left

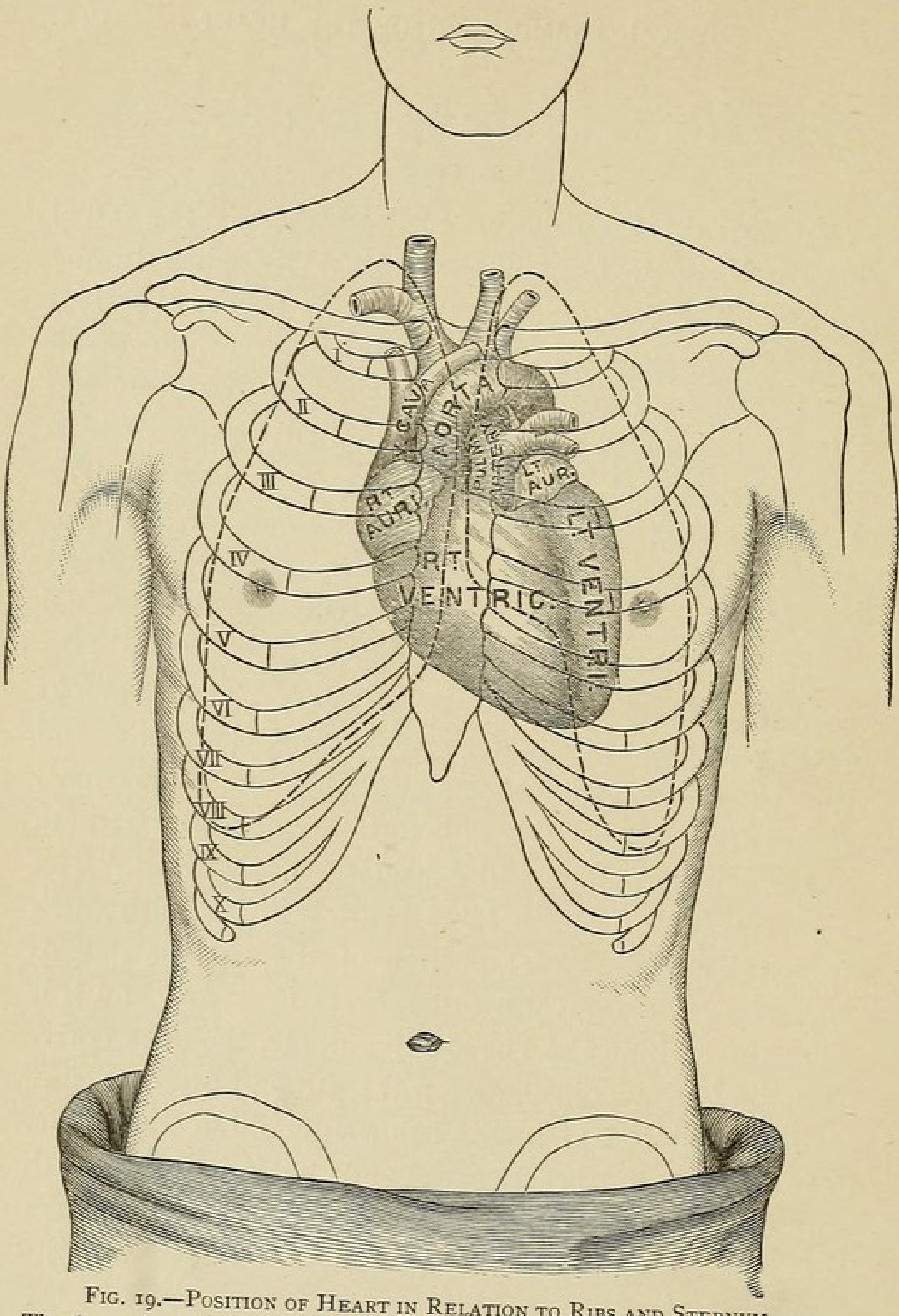


Fig. 19.—Position of Heart in Relation to Ribs and Sternum.

The heart in this drawing is placed in a position too oblique. The heart actually rests with its right ventricle more flatly on the diaphragm. Very little, if any, of the right ventricle is to the right of the sternum.

also to the middle as low as a line continuous with the lower edge of the 4th cartilage, along which it passes; thence obliquely across the 4th interspace and the 5th rib, the lung covering the whole of the left ventricle except the apex.

The **size** of the heart approximates that of the fist of its owner. I am inclined to think it is commonly a little larger. Its weight in adult males is 311.6 grams (11 ozs.); in females 255 grams (9 ozs.).

The Præcordium.—By the **præcordial region** or præcordium is meant that portion of the thoracic wall covering the heart, and it may be said to be bounded above by a line drawn through the junction of the manubrium with the blade of the sternum, below by a line drawn along the upper edge of the 6th cartilage, and laterally by a vertical line drawn through the seat of the apex-beat, and another ¾ of an inch to the right of the sternum. In this region inspection and palpation recognize the apex-beat between the 5th and 6th ribs, and 1½ inches below and within the nipple. In children it may be found an interspace higher, and in the aged and in persons with long and narrow thoraxes it may be an interspace lower. Occasionally, in the 2d interspace to the left of the sternum in thin persons, a feeble impulse can be seen, produced by the filling of the left auricle. The situation of the apex is slightly altered by changes of position or by distension of the stomach from any cause. The act of breathing, however, influences it most. With a deep breath the heart descends and is pushed inward by the inflated lung, and the apex approaches the epigastrium. On deep expiration it rises slightly, and while the breath is held remains higher. The apex-beat is rendered more distinct by exercise or emotion. This is still more the case in pathological states where there is enlargement. Emphysema of the lungs and effusion into the pericardial sac render it more or less indistinct. Its position is also variously changed by morbid conditions, and a thrill or fremitus is often communicated to the hand in valvular diseases.

Fremitus is also sometimes noticeable as the result of pericardial friction. The whole præcordial region is sometimes abnormally prominent in hypertrophy and pericardial effusion, especially in the young, while retraction due to adhesion is also seen. In the neighborhood of the præcordium, at the root of the neck, pulsations, arterial and venous, are noted, also in the epigastrium, which will be explained under the head of the conditions that produce them.

PERCUSSION AND AUSCULTATION OF THE NORMAL HEART.

The **percussion boundaries** of the heart have been already pointed out on page 47, but it may not be amiss to review them at this point in somewhat further detail.

To map out the percussion border of the heart, we begin percussing on a horizontal line at the left edge of the sternum, at about the 2d interspace, proceeding downward, by moderately strong percussion only, until

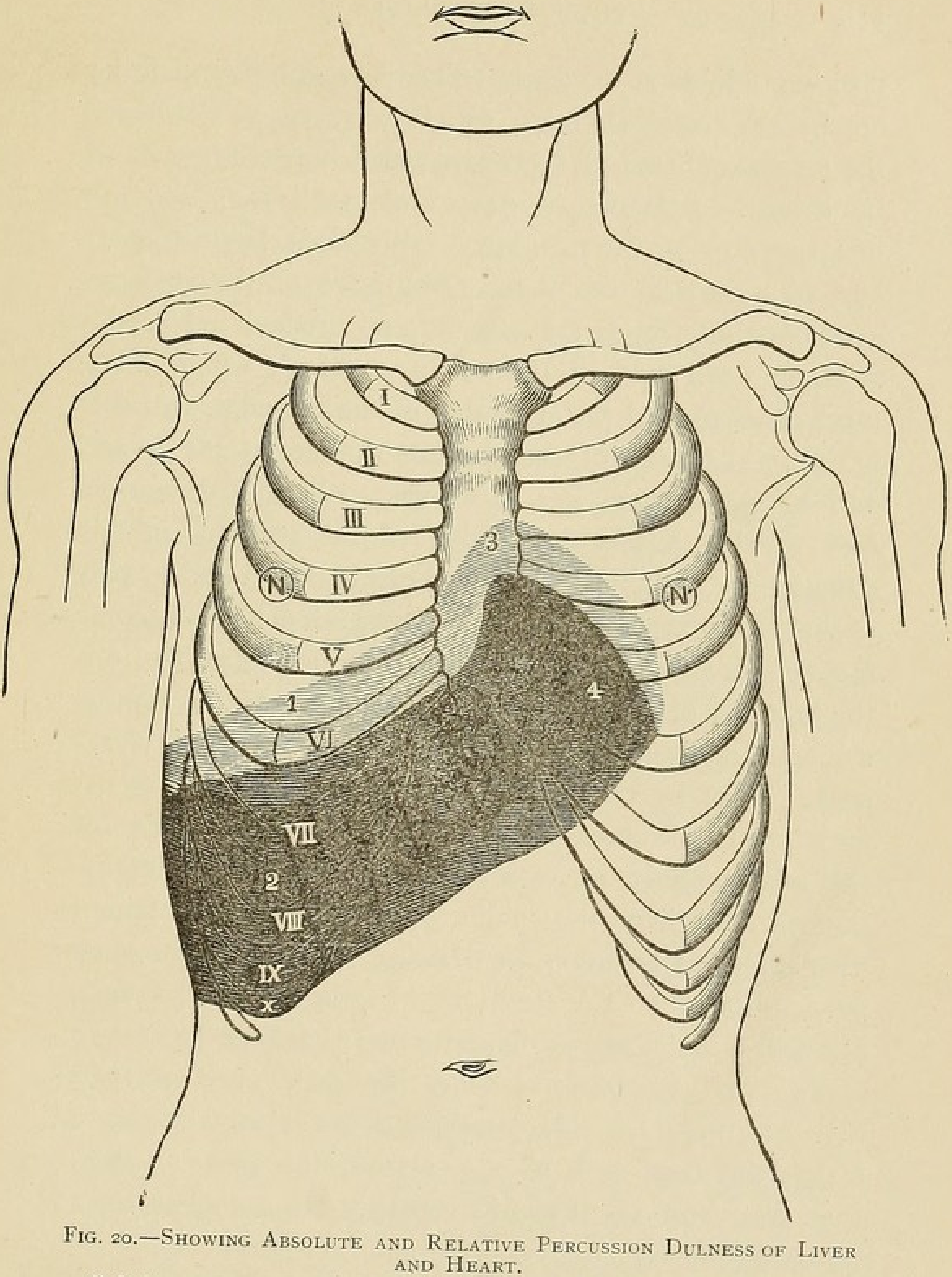


Fig. 20.—Showing Absolute and Relative Percussion Dulness of Liver and Heart.

1. Relative percussion dulness of liver. 2. Absolute percussion dulness of liver. 3. Relative percussion dulness of heart. 4. Absolute percussion dulness of heart.

positive dulness is reached. This is usually found to be on the 4th costal cartilage, which is the upper border of the uncovered area of the heart, and where a line should be drawn. Relative or deep dulness is found in the interspace or on the rib above. We then begin to percuss on a vertical line at the right edge of the sternum at about the level of the 4th rib, and proceed across the sternum until evident dulness is reached, which is in most cases toward the left edge of the sternum, and this is the right border of the absolute dulness of the heart, and here a vertical line is drawn. Relative dulness is met usually at the right edge of the sternum in this situation. The situation of the apex is then found by palpation or by the stethoscope. Percussion is again commenced on an oblique line, in the direction of a line from the junction of the 4th cartilage with the sternum toward the apex, but sufficiently beyond to be certain of clearness. Then, parallel with such a line, proceed downward until positive dulness is reached. The lower border of the heart cannot be satisfactorily separated by percussion from the liver, but such a boundary can be obtained with sufficient accuracy by drawing a line from the apex perpendicular to the sternum. By the phonendoscope, however, the line of demarcation between the two organs can be found. Thus the area of **absolute dulness** in adults will correspond to a rude triangle, of which the base is 2 to 2½ inches, the perpendicular 2 inches, and the hypothenuse 3½ to 4 inches on a somewhat curved line.

The area of **relative dulness**, elicited by stronger percussion, extends a short distance beyond the boundaries indicated in every direction except downward. The exact measure of this must depend somewhat on the delicacy of the ear of the examiner and the mode in which he percusses, but it may be put down approximately as a finger's breadth, and on the left side still within an oblique line drawn through the nipple in adults.

Various causes influence the area of cardiac percussion dulness in health. In children, the area of the cardiac dulness is decidedly reduced on account of the intense resonance of the child's thorax. In old age, on the other hand, the area of absolute cardiac dulness is increased on account of the shrinkage of the lungs. The upper border of absolute dulness may be at the 3d rib, and the apex may be in the 6th interspace. The effect of a deep inspiration is materially to diminish the area of dulness, while that of expiration enlarges it.

Pathologically the normal area is increased downward to the left in hypertrophy of the left ventricle, downward toward the epigastrium and to the right in hypertrophy of the right ventricle.

Auscultation of the **normal heart** is very simple. By it we recognize the normal heart-sounds, known as first and second. Both sounds are audible over he whole præcordial region in health, but the **first sound**, characterized by its longer, booming character and lower pitch, is heard most loudly at the seat of the *apex-beat*, where it is the louder of the two.

The **second**—shorter, sharper, higher pitched, and more snapping in character—is most intense at the base of the heart, *on the sternum opposite the 2d interspace.* Both sounds are heard at both situations, but each has its situation of greatest loudness. Hence, at the apex the rhythm may be said to be represented by the trochaic foot — ⏑, while at the base it is represented by the iambus ⏑ —. The two sounds have also been long compared to the word *lub-tup*, the first syllable corresponding to the first sound and the second to the second part. While this word cannot be said to resemble the heart sounds very closely, there seems to be no other that resembles them more.

As to the **mechanism** of the sounds, while that of the *first* is probably somewhat complex,—including the shutting down of the auriculo-ventricular valves, the apex-beat, the rush of blood through the aorta and pulmonary artery, and the noise of muscular contraction,—it is sufficient for clinical purposes to consider it produced, as it is for the most part, by the shutting down of the auriculo-ventricular valves, the mitral or bicuspid on the left side and the tricuspid on the right. Both sets of valves shut down simultaneously, both contribute to the production of the sound, while the greater muscular power of the left side gives to it a distinct predominance.

The *second sound* is of simpler mechanism, and is caused solely by the shutting down of the semilunar valves of the aorta and pulmonary artery, with the recoil of the blood upon them. On account of the more powerful recoil in the aorta, the aortic is the predominating sound.

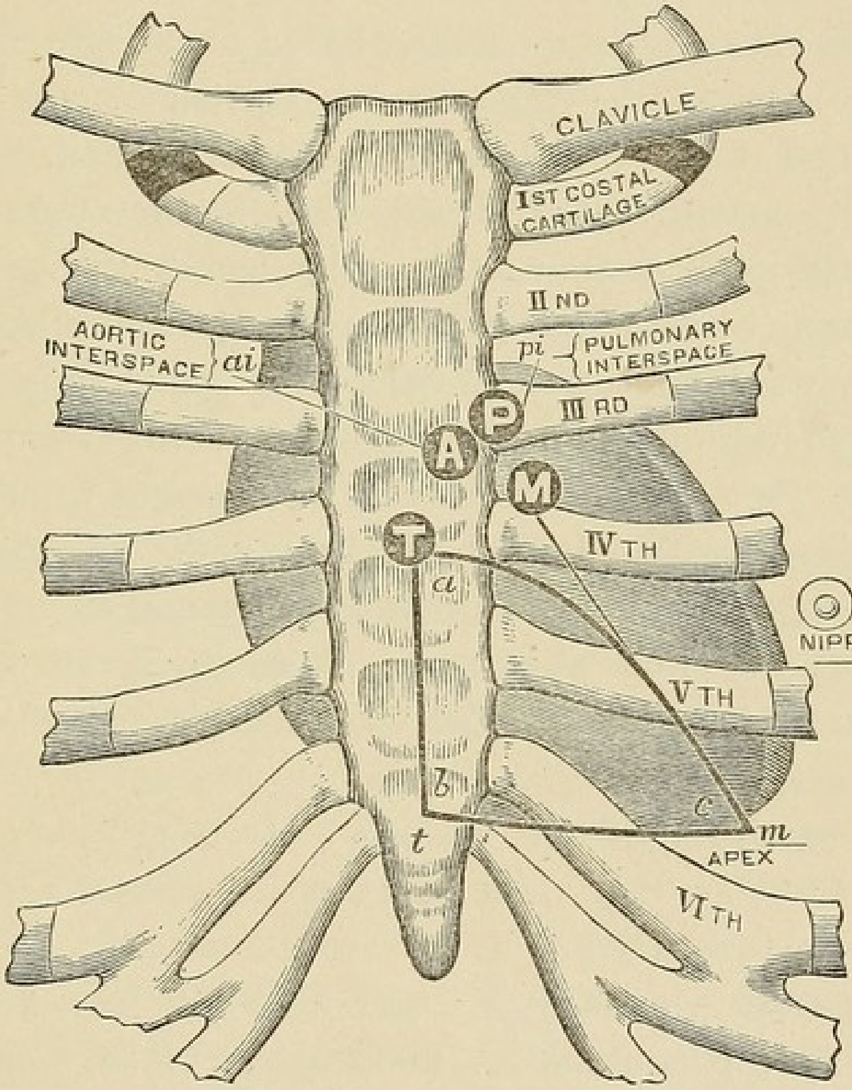


FIG. 21.—DIAGRAM SHOWING THE LOCATION OF CARDIAC VALVES AND POINTS OF MAXIMUM INTENSITY CONNECTED WITH THEM.

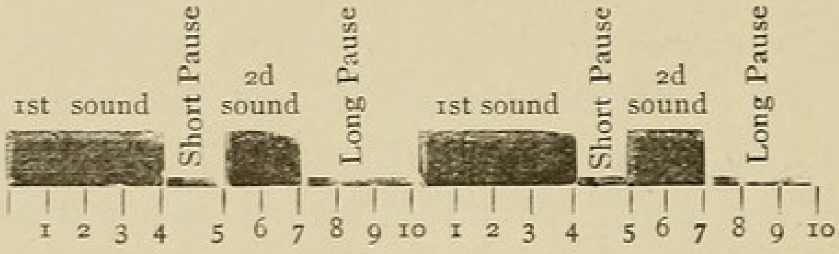
The triangle, *a b c*, is the area of superficial or absolute dulness. A corresponds to the anatomical *seat* of the aortic valves, P to the pulmonary, M to the mitral, T to the tricuspid. The points of greatest *intensity* of the sounds are *ai* for the aortic, *pi* for the pulmonary, *m* for the mitral, *t* for the tricuspid.—(*After Page.*)

We may isolate the part played by each set of valves by carrying the stethoscope to certain situations, and in diagnosis constant advanage is taken of this. Thus, in order to pick out the mitral part of the first sound, the stethoscope is placed at the seat of the apex-beat, while the tricuspid factor is best heard at the left sternal border, between the 5th and 6th cartilages. So with the second sound, the aortic factor is best heard at the 2d interspace to the *right* edge of the sternum; and the cartilage just above this is known as the **aortic cartilage**, because this great vessel approaches next to the chest-wall in this situation. The pulmonary part of the sound, on the other hand, is heard at the *left* edge of the sternum at the 2d interspace, while the cartilage above this, behind which ascends the pulmonary artery, is called the **pulmonary cartilage**. These points, and a circle about an inch in diameter around them, are known as the mitral, tricuspid, aortic, and pulmonary **areas**.

Topography of the Valves.—It is to be remembered, however, that these are not the *precise seats* of the valves themselves. These are all situated in wonderfully close proximity to each other—in fact, a portion of each is contained within a space of *less than ½ inch square*. The **mitral valve** is placed behind all the others, at a point corresponding to the left border of the sternum at the 3d interspace. It lies almost horizontally about ¼ inch below the attachment of the aortic valves. The **tricuspid valve** corresponds to a line drawn obliquely across the sternum from the 3d left interspace to the 5th costal cartilage of the opposite side. The **aortic valve** lies nearly horizontally behind a line joining the middle of the sternum and the end of the 3d left costal cartilage. The **pulmonary valve**, a little higher and to the left of the aortic, runs quite horizontally, corresponding to a line drawn along the upper border of the 3d left costal cartilage. Thus all of the valve attachments except the tricuspid are horizontal or very nearly horizontal. The want of identity of the auditory valve area, or place where the sounds are best isolated, with the actual sites of the valves, is due to the fact that the sounds are best heard at points on the chest-walls nearest the cavity or channel in which vibrating blood is flowing.

The normal heart-sounds are heard less loudly over the normal areas during deep inspiration, when they are more completely covered by the fully expanded lungs, and the first sound is heard more loudly at a new point toward the median line, to which the apex is pushed by the inflated lungs. On the other hand, forced expiration increases the area over which the sounds are heard.

The **time** of the normal heart-sounds requires some further study, because on a thorough understanding of this depends largely skill in diagnosis. The first sound begins with the systole of the ventricles and is coincident with the apex-beat; the second occurs in the diastole, immediately after the first, with a short pause between. The second sound is succeeded by a longer pause occupied with the diastole of the ventricles, during the latter part of which occurs the systole of the auricles, terminating the diastole of the ventricles. Thus, if a revolution of the heart's sounds and pauses be represented by a dash and interspaces we will have the following:



of which the first sound will occupy four-tenths, the short pause one-tenth, the second sound two-tenths, and the long pause three-tenths.

It is to be remembered that each one of these sounds is double, two systolic, occurring at the ventricular orifices, and two diastolic, at the aortic and pulmonary orifices. It may be further conceded that the first sound as heard at the base of the heart and the second sound as heard at the apex are simply conducted from the seat of their production, and that they are in no part produced at the situation where they are less loud.

ABNORMAL MODIFICATIONS OF HEART-SOUNDS.

It is not impossible, even in health, to have these paired sounds separated, and thus is produced what is known as **reduplication** of the heart-sounds, a phenomenon more common in diseases of the heart. Thus, as the effect of running there may result such an engorgement of the lesser circulation and high tension in the pulmonary artery, that the pulmonary valve closes a little sooner than the aortic, and reduplication of the second sound occurs. In like manner the closure of the tricuspid valve may be retarded, the synchronism destroyed, and reduplication of the first sound thus produced. Intermission is an almost constant feature of reduplication, the double sound occurring with certain beats of the heart, with others not. This intermission has a close relation with the movements of respiration. Thus the first sound is reduplicated at the end of expiration and beginning of inspiration, the second at the end of inspiration and the beginning of expiration. The same and similar conditions operate to produce reduplication of the heart-sounds in disease. In labored breathing the order of reduplication is reversed, the first sound being doubled at the end of inspiration and beginning of expiration, and the second sound at the end of expiration and beginning of inspiration.

The **intensity** of the heart-sounds is greater in persons with thin chest-walls and under the influence of excitement. Abnormally the feverish state and general hypertrophy have the same effect, but the latter is more apt to influence the sound of the particular cavity which is hypertrophied. The heart-sounds are often heard with unusual distinctness at points distant from their normal areas because of consolidation of adjacent lung, and sometimes inexplicably. Intensification or **accentuation**, as it is called, of the *aortic* or *pulmonary* element of the second sound is caused by whatever produces increased tension in the arterial or pulmonary circulations. Heart-sounds are also sometimes made ringing by their proximity to a cavity with firm walls or even a tensely distended stomach.

Abnormally, heart-sounds are rendered less intense by general and cardiac weakness, fatty degeneration of the myocardium, pericardial and pleural effusions, and emphysematous lungs, which cover up the heart more completely.

Abnormal heart-sounds or **murmurs** are modifications of the normal sounds, either superadded to them or altogether substituting them. These are produced within the cavity of the heart, and are accordingly known as endocardial. In addition an altogether new sound is engendered external to the heart, and therefore called exocardial or pericardial. To this the term murmur is also applied, although the mechanism of its production is so widely different it does not seem to me desirable to perpetuate the practice.

The **endocardial abnormal sounds,** or **heart murmurs,** are sounds due to alteration in the conditions of normal blood currents, produced either by structural changes in the heart, its valves, or in the composition of the blood.

The former are called **organic** murmurs, the latter **functional** or **accidental.*** Both are due to vibra-

* The term inorganic is sometimes applied to the functional murmurs, but this word has another meaning so definite, that of mineral, that it seems almost misleading to apply it in the sense referred to in the text.

tions or oscillations in the blood stream produced by the causes referred to, and not to a friction between the blood current and the narrowed orifices or inequalities on the valves. Hydraulic laws teach us that when a fluid passes through a tube the inner surface of which it wets, a thin film of fluid becomes attached to this surface, over which the remainder of the fluid moves without friction. So it is with the cardiac cavity and its valves over which the blood moves. Further, while a fluid passing along a tube of uniform diameter at a moderate speed, no murmur results, whether the inner wall of the tube be smooth or rough. A murmur is only produced when the tube becomes suddenly narrower and then widens again, and the greater the narrowing the less speed of current required to produce the murmur. Thus the vibrations arise, and thus the sound is produced.

In the case of *functional* murmurs, which apparently occur without the intermediation of sudden narrowing, we must suppose such a change in the composition of the blood either as to its density or viscidity, which permits it to be more readily thrown into vibration. In either event there is a derangement of that adaptation of the column of blood to the orifices and cavities through which it has to pass, which ordinarily permits the function of the heart to be performed noiselessly except so far as its normal sounds are concerned. In the case of the organic murmurs the alteration is produced by the various valvular defects to which the heart is subject, in that of the functional murmurs by the various anæmias which are principally associated with such murmurs. The true valvular murmurs may be intensified by conditions of the blood.

It should be mentioned that Ernest Sansom considers that the vibration of solids is by far the most important in the generation of murmurs, the influence of fluids being intermediate, and not immediate.*

ORGANIC MURMURS.

An organic murmur may be produced at any one of the four cardiac orifices, mitral, tricuspid, aortic, or pulmonary. They are far more common at the mitral and aortic.

Murmurs are also classified as systolic, diastolic, and presystolic. **Systolic** murmurs occur during the systole of the ventricles, **diastolic** murmurs during their diastole and alternate with the apex-beat. A diastolic murmur which immediately precedes the systole is called a **presystolic** murmur. Murmurs are further classified as direct and indirect. **Direct** murmurs are those which arise in the blood current as it is flowing in the normal direction; **indirect** are those which arise in a current flowing opposite to the natural direction. The order in which murmurs are considered is of little importance. Their great frequency seems a sufficient reason for taking up mitral murmurs first.

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* "Diagnosis of Diseases of Heart and Aorta," Philadelphia, 1892, p. 236.

Mitral Murmurs.—*The Mitral Systolic or Mitral Indirect Murmur.*—During the systole of the ventricles the auriculo-ventricular orifices in a perfect heart are closed in order to prevent the return of blood to

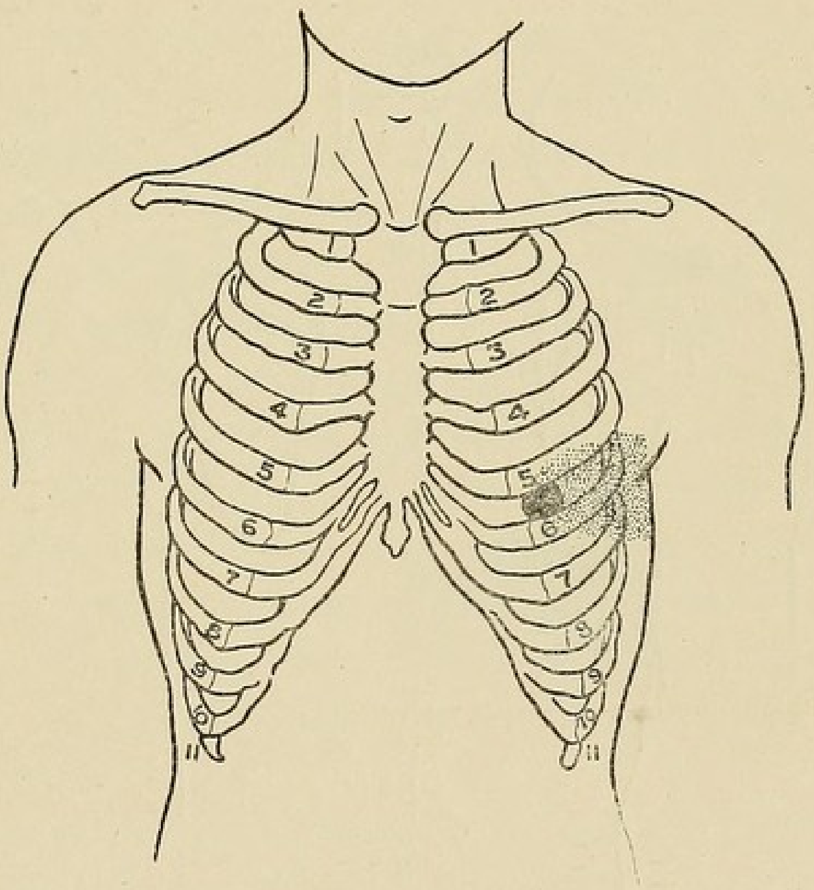

FIG. 22.—MITRAL SYSTOLIC MURMUR, PROPAGATED IN FRONT. (*After Hutchison and Rainy.*)

the auricles, while the aortic and pulmonary orifices are wide open to permit the blood to enter these great vessels, and the ear placed at the apex hears mainly the first sound. If, however, there be a defect in the mitral valve, as the result of which it closes imperfectly, then, during the systole a stream of blood will flow backward into the left auricle accompanied by a murmur. This is the mitral systolic murmur, and it means **incompetency** or **insufficiency** of the valve with consequent **regurgitation** of blood. The mitral systolic murmurs are almost invariably best heard in the mitral area at the

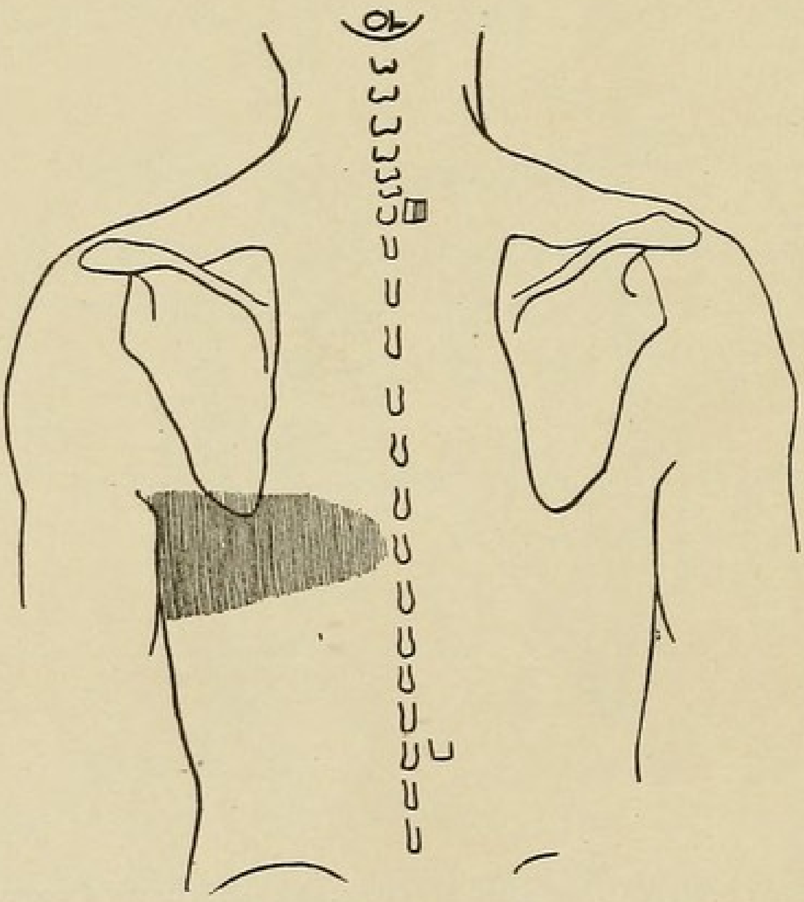

FIG. 23.—MITRAL SYSTOLIC MURMUR, PROPAGATED BEHIND. (*After Hutchison and Rainy.*)

apex, and are conducted into the left axilla and under the angle of the left scapula. Rarely, however, they are heard just to the left of the pulmonary area, probably because the vibrations are conducted into the appendage of the auricle and are best heard where this approaches nearest the surface, namely, 1½ inches to the left of the pulmonary area. This occurs more frequently, too, with functional murmurs.

Mitral Diastolic and Presystolic Murmurs, or Mitral Direct Murmurs.—During the diastole of the ventricles the aortic orifice is closed and the mitral orifice open, and the blood flows noiselessly into the left ventricle, the filling of which is finally completed by the systole of the auricle. If, however, the mitral orifice be narrowed from any cause, the blood column is thrown into vibration and a murmur results—a diastolic murmur. When, as frequently happens, the narrowing or stenosis is not sufficient to cause a murmur throughout the entire diastole, but only when the additional momentum is given to the blood by the systole of the auricle, a murmur occurs only at this time—that is, just before the systole commences. It is then called *presystolic*. These murmurs mean, therefore, **mitral stenosis**, which is, however, generally associated with incompetency of the mitral valve.

The systolic mitral murmur is, for the most part, soft, but may have every variety of character and be high pitched or low pitched, but the presystolic is always rough, and is variously characterized as rattling, rolling, churning, grinding, blubbering, and bubbling, being compared to the vibration in the lips caused by blowing the breath through them. The sound is further characterized by its *abrupt* termination, although this is not invariable. It may also disappear for a time or even altogether. A presystolic *thrill*, felt at the apex of the heart, often accompanies the murmur. The presystolic murmur is best heard in the mitral area, and is *not*, as a rule, *conducted* thence in any direction. Sometimes the murmur is heard slightly to the right of the apex.

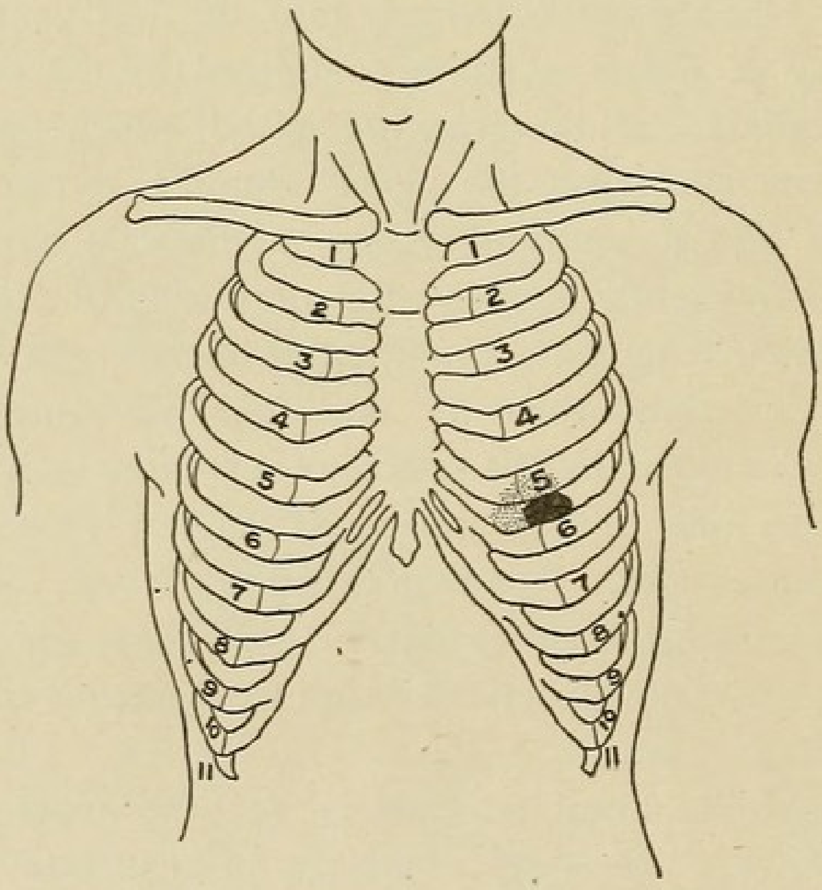

FIG. 24.—MITRAL PRESYSTOLIC MURMUR.—(*After Hutchison and Rainy.*)

A diastolic murmur heard in the mitral area may also be due to aortic regurgitation, the sound being conducted from the seat of its production to the apex. *This is a frequent matter of misinterpretation.* It is often difficult to differentiate the presystolic murmur from a systolic mitral murmur when, as is often the case, the two are associated, the presystolic murmur passing indistinguishably into the systolic murmur. The difficulty is further increased because in mitral stenosis the first sound is usually short, resembling the second. The point, therefore, is to get the exact time of the murmur by noting carefully its anticipation of the apex-beat or the carotid pulse. The so-called Flint's murmur also closely resembles the murmur of mitral stenosis, and the infrequency of the latter alone prevents more mistakes. This murmur is heard at the apex, the same site as the presystolic, and may be similar in quality. It is said to occur with high degrees of dilatation of the ventricle, and is due to the fact that in such dilatation the mitral leaflets cannot during diastole be kept back against the ventricle wall, but remain in the blood current, throwing the latter into audible vibration.

Mitral diastolic murmurs are not always presystolic. More rarely they follow immediately on the second sound, when they are called simply diastolic. In other instances they are *mid-diastolic*, being separated from the second sound by a brief interval; in others still there is a brief interval between the diastolic and presystolic murmurs. These are refinements which can only be made by the skilled ear. They are always organic.

Aortic Murmurs.—*Aortic Systolic or Aortic Direct Murmur.*—During the systole of the ventricles in health the aortic orifice is wide open, and the blood flows noiselessly through it. If any interference with the complete opening of the orifice or roughness or inequality exists, the stream of blood is thrown into vibration, and the aortic systolic murmur results, heard at the base of the heart in the aortic area. Such a murmur, therefore, means narrowing or **stenosis** of the

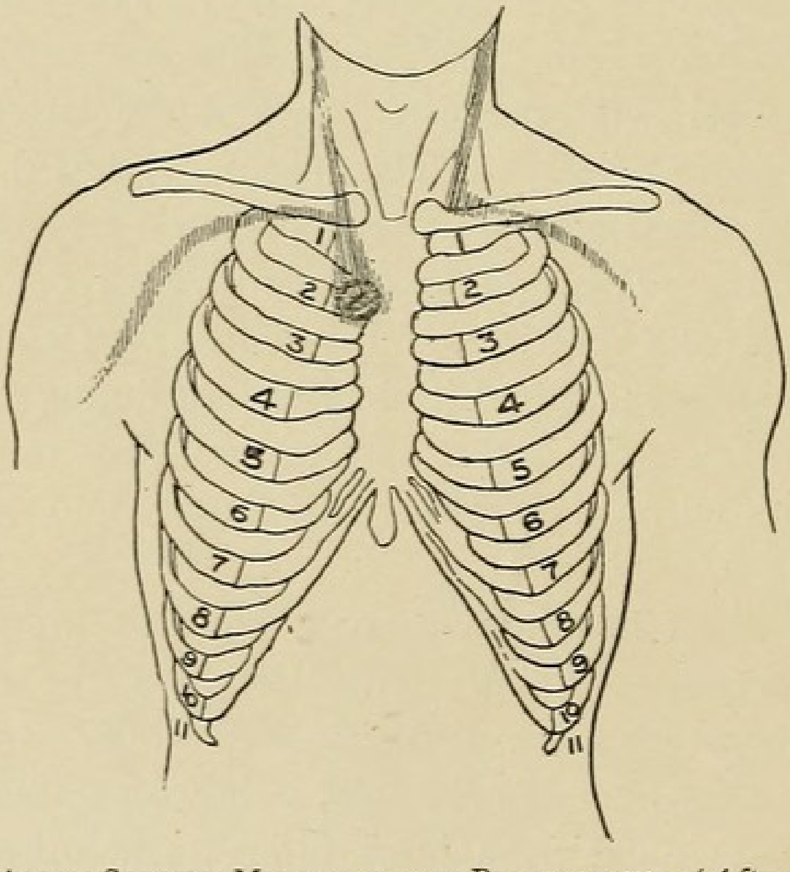

FIG. 25.—AORTIC SYSTOLIC MURMUR AND ITS PROPAGATION.—(*After Hutchison and Rainy.*)

aortic orifice or **roughening** at the beginning of the aorta. It is generally loud and harsh, sometimes musical, heard most loudly in the aortic area—second *right* interspace—but generally all over the præcordium. It is conducted into the great vessels of the neck with great intensity.

Aortic Diastolic or Aortic Indirect Murmur.—During diastole the aortic orifice should be closed and impermeable to blood. If, however, as the result of disease, perfect closure be impossible, a stream of blood will flow backward into the left ventricle, accompanied by

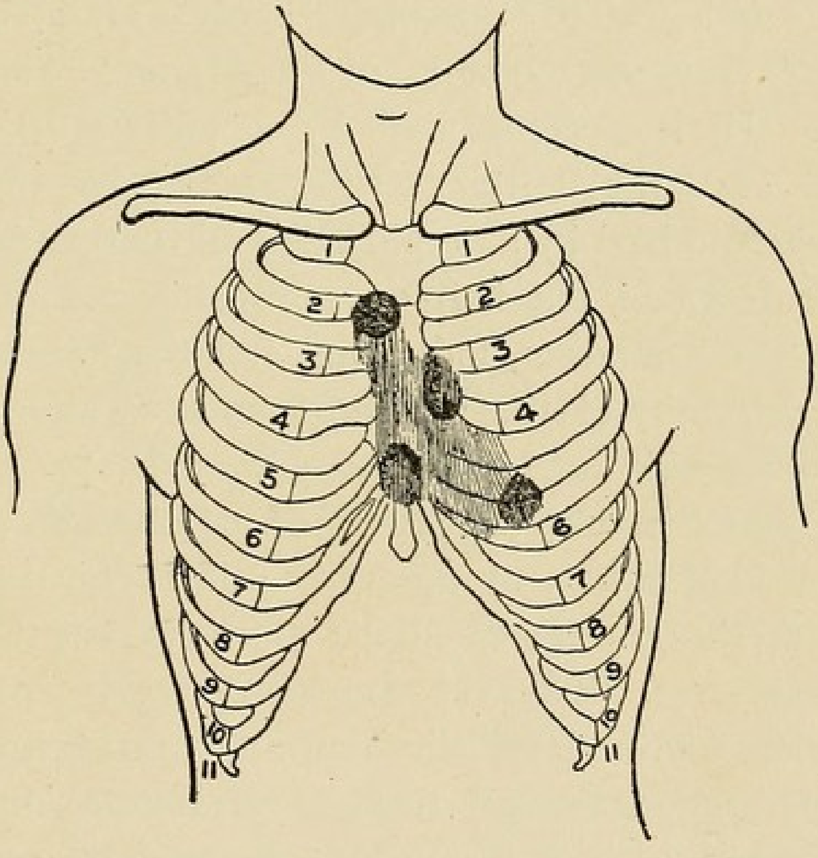

FIG. 26.—AORTIC DIASTOLIC MURMUR AND ITS SEATS OF PROPAGATION.—(*After Hutchison and Rainy.*)

a murmur at the base of the heart, which is the aortic diastolic murmur, and means always **insufficiency** or **incompetency** of the **aortic** valve. This murmur more or less replaces the second sound of the heart, is generally loud, long, and blowing, though less harsh than the aortic systolic murmur, and varies more in the seat of its intensity and condition than any other cardiac murmur. It is sometimes loudest in the aortic area, but often over the midsternum, and it is even well heard as low as the ensiform cartilage, or at the apex itself. It has been mistaken in this situation for a presystolic mitral murmur. It is also transmitted downward along the sternum and toward the apex, because it is in this direction that the column of regurgitant blood is moving. It is accompanied by a powerful heaving impulse and the striking trip-hammer or Corrigan pulse characterized by its rapid rise and sudden fall. It also occurs alone, but is frequently associated with the aortic systolic murmur, indicating stenosis or roughening or deformity of the valve-segments. Thus is produced the *double*, *sawing*, or *steam-tug* murmur.

Murmurs in the Right Side of the Heart.—The same conditions at the valve-orifices on the right side of the heart produce similar murmurs, but they are very much rarer. Thus **tricuspid regurgitation** produces the tricuspid systolic murmur, and **tricuspid stenosis** produces the tricuspid presystolic murmur. These are heard in the tricuspid area at the lower part of the sternum, at its junction with the 5th and 6th cartilages. Tricuspid regurgitation is apt to occur sooner or later in connection with mitral disease, but independent of mitral diseases it is very rare, being generally congenital. (See, however, page 169.) **Pulmonary stenosis** scarcely occurring, except congenitally, produces the pulmonary systolic murmur, and **pulmonary regurgitation**, the rarest of all, would produce a dias tolic murmur. Both are heard in the pulmonary area at the second interspace, at the left edge of the sternum.

Impurity of Heart-Sounds.—In addition to the easily recognizable abnormal sounds described, there occur more or less marked modifications of the normal sounds due to slight defects of the valves, which render them less typical, whence the term impurity of heart-sound. They may be caused by slight thickenings or other changes which modify the normal closure of the valves, and are of uncertain significance. On the other hand, very decided alterations in the valves and orifices are sometimes found at necropsy when no modifications of the normal sounds were detectable during life.

The Exocardial or Friction Sound.—The only true exocardial murmur is the **pericardial friction** sound caused by rubbing of the two surfaces of the pericardium upon each other, in health a noiseless act like that of the pleural surfaces. When roughened, however, by disease a to-and-fro sound of varying loudness and harshness is produced. The most frequent cause is pericarditis, but any cause which roughens the two opposite surfaces, such as tubercular and other morbid growths, will produce a friction sound

The friction sound sometimes resembles the intracardial murmur, but a little experience enables one to distinguish them. The friction sound is a superficial to-and-fro sound heard directly under the ear, commonly loud and rasping, never blowing, sometimes creaking. It is most loud over the middle of the heart, not synchronous with the normal heart-sounds and not conducted in the direction of the blood current. It is often influenced by changes of position or by breathing, or by pressure with the stethoscope. It may sometimes be felt by the hand placed over the heart. It is generally of short duration and disappears with the filling of the pericardium by effusion.

A friction may be *pleuropericardial*, that is, given a circumscribed pleurisy, the pericardium in its motion over the rough surface of the pleura may produce a friction sound simulating the pericardial friction, but such sound ceases with the compelte holding of the breath.

A **churning** or **water-wheel sound** is produced when air and water are both present in the pericardium, —a rare event.

Cardio-respiratory murmurs are systolic murmurs heard at the end of a full inspiration, and are caused by the heart's impulse forcing with its contraction the air out of some adjacent air-vesicles, or possibly even a cavity. The sound resembles a soft systolic murmur, but ceases when the breath is held in expiration. Similarly caused are *pulsating crepitations*.

FUNCTIONAL, OR ACCIDENTAL, OR HÆMIC MURMURS.

These are murmurs usually supposed to arise independently of any abnormality in the state of the cardiac valves or orifices. They have certain characters by which they are commonly distinguished from organic murmurs, although such distinction is not always easy.

1. They are invariably systolic. 2. They are almost always soft and blowing, and greatly influenced by posture, being more pronounced in the recumbent position than in the upright, although this relation is sometimes reversed. 3. They are most frequently basic, and far more common pulmonary than aortic, but occasionally they are heard at the apex. 4. Functional murmurs are unattended by the unequal distribution of blood and the alteration in the size of the heart and its cavities, which always, sooner or later, accompany the organic murmurs.

They have therefore been regarded as due to some condition of the blood, as the result of which its particles are thrown into vibration more readily than in health. Hence they are also called *hæmic* murmurs. Such condition is generally accompanied by a watery state of the blood; for this reason they are also called anæmic murmurs, being especially frequent in anæmia and chlorosis, and in women immediately after childbirth. Whether it be this thinness of the blood which is responsible for the murmur, or some accompaniment of such a state is not known.

These murmurs also occur in connection with various morbid states of the blood, such as exist in the infectious fevers as well as the various anæmias; also in certain neuroses, especially in Graves' disease and allied affections. In these latter there are also arterial murmurs, which are ascribed to vasomotor influences producing inequalities of calibre of the vessel, which engender murmurs. From these facts *Sansom's theory* ascribes to a similar origin the murmurs in the great vessels in neuroses and anæmia. The ventricle, weakened by impaired nerve force, toils to overcome an unusual resistance due to tension in the great vessels, and the muscular fibrillæ of the conus of the ventricle just below the valves are thrown into tremor. The valves themselves may vibrate, and these vibrations are communicated to the area of the thorax adjacent to these vessels through the portions of these vessels immediately above the valves. The right ventricle and its conus are more superficial, its muscular walls are thinner, and in the conditions named it has to contend against relatively greater obstruction, hence murmurs at its site are more frequent.*

Naunyn's theory ascribes the so called pulmonary murmur to a regurgitation through the mitral valve into the left auricle, reaching the ear by the auricular appendix. Hence the fact that the murmur attains its greatest intensity not in the pulmonary area but to its left.

Russell's theory ascribes the pulmonary murmur to pressure of a distended auricle on the artery.

Certain systolic murmurs at the *apex*, associated with anæmia and neuroses, but unaccompanied by valve lesions, Sansom ascribes to an actual mitral regurgita-

* It will be remembered, as stated on p. 128, that Sansom ascribes murmurs to vibrations in solids rather than in fluids as commonly accepted. To make the statements quoted accord with such view we have only to suppose that the vibrations described are communicated to the blood stream and conducted thence to the ear.

tion, the result of weakness of the muscles concerned in closure of the mitral orifice. Other explanations than these are assigned by various authors, for information as to which the student is referred to Sansom's recent work on "Diseases of the Heart and Thoracic Aorta." I will only add that Balfour, for one, holds that the pulmonary murmur is not an arterial but an auricular murmur.

VASCULAR MURMURS.

In the examination of arteries the stethoscope is applied—for the carotid, at the intersection of the sterno-cleido-mastoid muscle into the clavicle and sternum, and carried upward along the anterior edge of the muscle; for the subclavian, *behind* the clavicular insertion of the sterno-cleido-mastoid muscle, the arm being dependent; for the brachial, on the inner border of the biceps at the bend of the elbow, with the arm partially flexed, and for the crural, in the popliteal space. Care should be taken to apply the stethoscope very lightly, as pressure itself will engender a sound called the acoustic pressure murmur. This may be made self audible at almost any time with sufficiently quiet surroundings by pressing upon the artery in front of the ear.

Normal Arterial Murmurs.—Considering the apparent simplicity of the matter, there is a singular discrepancy in the statements concerning the so-called normal arterial murmurs. I am inclined to agree with W. Russell, who says no murmur originates in the great vessels of the neck in health, unless it be as the result of undue pressure with the stethoscope. On the other hand, there can be no doubt that two sounds are commonly heard on such auscultation. My own observations go to show the following: If a stethoscope be thus lightly placed over the carotid or subclavian arteries, so as not to compress the vessels, two sounds are heard with each movement of the heart—one corresponding to the systole of the ventricles and the expansion of the arteries, the other to the diastole of the heart and the contracting recoil of the arteries. The first is shorter and fainter and is the first sound propagated from its seat of production, the auriculo-ventricular valves. The longer and louder is the second or aortic heart-sound, conducted from the site of its production, the aortic valves. The latter sound is occasionally heard in the abdominal aorta, more rarely in the brachial and femoral. The fainter sound is not conducted so far.

Abnormal Arterial Murmurs.—Abnormal sounds are conducted into the arteries in valvular disease of the heart, particularly aortic disease, both obstructive and regurgitant, and rarely also in mitral disease. The systolic murmur of aortic stenosis is always conducted at least into the great vessels of the neck.

Finally, murmurs may arise in the larger arteries themselves from any causes which produce a change in the diameter of the vessel, such as aneurismal dilatation, congenital narrowing, or narrowing due to thrombi or to compression from any cause, such as adhesions, contraction of cicatricial tissue, morbid growths or inflammatory infiltration, or the pregnant uterus. Thu a murmur may occur in a branch of the pulmonary artery from pressure by a tubercular deposit or pneumonic infiltration or enlarged bronchial gland, and a murmur may even be produced in the subclavian artery by a tubercular deposit at the left apex. A murmur in a branch of the pulmonary artery from such cause is intensified during expiration, while a murmur in the left subclavian from the same cause is said to be intensified by holding the breath at inspiration. Thyroid tumors in the neck also produce arterial murmurs by pressure.

Sounds also arise in the larger arteries as the result of change of pressure. Such is **Traube's** sound produced in aortic regurgitation. This is usually a double sound, of which the first element is due to the rapid distension of the artery by a blood-wave which throws its walls into vibration. A second sound occurs with the cessation of the pressure.

The **placental murmur** is a mixed venous and arterial murmur.

Venous Murmurs.—These are distinguished from arterial murmurs by their continuousness as contrasted with the intermittent arterial murmur. An acoustic pressure murmur may be produced in any vein which is large enough, as the jugular and femoral, by pressing slightly upon it with the stethoscope, without, however, pressing so hard as to obliterate the blood current.

Murmurs independent of such pressure are sometimes heard in these large veins, including the femoral, from tricuspid regurgitation, but the principal pathological venous murmur is the **venous hum** or **bruit de diable.** It is compared to the sound heard on placing a sea-shell of moderately large size against the ear. It is frequently heard in chlorotic females over the bulb or dilatation of the internal jugular vein; also sometimes in the large intrathoracic trunks, the superior cava, and the innominata. It is best heard on the right side by turning the head as far as possible to the left and then placing the stethoscope above the right clavicle behind the sterno-cleido-mastoid muscle, or over the sterno-clavicular articulation, by which an artificial murmur from pressure is avoided. It is a **continuous** soft murmur resembling the humming of a top, and by its continuousness can be readily distinguished from an intermittent arterial murmur. This murmur cannot be regarded as always abnormal, since it is often heard in healthy individuals. Thus Winterich found it in 80 per cent. of the Bavarian cuirassiers whom he examined. It is much more frequent in women than men in the proportion of 7 to 1, according to Aran. Extreme loudness may be regarded as an indication of abnormality. Its presence may especially be regarded as corroborative.

THE SPHYGMOGRAPH IN DIAGNOSIS.

Whatever the diagnostic value of the sphygmographic tracing in valvular heart disease, and it is sometimes considerable, no study of a case of such disease is complete without it. While the original sphygmograph of Marey probably furnishes a better tracing than any of the modern instruments, the latter have the advantage of cheapness. That of Dudgeon is the most popular at the present day, especially Richardson's modification with sphygmometric attachment. Directions for its use and the preparation of suitable paper always accompany the instrument. Space need not therefore be occupied by them. By means of the sphygmometer varying degrees of tension may be measured before the tracing is made. In the pulse of low tension the maximum movement of the lever is attained with slight degrees of pressure, and small increase of the same tends to extinguish the tracing. In pulses of high tension the maximum excursion of the lever is brought only by rather strong pressure, and the strongest pressure will not extinguish the tracing.

The Normal Pulse Tracing.—This is shown in the drawing on p. 146. It consists, first, of a vertical or almost vertical up-stroke, *a b*, a sudden oblique fall, soon interrupted by a notch, *c*, followed by a short rise to *d*, another fall, a second notch, *e*, and another rise to *f*, followed by an undulating fall to the base line of the sphygmogram. The anacrotic or up-stroke, or *percussion stroke*, as it is also called, is the effect of the sudden dilatation * of the artery upon the lever, which, having

* It is held by Broadbent that no actual increase of the lumen of the artery takes place in the formation of the pulse, but that with the filling of the vessel it simply changes from the oval to the circular shape. This seems, however, to be an error, as an actual increase in diameter is easily demonstrable by suitable instruments.

reached its maximum height, falls to rise again and form the so-called *tidal* or *predicrotic wave*, *c d e*. This wave is still a part of the effect of the distending force of the vessel on the lever, which through its inertia is carried too high, then falls, and is again caught by the still dilating vessel and carried to *d*. The vessel now begins to collapse and the lever to fall with it, but soon rises again to form the curve, *e f a*, called the *normal dicrotic*

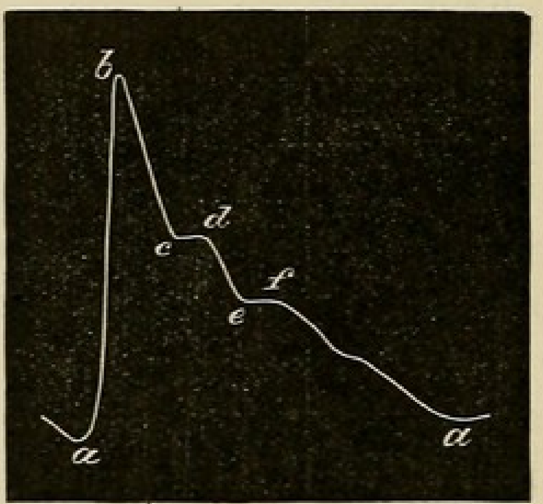

Fig. 27.—Normal Sphygmogram Enlarged.

a b. Percussion up-stroke. *a b c*. Percussion wave. *c d e*. Tidal or predicrotic wave. *e f a*. Dicrotic wave. *d e f*. Aortic notch. *f a*. Diastolic notch.— *Sansom.*)

wave, while the notch immediately before it is the *aortic* or *predicrotic* notch. The dicrotic wave is the result of a second rise of the vessel wall due to the elastic recoil of the over-dilated aorta on the contained blood, which, being prevented from going backward by the closed aortic valve, moves forward, producing the dicrotic wave. The second sound of the heart is found to coincide exactly with the predicrotic notch, *d e f*. Subsequent slight waves, which may or may not be present, are ascribed to vibrations due to the elasticity of the vessel. The further the vessel is tested from the heart, the greater is the distance as a rule between the dicrotic and the predicrotic wave. The pulse wave reaches the more distant parts of the arterial system at successive intervals.

The effect of increased pressure of the button of the sphygmograph on the artery is to shorten the first or percussion wave, and to render the dicrotic wave more distinct, also the smaller vibrations in the down stroke. Apart from this, the altitude of the percussion stroke depends upon the quantity of blood thrown from the ventricle, but is more or less peculiar to the individual, and its smallness in one as compared with another does not necessarily imply that such person has an abnormality in his circulatory apparatus, while the tracings, even in the two radials, of a person perfectly healthy may not be identical, because of difficulty in applying the instrument in precisely the same manner, or of anatomical differences on the two sides, making such application impossible. The special features of the sphygmogram in different cardiac affections will be given in connection with them.

Two modifications of the normal sphygmogram require, however, special allusion, since they are the consequences of a variety of morbid states. They are the sphygmogram of *high arterial* tension, or, as Dr. Sansom prefers to call it, *prolonged arterial tension*, and *low arterial tension.*

Prolonged arterial tension is a condition in which the pressure in the interior of a blood-vessel is unduly prolonged. The effect of the tracing is, in a word, to broaden the top of the primary curve, as shown in the accompanying sphygmogram.

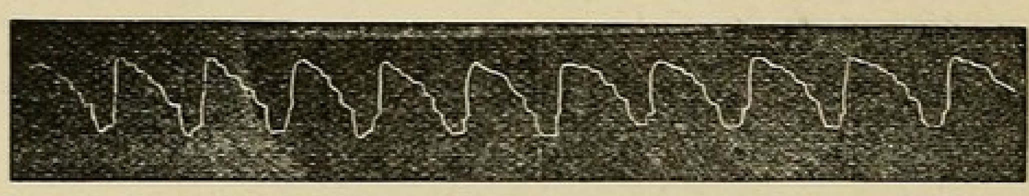

FIG. 28.—SPHYGMOGRAM SHOWING PROLONGED ARTERIAL TENSION.—(*Sansom.*)

In some instances the ascending limb of the sphygmogram is broken into two, as shown in Fig. 28, the attainment of the maximum altitude being delayed by the intravascular resistance. The dicrotic wave is small.

Such a sphygmogram is called *anacrotic*, and the pulse producing it an *anacrotic* pulse.

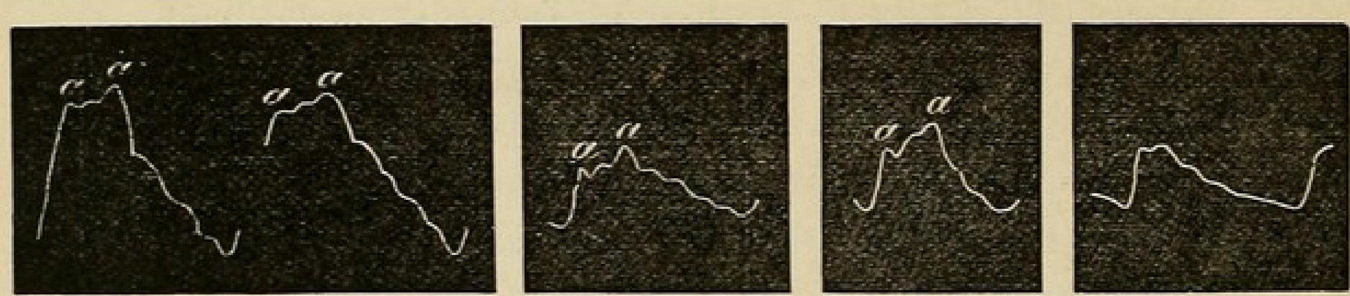

FIG. 29.—ANACROTIC PULSE-CURVES FROM THE RADIAL ARTERY.—(*Landois and Stirling.*)

The pulse of prolonged arterial tension is produced by any cause of resistance to the motion of the blood through the capillaries and arterioles, and such causes are numerous. Chronic renal disease, especially interstitial nephritis, is one of them; so are gout, lead poisoning, constipation, atheroma of the arterial walls, and even anæmia. The anacrotic pulse is also produced in aortic stenosis, where it has diagnostic value.

Low arterial tension is the reverse of prolonged arterial tension. Instead of the filled state of the vessel being maintained, the fulness is of short duration and the wall drops away at once. Such a pulse is easily

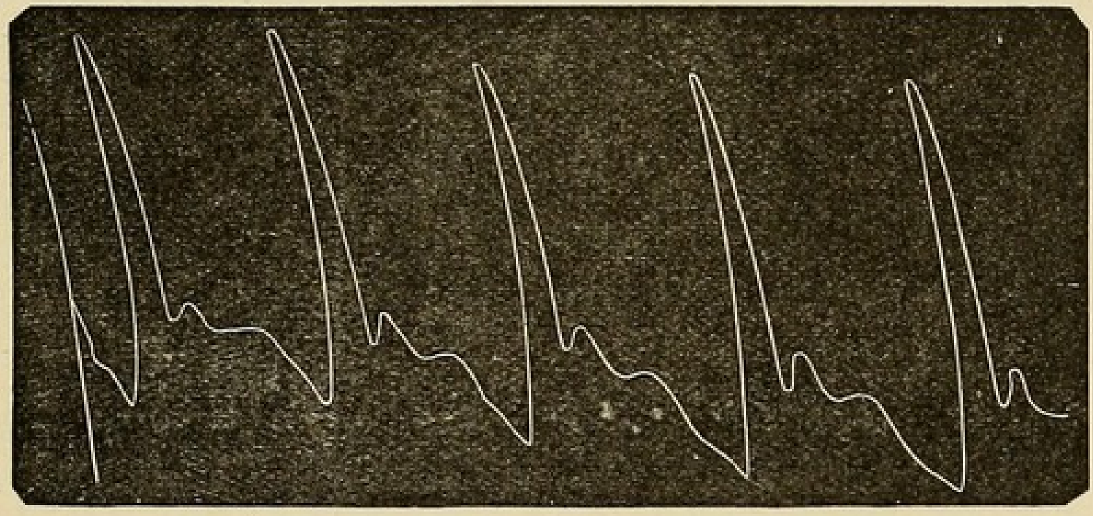

Fig. 30.—Tracing of Pulse of Aortic Regurgitation.—(*Strümpell.*)

obliterated by pressure, while the pulse of high tension is difficult to obliterate. As to the sphygmographic tracing, the up-stroke is vertical, the apex angle is acute, the tidal wave is insignificant, while the dicrotic wave is the most conspicuous feature of the tracing. Fig. 30 furnishes a marked example of such a tracing, in which the first wave of the down-stroke is the dicrotic wave, the tidal wave being wanting.

Dicrotism in pulse of low tension may even exceed that indicated in the sphygmogram. Thus it may spring from the level of the base line, when it is called *full dicrotic*, or it may start from below the base line, when it is called *hyperdicrotic*, or even be in the ascending line of the succeeding trace, when it is called *monocrotic*.

The pulse of low tension may be produced artificially by the administration of nitroglycerin or the application of heat to the surface of the body, as by the warm bath, the conditions being suddenness of cardiac im-

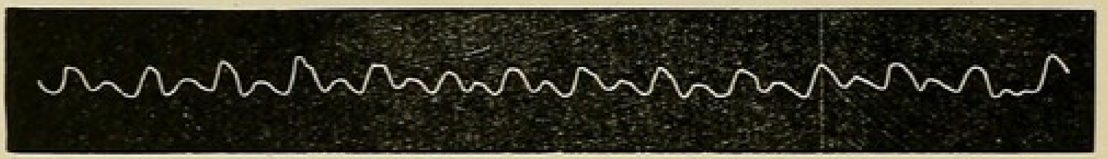

FIG. 31.—TRACING FROM CASE OF PROLONGED ARTERIAL TENSION, SHOWING DICROTIC WAVE.—(*Sansom.*)

pulse and absence of resistance to the onward movement of the blood; it is very characteristic of aortic regurgitation, of collapsed conditions such as are the result of depressing emotions and colliquative discharges like diarrhœa and copious diuresis. It is also found in fever, of which the dicrotic pulse is more or less characteristic. Abnormal dicrotism is not, however, confined to low tension. It varies within the limits of health, and occurs at times in connection with high tension, as shown by Roi and Adami, where there is a sharp, sudden systole of the ventricle, leading to a corresponding sharp and energetic rebound or reactionary wave, as shown in Fig. 31.

Erroneous interpretations of such dicrotism may be avoided by increasing the pressure of the sphygmograph, when, if the tension is low, the tracing is obliterated,

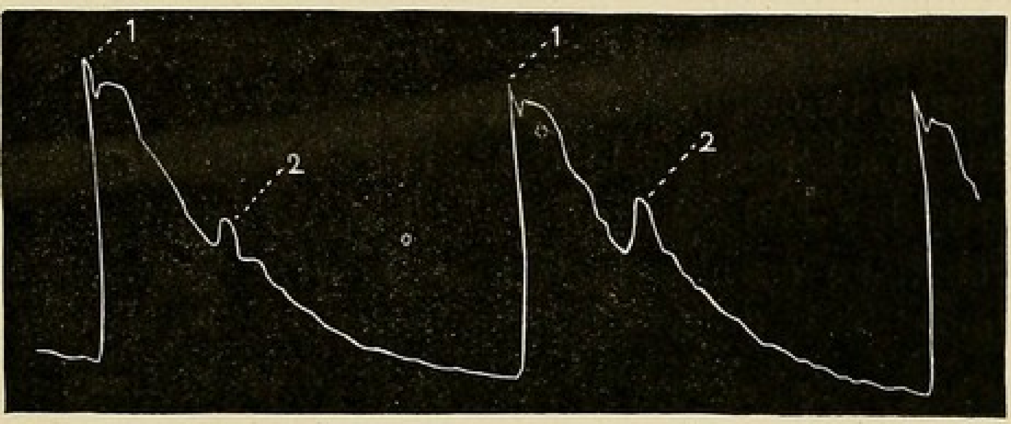

FIG. 32.—BIGEMINAL PULSE.—(*After Byrom Bramwell.*)

while if it is high the first wave becomes broadened and the dicrotism less.

Irregularity of pulse as recognized by the finger may be recorded by the sphygmograph and thus better submitted to analysis.

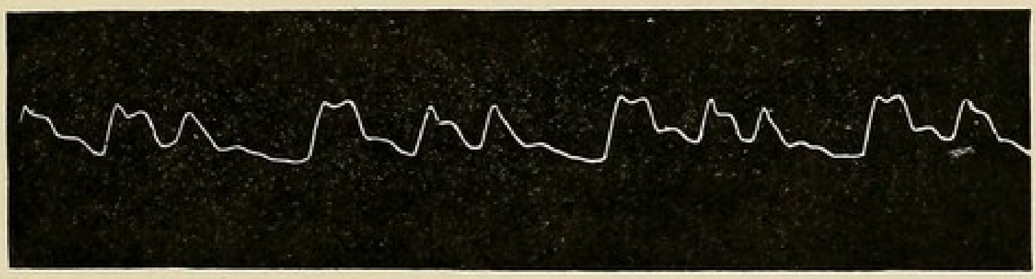

FIG. 33.—TRIGEMINAL PULSE.—(*From Hutchison and Rainy.*)

mitted to analysis. Such a record is the tracing of the *pulsus bigeminus* appended, in which the beats occur in regular sequence—two beats and a pause. Three beats and a pause give the *pulsus trigeminus* shown in Fig. 33.

THE CARDIOGRAPH IN DIAGNOSIS.

The cardiograph does not furnish as valuable assistance to diagnosis as the sphygmograph, chiefly because of the difficulty in getting typical tracings. Tracings are usually taken from the site of the apex, although they may also be obtained from the various chambers of the heart in a large animal like the horse by introducing an elastic bag and attached tube into the right cavities through an opening in the jugular vein, and into the left cavities through an incision in the carotid artery, connecting each bag and tube with a Marey's tambour and thence to a revolving drum. Any pulsating part of the heart, as the left auricle, may be brought into connection with the cardiograph and a tracing therefrom secured, while without an appreciable impulse a tracing is impossible even at the apex. Appended are a number of normal *apex* tracings in which *a* represents the auricular systole, the ascent, *a d* the contraction of the ventricle, *d e f* the continued systole, *k* the effect of the first sudden entrance of blood into the ventricles, *l* the gradual ascent from the gradually increasing flow of blood into the ventricles during diastole, and *a d* again the systole of the ventricles. The notch, *d e f*, is constant, the height of the primary elevation being exaggerated by the velocity of the needle in the instrument employed.

Considerable variation takes place in the apex cardiogram as the result of varying pressure, while partial and even complete inversion of the tracing may occur, whence another source of difficulty in the way of clinical availability of the cardiogaph, for it cannot be relied upon to express accurately the direction of the different events of the cardiac action.

The position of the sounds of the heart in relation to points in the apex trace have, however, been determined with some approach to accuracy. Thus the first sound, as determined by its *muscular* element, is regarded as commencing with the first ascent of the lever,

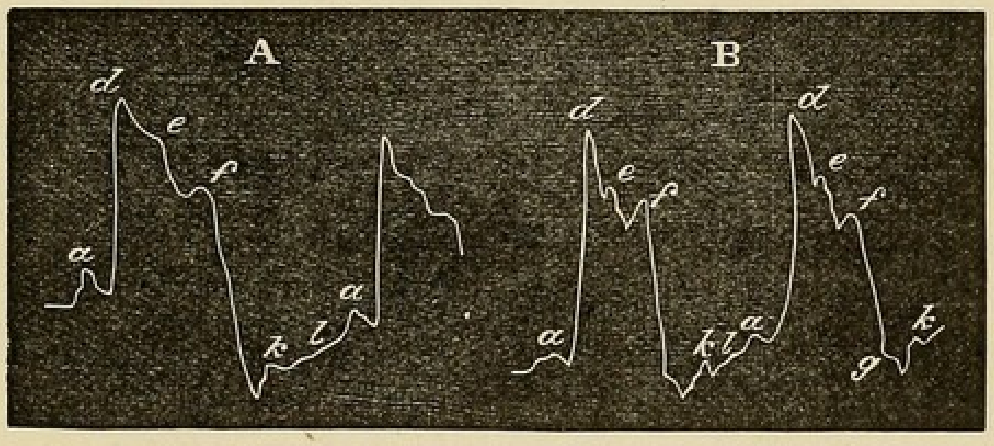

FIG. 34.—NORMAL CARDIAC APEX TRACING.—(*Galabin.*)

and continuing until the *termination* of the rounded shoulder, *f*, at which the muscle of the ventricular wall relaxes. So far as concerns the factor of valvular tension, the position of the first sound must be assigned to a point near the summit of the up-stroke, where the sudden contraction of the *papillary* muscles begins, contiuning to the *beginning* of the rounded shoulder, *f*, where this contraction ceases, the muscle of the ventricular *wall* remaining still contracted.

The second sound occurs somewhere between the shoulder, *f*, and the lower extremity of the descending line succeeding it.

In the apex cardiogram of the normal heart-beat the systole *a d* is decidedly shorter than the diastole *k a*, occupying two-fifths as compared with three-fifths. As the rate of the pulse increases the diastolic interval shortens, until the systole and diastole become equal, although precise measurement of the absolute deviations of these phases by the cardiograph is as yet impossible. Their relative duration may, however, be thus measured, as may also be the force of the ventricular contraction by the height of the up-stroke. The breadth of the summit of the trace measures the duration of the systole and increases with hypertrophy of the ventricles.

In abnormal states the diastolic portion of the tracing is (1) *relatively diminished* or (2) *relatively increased*.

1. It is relatively *diminished*—

(*a*.) In hypertrophy.

(*b*.) Where, in addition to hypertrophy, conditions exist in which the ventricle becomes too rapidly filled. This occurs in aortic regurgitation and in mitral regurgitation when there is hypertrophy of the left auricle; also in the two conditions combined.

2. The diastolic portion of the tracing is relatively *increased*—

(*a*.) When the heart's action becomes slow, the difference between a frequent pulse and a slow pulse being chiefly in the length of the diastole.

(*b.*) Dilatation of the left ventricle, the conditions being the opposite of those of hypertrophy. Herein we have one of the most valuable diagnostic uses of the cardiograph. It is not always easy by other clinical means to inform ourselves when this serious change has taken place which involves a loss of compensations. The cardiograph enables us to do so.

(*c.*) In mitral stenosis, where the diastolic interval is often markedly pronounced, while at other times it is found to vary greatly in duration, two systoles occurring without an appreciable diastolic interval, while between two others there may be a prolonged interval. Much more characteristic, according to Sansom, who has devoted much study to this subject, are the number of vibrations in the diastolic part of the trace. "In fact," says Sansom, * "the vibrations which are heard by the ear as murmurs, or felt by the finger as thrills, may be written on the smoked paper by the needle of the cardiograph." Many other clinical facts of interest and importance may be studied to advantage by the cardiograph, but I must refer the student to the larger works for their consideration.

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* Lettsomian Lectures on "Valvular Diseases of the Heart," 1886.

PHYSICAL SIGNS OF THE DIFFERENT FORMS OF VALVULAR DISEASE.

MITRAL INSUFFICIENCY.

This is the most frequent of the uncombined forms of valvular disease. The valve leaks, the blood flows backward during systole from the left ventricle to the left auricle and distends it. The auricle first attempting to resist the backward flow hypertrophies slightly, but eventually dilates, and the blood is crowded backward into the lungs, which become engorged. The right ventricle, in its efforts to push the blood through the engorged lungs, hypertrophies, and the pulmonary factor of the second sound becomes louder and sharply accentuated. The compensating effect of the hypertrophied right ventricle for a time arrests the mischief. At this stage may begin the hypertrophy of the left ventricle, which in all cases of mitral insufficiency presents itself sooner or later, although at first the double outlet for the blood from the ventricle would seem to demand less strength of the left ventricle. The right ventricle, however, in its hypertrophied state, delivers more blood to the left ventricle, which demands more power to drive it on, hypertrophy results, and thus compensation is a while longer maintained. Or it may be that hypertrophy of the left ventricle begins with the distension and hypertrophy of the left auricle. Sooner or later the right ventricle dilates, the tricuspid valve becomes relatively insufficient, the blood regurgitates into the right aurticle, and thence into the great veins of the neck. The valves of these ultimately yield, the jugular pulse appears, and the general venous system is engorged. In this engorgement the liver, stomach and kidneys share. Then comes transudation, dropsy, albuminuria. Among the latter phenomena in extreme cases are an enlarged, tender, and pulsating liver, a symptom which is pathognomonic of tricuspid regurgitation, but a liver lifted by some pulsating agency behind it must not be confounded with the true pulsating liver. More frequently the liver is visibly enlarged and tender without visible pulsation. Such enlargement disappears in part after death, and is not noticeable at the necropsy.

Inspection discovers the apex-beat to the left of its normal position and perhaps a little lower down. It may be in the line of the nipple, rarely beyond it, and more forcible and diffuse than in health. The outward dislocation of the apex-beat is due to the enlargement of the two ventricles. An auricular pulse may be present to the left of the pulmonic area in the 2d interspace, or systolic and passive for the auricle. A bulging præcordium may be looked for in young persons, and in advanced stages also a jugular pulse.

Palpation more precisely determines the position of the apex-beat, which is found more forcible than normal. It may detect a pulsation near the ensiform cartilage caused by the systole of the enlarged right ventricle. The apex is also displaced to the left. Sometimes an intermittent *systolic thrill* is felt in the 4th interspace in the left mammillary line.

The *radial pulse* in the early stages is comparatively unaltered. Later it becomes frequent and irregular in volume. Appended, Fig. 35, is a sphygmogram of the pulse in advanced mitral insufficiency. It is of the type of the *pulsus parvus irregularis*.

Percussion discovers enlargement of both the relative and absolute areas of dulness, upward in the direction of the left auricle, downward to the left and also to the right, the absolute dulness reaching at times the right

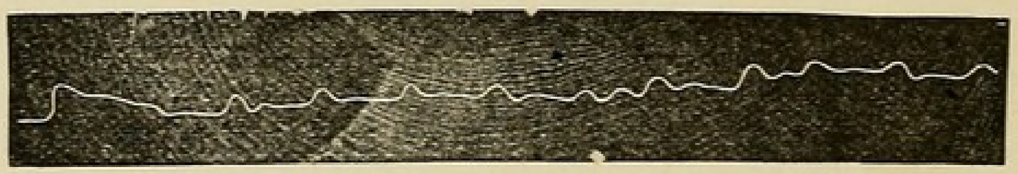

FIG. 35.—TRACING OF PULSE OF MITRAL INSUFFICIENCY.—(*Da Costa.*)

border of the sternum, though often enlargement in this direction is not demonstrable.

Auscultation recognizes a systolic murmur in the mitral area, conducted with various degree of loudness into the left axilla and under the angle of the scapula. This direction of its conduction is the distinctive feature of this murmur. It is usually soft, but occasionally rough, more rarely musical. It is also sometimes well heard to the left of the pulmonary cartilage, and rarely over the entire præcordium. Not always loud enough to be easily heard, it may be brought out by exertion on the part of the patient.

The *second sound of the heart is sharply accentuated* at the *pulmonary interspace* until the tricuspid valve fails, when the accentuation vanishes. The aortic second sound is less strong, corresponding with the less degree of hypertrophy of the left ventricle.

MITRAL STENOSIS.

This lesion occurs as an uncombined or simple form of valvular disease in young persons, especially women, but is very much more commonly combined with regurgitation. The orifice is stenosed and the blood is restrained from passing freely into the left ventricle. The same backward effect as in mitral regurgitation is produced upon the left auricle, the lungs, the right ventricle, and general venous circulation, but the left ventricle is not hypertrophied in simple mitral obstruction, because no extra muscular effort is called for, while hypertrophy of the left auricle is one of the most characteristic signs of mitral stenosis. Theoretically, the left ventricle should even atrophy, but the absence of the enlargement is of great diagnostic value.

Inspection, consistently with what would be expected in absence of hypertrophy of the left ventricle, recognizes little or no displacement of the apex. If there is any it is due to the hypertrophy of the right ventricle, pushing the left ventricle outward. Nor is the apex-beat increased in force. A left auricular impulse, presystolic, may be noted for the same reason as in mitral regurgitation, as may also a jugular impuse and pulsating liver. A bulging præcordium may be produced by the enlarged left auricle and right ventricle, but is not often seen.

Palpation discerns that the apex-beat is without undue force, but it may be diffuse, and an impulse may be felt in the situation of the apex of the right ventricle. The most marked feature of palpation when present is the *presystolic thrill* at the apex. It is similar in rhythm to the presystolic murmur, but may be present without it, and is not always present.

In moderate degrees of stenosis the pulse is not

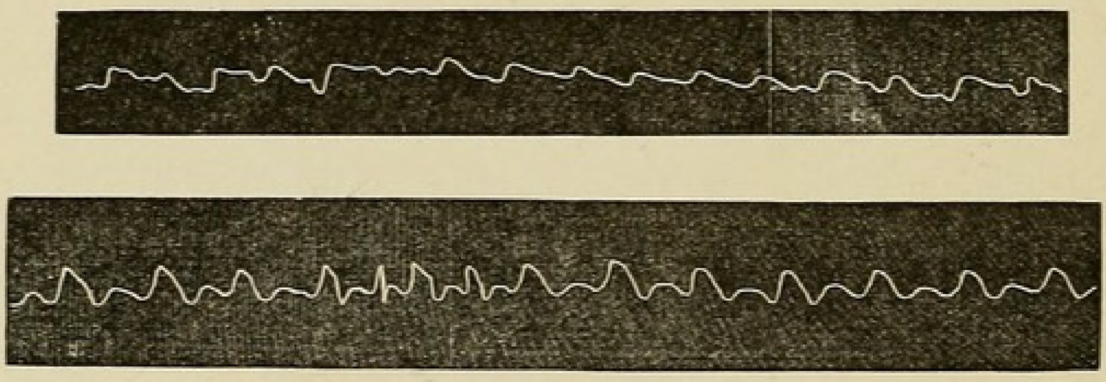

FIG. 36.—TRACINGS OF PULSE IN MITRAL STENOSIS.

altered; in high degrees it is very small, from want of left ventricular power; also irregular, like that of mitral regurgitations. Two tracings from cases of mitral stenosis are introduced in the text.

Percussion recognizes cardiac enlargement in the direction of the left auricle and right ventricle, but not of the left ventricle.

Auscultation does not discover a murmur in every case of mitral stenosis, because of the feebleness of the auricular contraction, especially at the beginning.

Most characteristic is the abruptly terminating *presystolic* murmur described on p. 131, confined for the most part to the mitral area, though it may be conveyed upward, and it is even heard posteriorly, though rarely. Dr. Sansom places it rather at the right of the apex.

Accentuation of the second sound is marked, but confined to the pulmonary area, because there is no hypertrophy of the left ventricle. The second sound may also be duplicated, because of the want of synchronousness in the closure of the aortic and the pulmonary valves. Dr. Sansom regards this reduplication as a seeming one only of the second sound. He considers rather that the normal second sound is followed by another sound due to a sudden tension of the mitral valve itself, producing thus a seeming reduplication. He also says it occurs in at least a third of all cases of mitral stenosis, and is rare in other cardiac conditions.

The murmur of mitral stenosis is sometimes difficult to distinguish from that of aortic regurgitation, but in the latter there is enormous hypertrophy of the left ventricle, which is wanting in mitral stenosis. The time of *tricuspid* stenosis is identical with that of aortic regurgitation, but it is heard in a different part of the præcordium—in the epigastrium. On account of these difficulties, while the presystolic murmur is a valuable sign of mitral stenosis, it should not be alone relied upon for diagnosis, but should be taken in connection with other signs. Tricuspid stenosis may be associated with mitral stenosis, or insufficiency, or both, though it is a rare lesion. (See p. 131 for further characterization of the presystolic murmur; also Flint's murmur.)

Dr. Sansom lays great stress on the evidence of the cardiograph in the diagnosis of mitral stenosis, which enables one to judge of the relative length of systole and diastole. In stenosis the interval between the systoles may be greatly prolonged, or the diastolic intervals vary greatly in duration. In mitral regurgitation, on the other hand, a short interval only separates the systoles.

MITRAL INSUFFICIENCY AND STENOSIS.

More common than mitral stenosis as an uncombined lesion, about twice as often, according to Frederick J. Smith's analyses, is stenosis associated with insufficiency, producing the double mitral murmur, sometimes with difficulty divisible into its two parts. Extreme irregularity of rhythm and pulse, with frequency and smallness of the latter, conspicuous thrill, marked right-sided hypertrophy, and sharply accentuated pulmonic sound are characteristic.

AORTIC STENOSIS.

This, as a simple, uncomplicated lesion, is the most infrequent form of valvular disease. When uncombined with regurgitation it is the least dangerous. The aortic orifice is narrowed and prevents the free discharge of blood from the left ventricle into the aorta. The ventricle attempts to overcome this, and its walls hypertrophy in proportion to the degree of resistance, and often for a long time compensate for the obstruction—until dilatation occurs, when the danger really begins. Dizziness is a frequent symptom; there are often heard noises in the ears, the patient is pale and subject to fainting and cramps in the muscles.

Inspection and *palpation* recognize a forcible apex-beat beyond the normal situation and at varying distances according to the degree of hypertrophy, while palpation adds occasionally a purring basic thrill with each beat of the heart, more especially when dilated hypertrophy is established. A bulging of the præcordium is also present.

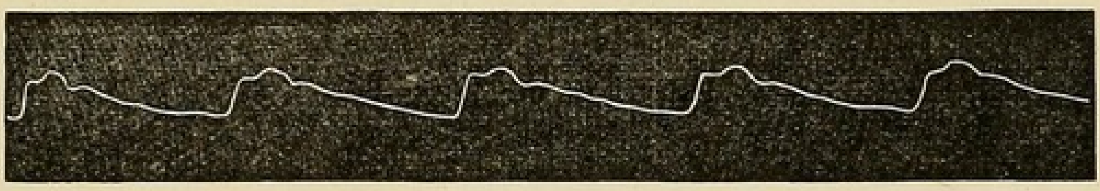

FIG. 37.—PULSE TRACING OF AORTIC STENOSIS.

The pulse is the *pulsus tardus*, *parvus*, *rarus*, slow in reaching its maximum volume, which is small. It is frequent but regular, contrasting in the latter respect with the pulse of mitral disease. Fig. 37 is a sphygmogram.

Percussion elicits dulness downward and laterally toward the left, since, as a rule, the enlargement is confined to the left ventricle. There may, however, be enlargement upward to the left of the sternum.

Auscultation discloses a systolic basic murmur, loudest at the aortic area—2d interspace at the right of the sternum—which is conducted distinctly into the carotids, and even sometimes along the course of the aorta behind and to the left of the vertebral column, into the popliteals and dorsal arteries of the feet. It is not, however, confined to this area, but may be heard over the entire præcordium. It is usually rough, but may be soft and musical. It is made louder by exercise. The aortic factor of the second sound is weak if the constriction be at all decided, because of the feeble recoil, a necessary result of the small amount of blood in the vessel. The first sound is normal and somewhat louder and more prolonged than natural, because of the powerful contraction of the left ventricle.

Roughness of the aorta due to atheroma, dilatation, or narrowing of the vessels by pressure or otherwise, may also cause a systolic murmur, and so may roughness within the ventricle in the course of the outgoing column of blood; but these causes have generally a less positive effect upon the substance of the heart. It is important, therefore, to remember that an aortic systolic murmur *by no means always indicates aortic stenosis.* In like manner anæmic or hæmic murmurs, which are always systolic and for the most part basic, may simulate aortic systolic murmurs, but these occur in young, delicate persons, of both sexes, and are often intermittent and without other effect on the circulation. There may be roughness, too, in the pulmonary artery, which can be localized to the left of the sternum.

AORTIC INSUFFICIENCY.

The most serious and irremediable of the valvular diseases of the heart commonly met with; more frequently associated with aortic stenosis, it is still not rare uncombined. It is the lesion most frequently followed by sudden death. The aortic valves are incompetent and the blood flows backward into the left ventricle during diastole. The ventricle, seeking to restore the balance, redoubles its energy, hypertrophies. The blood is thus driven into the aorta with great force, swelling the arteries to extreme fulness, which, however, falls away promptly, because of the backward flow into the ventricle at the same time with the forward movement into arteries and capillaries. This sudden falling away of the pulse, from extreme distension to collapse, is very characteristic of this form of valvular disease, and is called the "trip-hammer" or "water-hammer pulse," also Corrigan pulse. It may even be visible to the casual observer in the exposed arteries, such as the carotid, temporal, and radial, while the aoric beat, ordinarily beyond reach in the suprasternal notch, may sometimes be felt in this situation. The abrupt jerking impulse with sudden recoil is easily recognized by the finger, which, however, fails to find the pulse as strong and hard as would be expected from the appearance. On the other hand, it is soft and receding—a pulse of low tension. A tracing of this pulse is found in Fig. 38. It is the typical *pulsus celer et altus*.

The tremendous systole of the ventricle may ultimately force the mitral valve to yield, and compensation to be gradually lost *pari passu* with a growing dilatation. To this succeed the phenomena of relative mitral insufficiency, regurgitation, and hypertrophy of the right ventricle. The latter comes for a time to the rescue, but weakens with the giving away of the tricuspid valve.

Inspection often discerns the præcordium prominent,

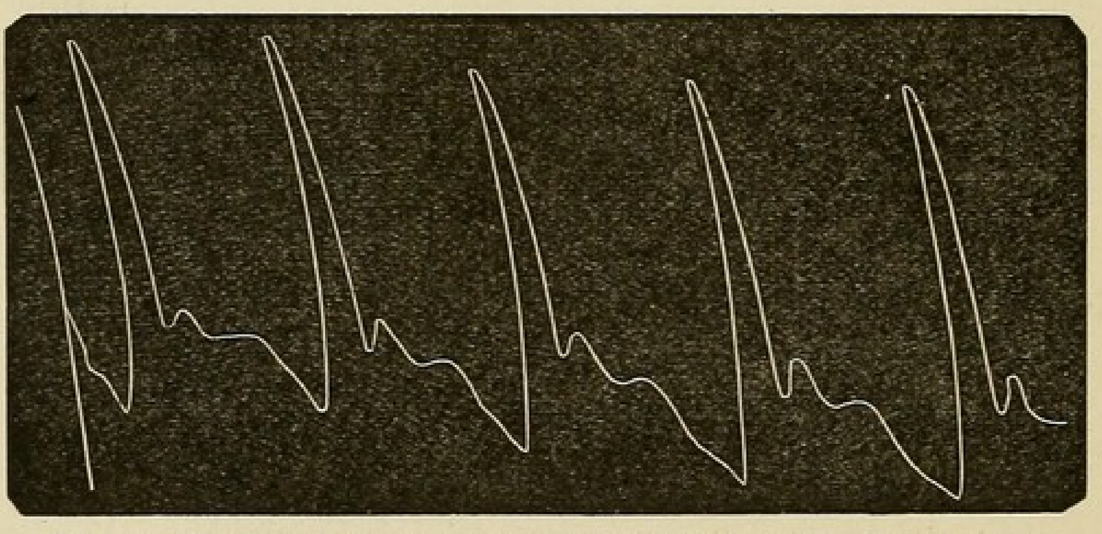

FIG. 38.—TRACING OF PULSE OF AORTIC REGURGITATION.—(*Strümpell.*)

with the apex-beat lowered and to the left, and the visible pulsation far beyond the normal situation of the apex, all confirmed by palpation, to which is also evident at times a systolic thrill over the carotids and subclavians, and sometimes in the aorta at the suprasternal notch. A *capillary pulse* is also sometimes demonstrable in the skin and mucous membrane. This may be brought out by pressing the end of the finger-nail and watching the pink zonula; or in the line of congestion produced by drawing a pencil lightly across the skin of the cheek or forehead, and on the mucous membrane of the averted lower lip, by pressing a glass microscopic slide against it, as suggested by F. C. Shattuck.

Percussion discloses increased dulness to the left and downward, and also, sometimes, in advanced cases, upward to the left of the sternum, not from hypertrophy of the left auricle, but to enlargement of the ventricle upward.

Auscultation recognizes a diastolic murmur, long and various in quality, but usually blowing and harsher than the aortic obstructive murmur. Its area of maximum intensity is commonly at the aortic interspace or mid sternum, sometimes as low as the 4th left costal cartilage, and even at the apex and at the ensiform cartilage. Hence it may be mistaken for the mitral obstructive murmur and for the murmur of tricuspid stenosis, but both of these, be it remembered, are unaccompanied by hypertrophy of the left ventricle. The murmur is naturally transmitted downward toward the ensiform cartilage or along the left edge of the sternum, and toward the apex in the direction of the regurgitating column, but it may also be heard in the direction of the great vessels of the neck, though less loudly than the aortic systolic murmur.

Various sounds may be heard in the arteries of middle size, such as the popliteals and femorals. Included in these is Traube's double sound described on p. 143.

AORTIC STENOSIS AND INSUFFICIENCY.

This double lesion is a comparatively frequent one, indeed, commonly regarded as the next in frequency after mitral incompetency, and therefore more frequent than either aortic stenosis or aortic insufficiency alone. It occasions a double basic murmur, systolic and diastolic, well named the *steam-tug* murmur. It is also a grave condition giving rise to the same dangers as aortic regurgitation, and the same enormous hypertrophy of the left ventricle.

AORTIC STENOSIS AND MITRAL INSUFFICIENCY.

This is the second in frequency of the combined murmurs, according to F. J. Smith's statistics, and these murmurs probably as frequently indicate the corresponding lesions. The murmurs occur at the same time, *i. e.*, during systole, that of aortic stenosis in the aortic area conducted into the neck; the mitral in the mitral area conducted into the axilla, as shown in Fig. 39.

TRICUSPID INSUFFICIENCY.

Tricuspid regurgitation as a primary condition is extremely rare, and when present is probably the result of an endocarditis during fœtal life, endocarditis at this period being more prone to attack the right than the left side. Endocarditis involving the tricuspid valve may, however, occur in children, according to Byrom

Bramwell,* more commonly than has been supposed. Infectious or mycotic endocarditis also affects the tricuspid valve, according to William Osler, in 19 out of 238 cases. More frequently tricuspid regurgitation is one of the terminal events of mitral disease, the tricus-

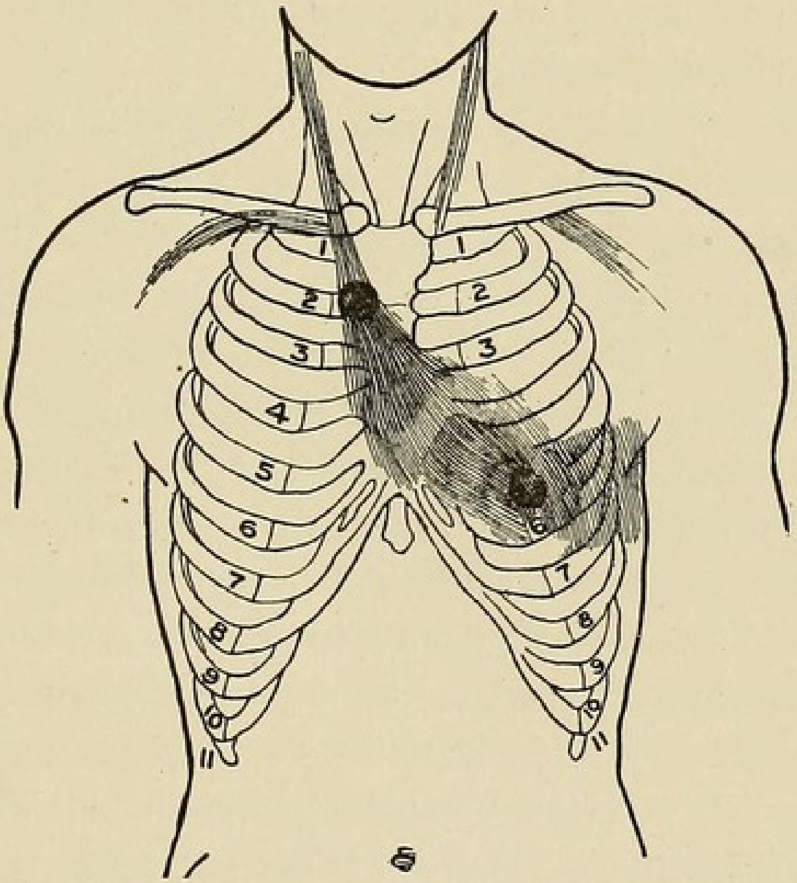

FIG. 39.—COMBINED AORTIC AND MITRAL SYSTOLIC MURMURS.—(*After Hutchison and Rainy.*)

pid orifice yielding to the dilatation of the right ventricle which succeeds upon its hypertrophy if the patient live long enough. It is also one of the possible sequelæ of emphysema of the lungs and long-standing fibroid

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* *Amer. Jour. Med. Sci.*, Apr., 1886, p. 419.

phthisis. Its effects, depending upon engorgement of the venous circulation, have already been detailed on p. 156.

In **primary** tricuspid insufficiency with regurgitation, *inspection* and *palpation* note an apex beat diffused from the normal area toward the epigastrium, and *percussion* may detect enlargement toward the right of the end of the sternum.

To *auscultation* the systolic murmur thus engendered is invariably feeble and is heard almost solely in the tricuspid area, just above and to the left of the ensiform cartilage. Occasionally only is the second pulmonic sound accentuated. There should be no confounding of this murmur with that of aortic regurgitation conducted toward the same situation, nor with that of mitral regurgitation heard at no great distance, for the reasons named. To these must be added a difference in quality and pitch between the tricuspid and the mitral murmur. The jugular pulse is also more or less constantly associated with tricuspid regurgitation. The presence of the pulsating liver is almost pathognomonic. The jugular pulse is sysolic in time and does not appear until the valves situated at the opening of the internal jugulars into the innominate veins yield. These give way first on the right side because the communication is more direct. The **false jugular** pulse must not be mistaken for the true one. It is commonly more superficial, and is found whenever the venous system is much engorged, whether in health or disease. It is presysolic in time, while the jugular is systolic, but is easiest distinguished by pressing on the vein above the valves, which will cause the false pulse to disappear, while the true pulse, coming from the right ventricle, will remain

TRICUSPID STENOSIS.

Tricuspid stenosis is a still more rare condition than primary tricuspid incompetency, but it may occur in association with left-sided heart disease as the result of rheumatic endocarditis and unknown causes. As in endocarditis of the left side, there is thickening, adhesion, narrowing. These cases are regarded as most frequently acquired, not congenital, although the diagnosis is seldom made because the murmur is masked by the mitral systolic murmur which is usually associated.

Tricuspid obstruction without coincident mitral disease is exceedingly rare. A presystolic tricuspid murmur pointing to such a condition in a case observed by Gardner was found due to a growth from the endocardium of the right auricle, so placed as to fall over the tricuspid orifice in the manner of a ball valve.

Congenital defects would include other cases.

Shattuck has met one instance of tricuspid stenosis with mitral stenosis and regurgitation, along with adherent pericardium, hepatic cirrhosis, and slightly granular kidney, determined by autopsy. In this case there was a presystolic tricuspid murmur observed for three years before death.

To *auscultation*, a presystolic murmur at the right edge of the sternum from the 4th costal cartilage to the ensiform cartilage and thence to the 6th left cartilage at its junction with the sternum, would be the murmur diagnostic of the condition. Frequently there is no murmur audible, even if such a lesion is found at necropsy. There should also be enlargement of the right auricle. A presystolic thrill may accompany the murmur.

PULMONARY STENOSIS

The great majority of systolic murmurs heard at the pulmonary orifice are functional. Pulmonary stenosis may, however, be present, and where it exists it is far more likely to be congenital from arrested development, although intra-uterine endocarditis may also cause it. So, also, may infectious endocarditis, and in rare instances atheroma.

Pulmonary stenosis should furnish a systolic murmur in the pulmonary area, to the left of the sternum. The murmur may even be heard behind, between the shoulders, and it may be rough. It is accompanied by hypertrophy of the right ventricle. There may be a basic thrill, as in aortic obstruction, but the pulse is uninfluenced. Compensation may be set up by means of a patulous foramen ovale, an open ductus arteriosus, or interventricular communication. The invariable association of cyanosis due to venous obstruction and of attacks of dyspnœa complete the picture and aid greatly in the diagnosis. Anæmic murmurs at the same time and place are unaccompanied by cyanosis.

Walshe has described a case of death from thrombosis of the pulmonary artery in which he heard a pulmonary systolic murmur before the end came.

PULMONARY INSUFFICIENCY.

Simple pulmonary regurgitation is scarcely known, but it is easy from what has gone before to deduce the physical signs which are to be expected—a diastolic murmur heard in the pulmonic area, hypertrophy of the right ventricle, jugular pulse, venous congestion, and cyanosis. A few cases are related in which a diastolic murmur has been found associated with defects in the pulmonary valves, in one warty, which might have been the result of infectious endocarditis. All others are congenital. Among them is aneurismal dilatation. Such was a case reported to the Pathological Society of Philadelphia by Edward T. Bruen. (See Transactions for 1883.)

It must not be forgotten that occasionally systolic and diastolic murmurs produced by aortic disease are best heard in the second left interspace instead of the right.

CONGENITAL DEFECTS.

Congenital defects in the cardiac valves and orifices deserve a passing notice. They may be the result of endocarditis during fœtal life or of arrest of development. Their most frequent seat is the right heart and the most frequent form is stenosis of the pulmonary orifice, the effects and signs of which have already been considered. Another is a permanently patulous foramen ovale; or there may be a defect of the septum of the ventricles, or a communication between the aorta and pulmonary artery—a persistent ductus arteriosus—or between the aorta and the vena cava or right auricle. All of these intercommunications produce murmurs difficult to separate, and it is, after all, by attention to the general condition that the defect is recognized. The patient, a child of arrested development, more or less permanently cyanosed, with continued embarrassed breathing, all of these are conditions which point to the congenital defect. If there be added to these a persistent loud murmur at the base of the heart without other signs or symptoms of valvular disease, this may be due to congenital defect.

RELATIVE FREQUENCY AND RELATIVE DANGER OF VALVULAR DEFECTS.

The order of frequency of the various valvular defects is not entirely agreed upon. As to one, however, there seems to be universal concurrence, and that is that mitral regurgitation is the most frequent. After this, however, statistics differ. Thus of the older authors Walshe presents the following order of frequency for the single or individual murmurs:

1. Mitral incompetency or insufficiency. 2. Aortic stenosis. 3. Aortic incompetency. 4. Mitral stenosis. 5. Tricuspid incompetency. 6. Pulmonary stenosis. 7. Tricuspid stenosis. 8. Pulmonary incompetency.

As already stated, all agree that the mitral systolic murmur indicating mitral regurgitation is the most frequent. Dr. Frederick J. Smith, analyzing the registers and post-mortem records of the London hospitals for eleven years—1877–1887—and taking the fatal cases only, arrived at the following order:

1. Mitral incompetency. 2. Mitral stenosis. 3. Aortic incompetency. 4. Aortic stenosis. 5. Tricuspid stenosis.

Out of the 705 cases Smith found 26, or 3.38 per cent., of mitral stenosis, and 25, or 3.25 per cent., of aortic regurgitation. So it cannot be said there is any practical difference in the relative frequency of these two lesions. Smith's statistics, being recent and based, as they are, upon the examination of registers and autopsy records, might be reasonably regarded as correct. Yet it is not easy to disprove the presence of a coincident regurgitation in many cases of anatomical stenosis, which would, therefore, have to be deducted from the cases of simple lesion and added to those of combined.

G. Klemperer considers simple mitral stenosis—*i. e.*, occurring alone—very rare, and says the same of aortic stenosis, aortic incompetency being very frequent and mitral incompetency the most frequent of all cardiac defects, and I am inclined with him to make the following order:

1. Mitral incompetency. 2. Aortic incompetency. 3. Aortic stenosis. 4. Mitral stenosis. 5. Tricuspid incompetency.

Two murmurs at one orifice are usually characterized as "double" murmurs, but Sansom suggests that the term "combined" be applied to these murmurs, and the term "associated" retained for murmurs at more than one orifice.

F. J. Smith's results as to associated murmurs are as follows:

1. Aortic regurgitation and stenosis; mitral regurgitation.

2. Aortic stenosis and mitral regurgitation.

3. Aortic regurgitation and mitral regurgitation.

4. Aortic regurgitation and stenosis; mitral stenosis and regurgitation.

5. Mitral regurgitation and tricuspid regurgitation.

6 Aortic regurgitation and stenosis; mitral regurgitation; tricuspid regurgitation.

7. Mitral stenosis and regurgitation; tricuspid regurgitation.

8. Aortic stenosis; mitral stenosis and regurgitation.

9. Aortic regurgitation; mitral stenosis and regurgitation.

10. Aortic stenosis; mitral regurgitation; tricuspid regurgitation.

11. Aortic regurgitation and stenosis; mitral regurgitation; pulmonary regurgitation.

12. Aortic stenosis and regurgitation; mitral stenosis.

13. Aortic regurgitation; mitral stenosis.

14. Aortic regurgitation; mitral regurgitation; tricuspid regurgitation.

15. Mitral stenosis; tricuspid regurgitation.

16. Aortic stenosis; mitral stenosis and regurgitation; tricuspid regurgitation.

17. Aortic stenosis; mitral stenosis.

18. Aortic regurgitation and stenosis; mitral stenosis and tricuspid regurgitation.

19. Aortic regurgitation; mitral stenosis and regurgitation; tricuspid regurgitation.

20. Aortic regurgitation and stenosis; mitral stenosis and regurgitation; tricuspid regurgitation.

21. Aortic regurgitation and stenosis; mitral stenosis and regurgitation; tricuspid stenosis and regurgitation.

22. Aortic stenosis; pulmonary stenosis.

23. Aortic stenosis; mitral stenosis and regurgitation; tricuspid stenosis and regurgitation.

24. Mitral stenosis and tricuspid stenosis.

Of the 10th and 11th there are the same number, 5 out of 705; of the 12th, 13th, and 14th, each 4, and of the last 5 each 1. Of the double or combined murmurs, it is generally conceded that that at the mitral orifice, indicating stenosis and insufficiency, is the most frequent, and women are far more liable to this lesion than men. In an analysis of cases at the Glasgow Infirmary, Dr. George S. Middleton found a far larger proportion of the double aortic lesion than Dr. Smith, 22 per cent. as against 4 per cent., and Walshe makes the double aortic lesion the second in frequency. But when we add together the cases of double aortic lesion and those of double aortic lesion combined with lesions at the other valves, as suggested by Dr. Sansom, we have almost exactly 22 per cent., and it is well known that in the majority of cases affecting the aortic valves, the mitral and tricuspid valves become sooner or later affected.

Although but one case of tricuspid stenosis associated with mitral stenosis is found by Smith in his 705 cases, Bedford Fenwick has collected a large number of cases of stenosis of the tricuspid orifice, in which the lesion was almost invariably accompanied by stenosis of the mitral orifice. Dr. Wilks regards the narrowing of the mitral orifice in these cases as secondary to that of the tricuspid, which allows only a small quantity of blood to pass into the right ventricle and lungs, in consequence of which a like small amount passes to the left heart, whence a reduction in the size of its cavities and orifices.

The relative danger of cardiac affections, beginning with the most serious, is also given by Walshe as follows:

1. Tricuspid incompetency.
2. Mitral stenosis and incompetency.
3. Aortic incompetency.
4. Pulmonary stenosis.
5. Aortic stenosis.

It will be remembered, however, that I have said that aortic regurgitation is the most irremediable of the valvular defects, at least of the more common forms, and the most serious from the standpoint of tendency to sudden death. It will be noted that no place is assigned by Walshe to simple mitral obstruction, and it is indeed difficult to assign the final position of this lesion with a good left auricle. Such cases run along for a long time, but the resulting congestion of the lung is troublesome, and invites to circumscribed pneumonias, which are of frequent occurrence.

ACUTE ENDOCARDITIS.

The two well-acknowledged forms of endocarditis, **simple** and **infectious** or ulcerative, furnish no distinctive physical signs by which they can be recognized one from the other. It is rather by the history and symptoms that such distinction is made, the almost invariable succession of the former upon rheumatism and of the latter on some coexisting infectious state being valuable aids. The evident septic character of the latter as indicated by chills, fever, and sweats is also distinctive.

Both have their most frequent site on the left side, the most vulnerable, and in the mitral leaflets. A systolic mitral murmur, in the course of a rheumatism, means almost invariably an endocarditis. The aortic leaflets may also be the seat of inflammation, though less frequently, when a basic murmur is the consequence. But not every aortic murmur in the course of rheumatism implies endocarditis, as the condition of the blood predisposes to a hæmic murmur; nor every murmur at the apex, because the state of the muscle predisposes to imperfect closure of the auriculo-ventricular orifice. Unless there has been previous valvular disease, there is no enlargement, so that neither palpation, inspection, nor percussion gives any information.

PERICARDITIS.

The only distinctive physical sign in the FIRST STAGE of pericarditis is the friction sound, described on p. 137. In addition, the impulse may be strong.

The SECOND STAGE, or that of effusion, has usually, but not always, signs discoverable to *inspection* and *palpation*. The præcordium may be bulging and the interspaces obliterated, and the impulse undulating, tumultuous, feeble, and indistinct. The præcordium may be tender to pressure. *Percussion* furnishes the most striking change. The area of dulness is enlarged, and peculiarly enlarged. It becomes rudely triangular, with the apex toward the inner end of the left clavicle, and the base as low as the 7th rib, and extending in extreme cases from nipple to nipple. Yet I have seen enlargement identical in shape and extent with this, produced by enormous hypertrophy associated with pericardial friction.

The *dorsal test* for pericardial effusion, to which attention was called by William Ewart,* consists in the recognition by percussion of a rectangular area of dulness from the 9th or 10th to the 12th rib on the left side of the median line behind. It is ascribed mainly to a displacement of the liver, due to depression of the anterior surface of the liver downward under the weight of the pericardial effusion, tilting the mass of the left

* *Brit. Med. Jour.*, March 21, 1896, and Jan. 23, 1897.

lobe backward. The test is of no value in children, in whom the dull patch is normally present, as here the liver is large and the thorax is short. The same normal dulness is present in wasted adults and also invalidates the test in them. Instances are met in cases of phthisis with enlarged liver. The same condition is possible in the emaciated person of the convalescent from typhoid fever.

Auscultation confirms palpation ; the impulse is feeble, indistinct, and often tumultuous. The heart-sounds are indistinct and best heard at the top of the sternum.

The THIRD STAGE consists in a gradual return to the normal state of affairs, which may be by the intermediation of a *friction redux* or not. Adhesions may result between the heart and the sac, embarrassing its movements permanently, and producing retraction of the chest-wall with systole. On the other hand, necropsy has often revealed close adhesions between the heart and the pericardium which were not suspected during life. Permanent roughening by organization in chronic pericarditis may produce permanent friction sound.

Hydropericardium, as a part of a general dropsy, is a rare condition, and furnishes the same physical signs as the inflammatory effusion.

DISEASES OF THE MYOCARDIUM.

The heart is subject to alterations in its muscular substance independent of valvular defect. Simple hypertrophy, dilatation, fatty infiltration, and fatty metamorphosis, or true fatty degeneration, are the most important.

Myositis, abscesses, and aneurisms of the walls of the heart are such rare conditions that they need only to be mentioned in passing, especially as there is no way to recognize them before death.

Hypertrophy of the left ventricle, without valvular disease, is always the result of obstruction to the movement of the blood through the aorta beyond the valves, or to some demand for compensation. The most common remote cause is chronic Bright's disease. Any variety of chronic Bright's disease may cause it, but it is most frequently associated with chronic interstitial nephritis. We have nothing to do here with the mechanism of its production, except to say that it has always seemed to me to be in some degree compensatory. Arterial sclerosis (atheroma) and aneurism of the aorta are attended by less degrees of hypertrophy, also compensatory, because of the loss of the elastic force in the arteries, requiring additional power on the part of the heart muscle. Excessive, long-continued muscular exertion and excessive liquid ingestion may produce it—the *beer heart.*

Inspection and *palpation* furnish much the same information as in hypertrophy of the left ventricle from valvular disease. *Percussion* shows enlargement to the left and downward. To *auscultation* there is no murmur, but a distinctive intensification of the aortic second sound is heard, quite characteristic, and itself of great diagnostic value. The first sound, while louder, is also duller, more prolonged, and diffuse, qualities which sometimes suggest a systolic mitral murmur which is not present.

Pure hypertrophy of the right ventricle occurs as the result of emphysema of the lungs, and sometimes, to a less degree, of fibroid disease of the same organs, compression of the lungs by pleural effusion or adhesion, or of any cause which resists the movement of the blood from the right heart. We have here the signs of enlargement in the direction of the right heart, also without murmur, but with sharp accentuation of the second sound at the pulmonary interspace to the left of the sternum.

General hypertrophy or physiological hypertrophy or symmetrical hypertrophy of both sides of the heart may be brought about by severe muscular exercise, demanding extra nourishment. Exophthalmic goitre is often accompanied by the same condition, due to over-nourishment, the result of vaso-dilator influence on the blood-vessels.

Dilatation of the heart, either of its right or left ventricle, may occur independently of valvular disease. A heart cavity is said to be dilated when it is enlarged out of all proportion to the thickness of its walls, even though the latter may be somewhat thicker than normal. Commonly, however, the walls are thinner or no thicker than in health, and when the muscular wall is thickened while the cavity is enlarged we commonly speak of the condition as **hypertrophy with dilatation.** The term **simple dilatation** is used to indicate undue enlargement of the cavity while the walls remain of normal thickness; **attenuated dilatation** where the walls are thinned. Dilatation in chronic cardiac disease is commonly associated with fatty degeneration, but it is hardly likely that there is fatty degeneration in acute dilatation, else recovery which occurs would hardly be possible.

Dilatation without valvular disease occurs rapidly and slowly: Rapidly in connection with grave cases of the acute infectious diseases attended with degeneration of the muscular substance of the heart. Such are typhus fever, typhoid fever, scarlet fever, smallpox, acute rheumatism, and infectious endocarditis. More slowly in connection with vesicular emphysema, when, of course, it is in the right heart, and succeeds hypertrophy. Tobacco and alcohol are conspicuous cases of such dilatation; also insufficient food, inanition, anæmia, and old age. In like manner the hypertrophied left ventricle of chronic Bright's disease may become dilated. Whatever causes obstruction to the outward flow of blood from a ventricle may cause dilatation, which is always, however, preceded by hypertrophy. Aneurism is such a cause for the left heart.

Inspection and *palpation* discover a diffuse feeble impulse and the pulse is weak. *Percussion* elicits signs of enlargement, while *auscultation* finds the sounds generally feeble and indistinct. I speak now of dilatation without valvular disease. When valvular disease is present its signs are superadded.

Fatty infiltration or obese heart is often a part of the conditions of *general obesity* and has the same causes. It is something very different from the true fatty heart, or fatty metamorphosis, in which the muscular fasciculi are converted into granular fat. In the fatty infiltration the fat first covers the surface of the heart, then insinuates itself between the fasciculi, and although these are never themselves invaded, in extreme cases they undergo degeneration and atrophy from the pressure of the intervening fat. The heart is therefore not only embarrassed by the fat around and between its fibres, but the integrity of its essential substance may also be impaired by interference with its nutrition, and occasionally death results from sudden failure, just as in true fatty metamorphosis.

Such a heart is usually somewhat symmetrically enlarged, but the heart-sounds are feeble and indistinct, and the same is true of the impulse. There are, of course, no murmurs unless the condition be complicated with valvular disease.

Its recognition is based chiefly on the association of the symptoms of cardiac weakness with general obesity.

True fatty metamorphosis consists in an actual substitution, to a greater or less extent, of the muscular substance of the heart by granular fat. It is constantly associated with dilatation of the heart. Such a heart muscle is soft and flabby, and its contraction power is greatly impaired.

The *physical signs* of such a condition are not at all distinctive. There is feebleness of sounds and impulse. The latter as well as the pulse may even be inappreciable. There may be some enlargement of the heart, the result of dilatation of the soft and yielding muscle. Nor is there murmur unless there be valvular disease.

It is rather by watching a case over a considerable period of time that the truth is arrived at. Treatment is without result, and its total inefficiency is an aid in diagnosis. Fainting is frequent and sudden death the usual termination.

Acute myocarditis associated with acute rheumatism or fever may be a cause of fatty degeneration, but there is no way of determining with certainty its presence. It may be suspected when, along with, or subsequent to, intense rheumatic fever, there is evidence of heart failure.

Myocarditis—Fibroid Heart. Slight degrees occasion no symptoms, while autopsies even disclose advanced stages of indurative myocarditis which were not suspected. In consequence of the frequent association of endocarditis and pericarditis with myocarditis, the symptoms of these diseases often mask the distinctive symptoms of the fibroid change. Unmasked, the symptoms are, in a word, those of dilatation of the heart, including dyspnœa, palpitation, small, frequent, and irregular pulse, præcordial oppression or attacks of faintness, and, finally, venous stasis with cyanosis, œdema, and congestion of the liver, stomach, and kidneys, feeble digestion, and scanty urine. These symptoms may set in gradually or suddenly. On such a heart digitalis and other heart tonics are without effect. A persistently slow pulse is an occasional symptom. Angina pectoris may also be a symptom of indurative myocarditis, though it also occurs in other cardiac diseases, especially aortic stenosis.

Physical Signs.—Physical examination recognizes a feeble impulse and on percussion enlargement of the heart—dilatation. The first sound lacks its muscular element and is more like the second, more purely valvular, and therefore short. Both maintain for a time considerable distinctness but ultimately grow feeble. Occasionally there is a mitral murmur, which may be functional and transitory, or permanent. This is explained by the experiments of Ludwig and Hesse, confirmed by Krehl, which go to show that a certain integrity of the muscles about the mitral orifice or of the papillary muscles is necessary to a complete closure of the latter. Such integrity is impaired by myocarditis, and the resulting murmurs increase the difficulties of diagnosis. There is, however, usually absence of accentuation of the pulmonic second sound characteristic of mitral regurgitation, though this may also be relatively present if the right ventricle happens to be less severely involved. The second sound is also sometimes reduplicated. The mitral murmur in the fibroid heart is more variable, more subject to intermissions, than that of mitral regurgitation. The sudden addition of a mitral systolic murmur in a fibroid heart previously without a murmur may be due to a lacerated valve.

Prolonged study of the case is often necessary before a diagnosis is possible. For the most part we are compelled to rely on the absence of the symptoms and signs of valvular disease and the presence of the symptoms of dilatation, the evidences of arterio-sclerosis elsewhere, a persistently slow pulse, angina pectoris, the history of syphilis and of other causes, together with the age of the patient. Where the fibroid condition is associated with murmurs, the diagnosis is still more difficult, and must, indeed, be a matter of probability if even suggested, so much more likely are the signs to be interpreted as those of valvular disease alone.

THORACIC ANEURISM.

Thoracic aneurism occurs in the ascending, transverse, and descending portions of the arch of the aorta, and in the thoracic aorta below the arch. The greater frequency of aneurism in the male sex and during early middle life may be mentioned.

The pressure symptoms of thoracic aneurism are so important, so frequently precede the physical signs, and so frequently are necessary to a correct diagnosis, that their consideration is indispensable and will be added after a study of the physical signs.

Physical Signs of Aneurism of the Arch.

Inspection does not always discover changes, but if the sac grows outwardly, sooner or later a **prominence** thus makes its appearance; to the right of the sternum the sac is in the ascending limb, possibly raising a rib or the end of the clavicle; above and behind the sternum, if in the transverse portion, raising the manubrium or boring its way through it; and to the left of the sternum if in the descending limb of the arch. Such a tumor may **pulsate** visibly or not. The aeurism is, as it were, a rudimental heart, dilating with every jet of blood that is shot into it so long as the wall is yielding, and contracting on the withdrawal of the intravascular pressure. Should these qualities be lost, either as the result of calcification or the deposit within the sac of successive layers of coagulum, such dilatation becomes impossible, and pulsation docs not occur. The pulsation is, however, of great importance in diagnosis. When present it is synchronous with the systole of the ventricles. *The heart* itself is sometimes *displaced downward*, as may be recognized by the lowering of the apex.

If the aeurismal tumor press upon the great veins of the neck there may be **venous engorgement** on one side of the neck or both, according as the innominate vein of one side only is compressed or the descending cava itself.

Palpation also appreciates the **impulse** of the aneurism, sometimes even when it is not visible. This beating is somewhat peculiar, being *expansile*, and by this peculiarity differs from the rising of a tumor over a pulsating blood-vessel. A **thrill** is also often felt, a vibration in the walls of the sac caused by the whirl of the blood into it. It is by no means, however, invariable, and it may come and go.

Percussion over the swelling of an aneurism invariably elicits **dulness**, varying greatly in extent. On the other hand, the adjacent lung may be compressed by an aneurismal tumor, and the area of dulness thus extended beyond the tumor itself. In the absence of swelling there may be no impairment of resonance.

Auscultation is no exception, as compared with the other modes of physical investigation, in the inconstancy of its results, sometimes furnishing the most distinctive signs, while at others it is totally negative. The **murmur** or **bruit** heard over an aneurism is various. Sometimes it is double, like the sounds of the heart, the first intense and prolonged, the second fainter and shorter. Sometimes but one murmur is produced, systolic, corresponding with the first sound over the ventricles, but more intense; more rarely it is diastolic only. More frequent than either systolic or diastolic is the combined or double murmur, both systolic and diastolic. It varies greatly, being sometimes rough, sometimes soft, sometimes musical. The murmur is, however, often absent. The mechanism of these sounds is not settled. The systolic is most easily explained. There can be little doubt that it is produced by the entrance of blood into the sac. When the aneurism is at the beginning of the aorta, the diastolic murmur will probably be an aortic regurgitant murmur, due to stretching apart of the aortic valves. When the aneurism is distant from the aortic orifice, the diastolic murmur may be due to the elastic recoil of the aneurismal sac propelling the blood through the sac with additional force. Rarely there is a diastolic murmur only, probably thus caused.

But any one or all of these signs may be wanting. Particularly is this the case where the aneurism occurs just after the aorta has left the heart. The most valuable are the pulsation, distinct and separate from that of the heart, and the sounds, separate and distinct from those of the heart, or, as graphically put by Da Costa, "two hearts, apparently, each with its own distinct beat, its own distinct sounds." *

Pressure Symptoms.—Not only may all these signs be wanting, but identical murmurs may be produced by double aortic disease, *i. e.*, aortic stenosis with regurgitation, and I have known a case to be diagnosed as double aortic disease after weeks of study, when the autopsy disclosed an aneurism of the ascending limb of the arch of the aorta. It is most important, therefore, to place alongside of these the so-called pressure signs of aneurism, some of which often precede the physical signs.

The first of these is *pain*, which may be sharp and acute when nerves are directly involved, or dull and boring when the result of pressure on the bone. In the latter case, too, it is localized; in the former it may extend all over the chest and down the arms, simulating that of angina pectoris. It may be unilateral. It may occur in aneurism of the ascending or descending part of the arch.

Dysphagia from pressure of the tumor on the œsophagus is also an occasional symptom.

Other signs are *alterations in the voice*, such as hoarseness, aphonia, stridor; also brassy cough, and defective

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* Op. cit., p. 451.

vocalization. Some of these symptoms may be produced by direct pressure on the trachea itself, others by pressure upon the left recurrent laryngeal nerve. A stridulous voice unaccompanied by dysphagia or aphonia was early pointed out by Tufnell, as indicating that the pressure is on the right side of the trachea and does not affect the œsophagus or recurrent laryngeal nerve. On the other hand, hoarseness, aphonia, and defective vocalization, and various degrees of paralysis of the vocal cord are due to involvement of the left recurrent laryngeal nerve, which passes round the arch of the aorta. The paralytic phenomena may be present without any other laryngeal symptoms. Hence any alteration of voice or defective vocalization in a person presenting symptoms of heart disease demands a laryngoscopic examination. Such examination may show little alteration in the position of the vocal cords in *ordinary* breathing, or the left may be a little nearer the median line. In total paralysis, which is one of abduction and adduction of the left vocal cord, this cord stands in the so-called cadaveric position, *i. e.*, midway between the position of ordinary respiration and phonation. On *deep inspiration*, however, the right vocal cord is well abducted, the left remaining quiescent. The attempt at *phonation* is more or less abortive. During it the right vocal cord may go to the median line, leaving a small opening between it and the motionless left cord, or it may even cross the line to its paralyzed neighbor.

If only the abductor twigs of the left recurrent laryngeal nerve are involved in the pressure, there ensues gradually a permanent shortening or "paralytic contraction" of the antagonistic adductors, and the paralyzed cord is drawn by this into a position of constant phonation,—that is, into the median line. The result is that the voice is natural, the paralyzed cord being in the position of adduction, while its tension is mainly regulated by the crico-thyroid which is innervated from the external branch of the superior laryngeal nerve, uninfluenced in aortic aneurism. More rarely the right nerve is involved, when the same phenomena may occur in the right vocal cord.

These events imply, of course, a functional destruction of the nerve, which may either be the result of simple pressure, which will lead sooner or later to structural degenerative change, or the latter may be due to a primary neuritis. The early stages of this, together with an associated irritation of the entire pneumogastric, may be held responsible for certain attacks of extreme *dyspnœa* sometimes experienced by subjects of aortic aneurism. Associated with the neutral degeneration may also be atrophy of the left abductor muscle—the crico-arytenoid,—while the adductors—the arytenoids—remain nearly intact. Constant dyspnœa is more likely to be due to direct compression of the trachea.

How shall these phenomena, which are, also, so much like those of a laryngitis, be interpreted as due to aneurism rather than to laryngitis, in the absence of the physical signs of aneurism?

In acute laryngitis we have often the cause—exposure to cold—to help us; in chronic we have not. In laryngitis there is more huskiness and less of stridor in the voice, nor is the cough so brassy, or the voice so uniformly changed; it is more apt to alternate with normal voice. In aneurism the voice grows progressively worse until aphonia results. The dyspnœa is more apt to be attended with wheezing, and is sometimes relieved for a time by coughing. Stokes called attention to the fact that in aneurism the stridor of the voice seems to come from the notch of the sternum rather than from the larynx itself. In aneurism the breathing is more apt to differ in the two lungs. Then we have the laryngoscopic picture. There is no swelling of the cords in aneurism, and there may be the paralytic phenomena detailed. Finally, in laryngitis there is apt to be fever.

Then there is the *tracheal tugging* of aneurism. This is a dragging downward of the larynx with each systole of the heart. The patient sits with his head slightly thrown back and the examiner, standing behind him, insinuates the ends of the fingers under the edge of the cricoid cartilage and gently holds it up, when with each impulse the larynx is pulled downward. It is said that it may be the sole sign of aneurism, and a sign, also, that the position of the aneurism is such as to involve the posterior aspect of the arch. It is said never to be present in aneurism of the innominate.

Aneurism of the arch or the aorta affects the *pulse* in distal arteries chiefly only when it involves the origin of blood-vessels leading to those arteries, as the innominate on the right and the carotid or subclavian on the left. If the right radial pulse is enfeebled or delayed, the aneurism will be on the right, involving the origin of the innominate; if on the left, involving the left carotid or subclavian. Great care should be taken in these investigations, and they should be made from the centre to the periphery; that is, the carotids, the subclavians, the brachials, and the radials should be successively examined as recommended by Sansom.

These effects are produced by the aneurismal sac, distorting and narrowing the orifice of the vessel by dragging on it; or by acting as the elastic air-chamber in a pump, diminishing thus the pulsatile force on vessels beyond it. Osler calls attention to the fact that the pulse even in the abdominal aorta and its branches may be thus obliterated by a large thoracic aneurism.

Inequality of pupils is another valuable sign of aneurism of the thoracic aorta, due to the involvement of the sympathetic, its organic or functional destruction, with resulting paralysis of the dilator fibres of the iris, which is thus given over to the control of the 3d nerve. Hence the pupil is contracted, more frequently on the left side.

Unilateral sweating is similarly caused.

Aneurism of the *descending aorta* below the arch, between it and the diaphragm, has its most constant symptom in pain—boring pain—generally due to intrusion on the vertebræ, and any persistent boring pain in this locality should suggest a thorough examination. The *bruit*, more apt to be systolic only, is often not heard, sometimes faintly. A *bulging* of the ribs in the posterior thoracic region should be sought for, and a *dullness* on percussion.

ANEURISM OF THE INNOMINATE.

This is especially indicated by its murmur, thrill,and an impulse in the vicinity of the inner end of the right clavicle, which is sometimes raised by the resulting tumor; also by the comparative absence of signs of pressure on the larynx or œsophagus. The differences in the right radial pulse alluded to are especially here present. Tracheal tugging is said never to be present in aneurism of the innominate.

ANEURISM OF THE SUBCLAVIAN.

If the subclavian is involved, the signs are further outward, on the outer side of the sterno-cleido-mastoid. To those named may be added pressure symptoms upon the subclavian vein, producing swelling of the arm and neck; upon the right recurrent laryngeal, producing defective speech and dyspnœa; on the sympathetic, producing contraction of the right pupil, and on the brachial plexus of nerves, pain. Especially would these signs point to aneurism of the subclavian if the pulse of the carotids is uninfluenced, while the right or left radial pulse is.

ANEURISM OF THE PULMONARY ARTERY.

The very rare condition of aneurism of the pulmonary artery may produce a swelling, with the other local symptoms described, to the left of the sternum, in the 2d interspace. A murmur is less constant and is not conducted into the vessels of the neck, while the superficial pressure signs are more conspicuous. There is lividity of the face and œdema, and the dyspnœa is naturally very great. There is no cough or voice alteration. It is to be remembered, too, that the swelling of an aneurism of the arch of the aorta *may* extend to the left of the sternum. A pulsating empyema in this vicinity in my experience resembled so closely a pulsating aneurism that I feared to tap it until suitable preliminary exploration was made.

PHYSICAL EXAMINATION OF THE ABDOMEN.

In mapping out the abdomen for the study of the topography of its organs it is usual to divide it as we do the thorax, by a set of lines which apportion it into nine regions. First, a line is drawn horizontally around the body at the level of the edge of the thorax; another at the level of the crest of the ilium. Then two vertical lines are drawn through the outer end of the cartilage of the 8th rib above, and the middle of Poupart's ligament below. The abdominal cavity above the line drawn around the edge of the thorax outside of the vertical lines forms the hypochondriac region, right and left—that *under the cartilages*. The intermediate region, is the epigastric. The others are sufficiently indicated in the drawing from Gray.

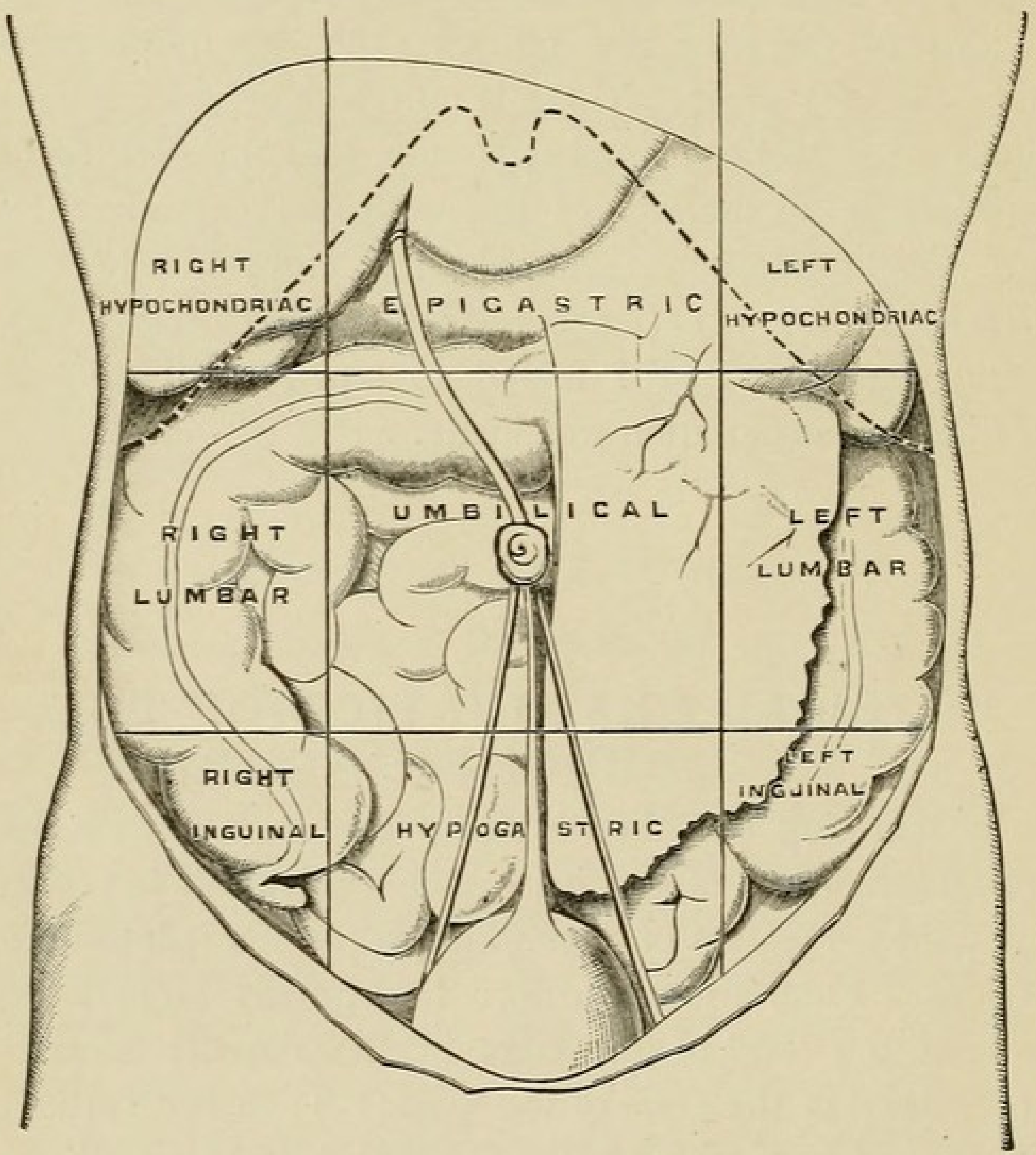


FIG. 40.—DRAWING SHOWING REGIONS OF THE ABDOMEN.—(*After Gray.*)

The following table of the viscera contained in each of the regions is from " Gray's Anatomy " :

Right Hypochondriac.	Epigastric Region.	Left Hypochondriac.
The right lobe of liver and the gall-bladder, hepatic flexure of the colon, and part of right kidney.	The middle and pyloric end of the stomach, left lobe of the liver and lobulus spigelii, the pancreas, the duodenum, parts of the kidneys, and the suprarenal capsules (aorta and branches, vena cava, semilunar ganglion, thoracic duct).	The splenic end of the stomach, the spleen and extremities of the pancreas, the splenic flexure of the colon, and part of the left kidney.
Right Lumbar.	**Umbilical Region.**	**Left Lumbar.**
Ascending colon, part of the right kidney, and some convolutions of the small intestine.	The transverse colon, part of the great omentum and mesentery, transverse part of the duodenum, and some convolutions of the jejunum and ileum, part of both kidneys (and the receptaculum chyli).	Descending colon, part of the omentum, part of the left kidney, and some convolutions of the small intestine.
Right Inguinal (Iliac).	**Hypogastric Region.**	**Left Inguinal (Iliac).**
The cæcum, appendix cæci (ureter, spermatic vessels).	Convolutions of the small intestine, the bladder in children, and in the adult if distended, and the uterus during pregnancy (often the cæcum, appendix vermiformis, and sigmoid flexure of colon).	Sigmoid flexure of the colon (ureter, spermatic vessels).

The division of the area of the abdomen into *four quadrants*, the right upper and lower and the left upper and lower, is simple, very convenient, and for most purposes sufficiently definite.

INSPECTION.

Inspection notes alterations in the shape of the abdomen from distension by gases or dropsical effusions, morbid growths, enlarged organs like the liver and spleen, pregnancy, distortions due to positions necessitated by occupation or caused by tight lacing. The abdomen of the little child and that of the man past fifty are both more protuberant than that at an intermediate age; the lower or pelvic portion of the woman is broader than that of the man. There is in nature quite a decided difference in the length of the waist or distance between the lower edge of the thorax and the crest of the ilia. Apart from the effect of tight lacing in women, there is naturally a good deal of difference in the width of their waists. In lacing, the pressure is generally brought to bear on the hypochondriac and the epigastric regions, the effect of which is to make the waist appear longer, or "wasp-like." After a full meal the upper part of the abdomen is fuller. Undue enlargement of the superficial veins is sometimes observed in inspecting the abdomen, the result of obstruction to the flow of blood in the portal vein or vena cava. Epigastric pulsation is often seen, and is commonly of no significance, though occasionally it is due to aneurism of the abdominal aorta. When the abdominal wall is very thin the outline of certain organs may be traced, and even peristaltic motions in the stomach and bowels are recognizable. Through such an abdominal wall the outline of an enormously distended stomach may even be recognized.

The patient should also be examined in the knee-elbow position, which will permit movable tumors to fall forward and facilitate their recognition by inspection as well as by palpation.

PALPATION.

Palpation of the abdomen should be practised by laying the hand flat upon the abdomen and depressing the ends of the fingers as the hand is moved about, rather than by "poking" with the fingers of the straight hand obliquely placed. The abdominal walls, too, should be relaxed by semi-flexing the thighs on the abdomen, and the legs upon the thighs. Thus we learn of the consistency and situation of various organs and abnormal growths, whether they are smooth or uneven, whether there is tenderness or tenseness. In so doing the degree of pressure must vary. Some pains are relieved by pressure, others aggravated. The former are more apt to be due to neuralgia or colic, the latter to be due to organic causes.

The presence of fluid may be settled by fluctuation, which is produced by placing the hand on one side in the flank and tapping the other side gently with the fingers, by which a wave is produced and is felt by the palpating hand. Our knowledge of the more precise situation of fluid, and even of growths, is often aided by changing the position of the patient. Circumscribed fluctuation may sometimes be detected in hyatid cysts of the liver, ovarian cysts, and rarely cystic kidneys. Sometimes a friction or roughness can be felt in connection with enlarged liver and spleen.

Under favorable circumstances the edge of the *liver* and even the end of the gall-bladder can be felt, especially if the latter is distended with bile or gall-stones, or is itself the seat of morbid growths. Especially can the liver be felt if it is much enlarged.

Only when enlarged can the *spleen* be felt downward and forward. Eichhorst gives the following directions for palpating the spleen when moderately enlarged, as in typhoid fever: Put the patient in the right diagonal position, and lay the finger gently between the anterior ends of the 11th and 12th ribs, when the enlarged spleen can be felt with almost every deep inspiration in spite of meteorism.

The *kidneys* are too deep-seated to be felt in health. When movable or floating, the right, which is that almost invariably involved, is often felt more toward the median line, below the liver, and may sometimes be recognized by its kidney shape and easy mobility, while more rarely even the beating of the renal artery can be felt. A deep inspiration will generally cause such a kidney to move downward. Enlargements of the kidney may bring the organ into such position that it can be felt anteriorly. Pressure of the normal kidney sometimes gives rise to a peculiar sickening pain like that caused by bruising the testicle.

The *pancreas* is beyond reach in health, and even when the subject of diseased enlargement, is rarely felt. Sometimes, however, between the right mammillary line and the median line and behind the edge of the liver can be felt a tumor covered by intestine, which is either the enlarged head of the pancreas or a part of the duodenum with adjacent glands, and which, if associated with *jaundice,* is likely to be a tumor or cyst of the pancreas. A tumor of the *pyloric orifice of the stomach*, also commonly higher up and more toward the median line, is characterized by its greater mobility and change of position with varying degrees of distension of the stomach. A peculiar rotary motion of such tumor is characteristic.

Only under the most unusual conditions can enlargements of the *suprarenal capsules* be felt.

Enlargements of the *mesenteric glands* are characterized by their smoothness and mobility. They differ from *fecal* tumors, which may often be felt in the right groin, by the softness and compressibility of the latter and their gradually forward motion. Only after great enlargement do the deep-seated or posterior abdominal glands come to the front, uniting with the more superficial glands to form large tumors, having communicated to them the impulse of the aorta from behind.

The *uterus* and *bladder*, always behind the pubes, when empty and normal, rise as palpable central tumors when distended by their physiological contents, whose distinctness depends largely upon the thinness of the abdominal walls, and is much more accurately investigated by percussion.

The *ovaries*, not to be felt in health, when enlarged form tumors which rise up from the pelvis into either flank, and thence toward the centre of the abdomen. When their contents are liquid, circumscribed fluctuation may be detected, although it is irregular and inconstant, and there is this difference between such liquid and liquid free in the abdominal cavity—the latter falls away into the flanks as the patient lies down, while the ovarian tumor remains central. It is to be remembered, however, that there may be tympany in the flanks even when there is abdominal dropsy, when the ascending and descending colon are distended with gas, the peritoneum covering them lining off the fluid.

These organs, the uterus and ovaries, are, however, even more satisfactorily investigated by palpation through the vagina, in the case of the uterus further aided by the uterine sound. In abdominal dropsy fluctuation may also be detected through the vagina, less commonly in ovarian cysts. In abdominal dropsy the uterus is not usually displaced unless simply prolapsed; in ovarian tumor it is apt to be displaced. The aortic impulse is sometmies conveyed to an ovarian tumor, heaving it forward with each pulse. This is not the case in an abdominal effusion.

The *rectum* may be similarly explored, the hand being sometimes carried far up into it after careful and gradual dilatation of the sphincters. Rectal exploration in this manner should, however, be cautiously carried out, as it is possible to produce rupture. This organ, as well as the uterus, is also investigated by the aid of specula, to which modern invention has added the electric light. So, too, the bladder is similarly explored.

PERCUSSION.

Much more tangible in abdominal investigation are sometimes the results of percussion. So far as the hypochondriac, epigastric, and even lumbar regions are concerned, the normal percussion phenomena have been necessarily detailed under thoracic percussion, which see.

For abdominal percussion the patient should be placed in a relaxed position, like that described for palpation. A pleximeter is here conveniently employed, and the force of the blow must be judicious in accordance with the viscera to be investigated. Thus, if studying the lower boundary of the liver or spleen, too strong a blow will bring out the tympany of adjacent gas-containing viscera, while the upper borders of these organs require strong percussion.

Percussion of the spleen requires some special consideration. Its dull sound is limited by the resonance of the adjacent lung and tympany of stomach and intestines, and at times it may even fail of detection. It may be percussed with the patient standing fully stripped or lying on the right side with the legs flexed. Pretty strong percussion should then be commenced in the midaxillary line from the axilla downward toward the crest of the ilium. At the 9th rib, usually, sometimes a little lower, in health, the dull sound comes out, associated with greater resistance. It usually continues downward as far as the 11th rib or a little below, where it is replaced by the tympany of the intestine. The anterior boundary of the spleen is determined by percussing backward of a line drawn downward from the anterior fold of the axilla. The spleen is seldom found anterior to the midaxillary line in health. Posteriorly the splenic dullness is not separable from that of the left kidney. Abnormal enlargements of the speen are downward and anteriorly and may reach colossal proportions.

The percussion borders of the *kidneys* have already been outlined on page 52.

Of the remaining abdominal organs the *stomach* and *intestines* alone approach the surface in health in such way as to make their limitation possible by percussion.

They require also some delicacy in discrimination of shades of sound, more particularly in pitch. The quality met in percussing these organs is, for the most part, tympanitic, and it is chiefly variations in the pitch of the tympany which are to be discriminated. The same organ may exhibit different degrees of pitch under different conditions. Thus, the stomach when moderately distended with gas gives a low-pitched tympanitic sound when percussed; when more distended it gives a higher pitch; when more distended still it may give a dull sound. (See p. 43.) Given the stomach and intestine in an equal degree of tension, the stomach will respond to percussion with a lower-pitched tympany than the intestine, because it is a larger cavity. This is sometimes spoken of as less tympanitic; sometimes the stomach percussion note is ringing, amphoric, echoing. By means of these differences when present we can distinguish one hollow organ from another. Again, the presence of liquids or solids in the stomach influences the percussion note.

The hollow viscera *en masse* can be mapped out by determining the boundaries of the solid viscera just described. But we want to do more than this. Below this line is the tympany of the whole abdominal cavity. We want to separate one hollow organ from another—the stomach from the small intestine, the small intestine from the large. For this the patient must be recumbent. As stated, the stomach tympany is ordinarily lower pitched than bowel tympany. Bearing this in mind, we can generally determine the stomach boundaries when the organ is not overdistended with liquid, gas, or food. The upper border of the stomach, as recognizable by percussion, corresponds with the lower edge of the liver and inner border of the spleen, as above outlined. To the left of the apex of the heart the stomach tympany is mixed with the resonance of the lung. At this point, about the 7th rib, is the cardiac end of the stomach. Percussing downward from these boundaries, we are generally able to find a difference of note—a higher pitch, a purer tympany, belonging to the transverse colon—bounded by a curved line which crosses the left edge of the thorax at about the inner end of the 10th rib, the median line just above the umbilicus, and thence upward to the edge of the liver to the right of the median line. This is the *boundary of the greater curvature of the stomach*, and includes between it and the upper border alluded to a hand-breadth space called by Traube the *half-moon space* of the stomach tympany, better termed crescentic shape. Leichtenstern has applied the name *pulmono-hepatic angle* to the point of junction between the lower edge of the left lobe of the liver and the lower border of the left lung. The tip of this angle is behind the 6th rib just below the apex seat, and is bisected by the pleural angle, which, it will be remembered, is not filled by the lung except in deep inspiration. This is the highest part of the chest-wall reached by the stomach, and it is a point pretty constantly maintained.

The half-moon tympanitic space may be converted into one of percussion dulness by filling the stomach with food, or the line of demarcation may be made more distinct by having the patient drink a glass of water just before the examination; or, as originally suggested by Frerichs, by taking in rapid succession the two portions of a Seidlitz powder,—tartaric acid and sodium bicarbonate. The gas thus liberated rapidly distends the stomach even beyond the limits described. The normal limit of the lower curvature may, however, be put above the umbilicus, although it cannot be said to be abnormally low when at the umbilicus, an event not unusual after fifty years of age. In men the greater curvature is not quite as low as in women, and in working-women not so low as in others. When the lower curvature is much below the umbilicus the stomach may be said to be dilated.

As stated, the *percussion note of the large intestine* is higher pitched and more purely tympanitic than that usual to the stomach. When containing fæces it is rendered duller, and in consequence of this fact there is often less resonance in the left iliac fossa than in the right, although fæces may also accumulate in the latter, and an impaction in the head of the colon give positive dulness. The colon may also be artificially distended with gas, for examination, if desired.

The *percussion note of the small intestine* is still higher pitched than that of the large, and by this it may be distinguished from that bowel, if not filled with solid matter or liquid. The differences in percussion note alluded to are not always equally marked, and it is not always possible, in consequence, to demark the organs.

The *bladder* is recognizable by its dull note above the pubis when distended with urine.

It remains to make some allusion to peculiarities in the percussion of **ovarian cysts** with fluid contents, as compared with dropsical effusions into the abdomen. In the former, the percussion note is dull in the central abdominal region, while in the flanks there is apt to be tympanitic percussion, from the fact that the intestines are pushed into them. With change of position, the dulness in ovarian dropsy does not change position, while in abdominal dropsies it does.

The two may, however, be combined, when the difficulty is increased, and a preliminary tapping may be necessary to settle the question.

AUSCULTATION.

Auscultation, of all the means of physical diagnosis, gives us least information in abdominal investigation. An aneurism may furnish a murmur over the aorta, and sometimes a murmur may be heard in an enlarged spleen, and even a friction sound may be heard. Borborygmi are sometimes audible at a distance; also metallic tinkling from the splashing of fluid in a distended stomach.

Certain *deglutition sounds* are described by Ewald. First there is a deglution murmur, with which all are familiar, produced by swallowing a mouthful of liquid, propagated from the pharynx into the œsophagus, and heard all along the latter tube. It has no diagnostic significance.

In addition are heard, only *near the cardia*, during deglutition, two murmurs. The best site for auscultating them is just below the xiphoid cartilage. The first, or *hissing murmur* (*Durchspritzgeräusch*), occurs almost immediately after the beginning of deglutition, and sounds as if fluid was being directly squirted through a tube containing air. The second sound, or *pressure murmur* (*Durchpressgeräusch*), is heard from six to twelve seconds later, and described by Ewald as a series of tones rapidly following one another,—either "gurgling, clucking, splashing, or sprinkling."

These two sounds alternate. The first is heard infrequently, and is said to indicate a relaxation of the cardiac orifice. The second sound is quite frequent, and is absent only when the first is heard. Its cause is not precisely determined, being ascribed by some to audible vibrations of the cardiac orifice, caused by the passage of food over it; by others to a "pressing through" of air swallowed with the food.

It is on the absence, therefore, of the second murmur that diagnostic value depends; *i. e.*, it is apt to be wanting in obstructive disease of the cardiac orifice, although too much stress must not be laid on this sign, since the murmur is not invariably present in health.

Splashing or succussion sounds are heard when the stomach is filled partly with air and partly with water. It is produced by tapping the lateral region adjacent to the stomach, and may often be produced by the patient himself by shaking the body. It is abnormal only when heard at a time when there should be no liquid in the stomach, as, for example, long after taking food. It is especially common at such time in dilatation of the stomach. A like sound may rarely be produced under like conditions in the colon.

Borborygmi, or "grumbling" noises occur in the stomach and bowels when distended with gas.

Heart sounds and breathing sounds are often intensified by a stomach distended with gas, becoming ringing or amphoric.

EXAMINATION OF BLOOD.

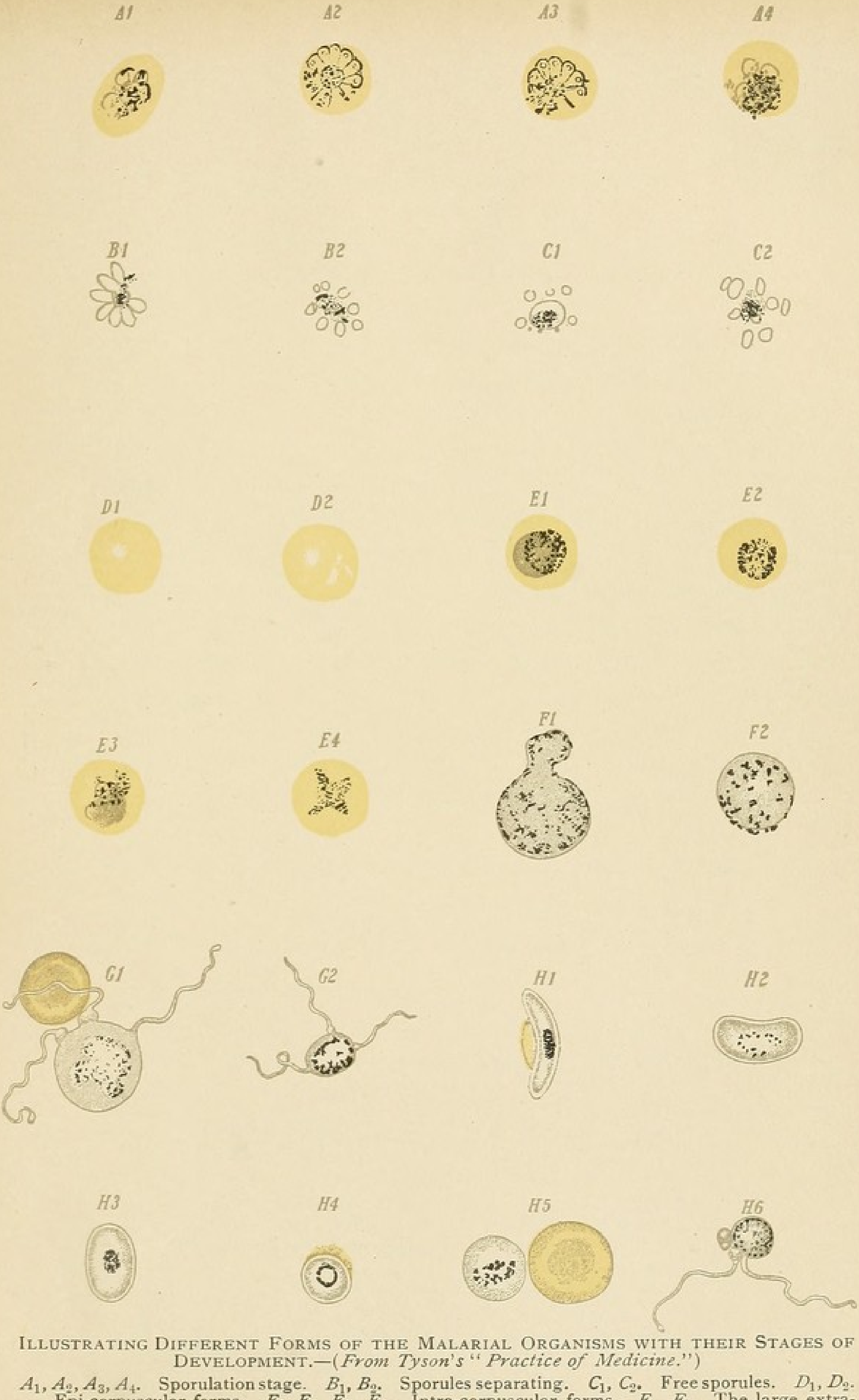
The examination of blood for ordinary purposes need include only: (1) The ordinary microscopic examination of fresh blood. (2) The counting of the corpuscles, red and white. (3) Measuring of hæmoglobin. (4) The preparation of stained films.

THE ORDINARY MICROSCOPIC EXAMINATION.

(*a*) Place a drop of blood from the cleansed finger or ear on a slide and drop the cover on without pressing. If the layer of blood be too thick, a fresh slide should be made. (*b*) Note the formation of rouleaux, less prone to occur when the number of red discs is small. (*c*) Note the leucocytes isolated in the open spaces between the rouleaux. (*d*) Note abnormality of size (*megalocytes* and *microcytes*) and shape (*poikilocytes*). The varieties of leucocytes are studied in the stained preparations to be described. (*e*) Look for abnormal elements including pigment granules, malarial organisms, filariæ. The malarial parasite requires a $\frac{1}{12}$ immersion, and the slide should be studied for at least half an hour.

THE COUNTING OF BLOOD CORPUSCLES.

Decidedly the most convenient instrument for estimating the number of corpuscles to the cubic millimeter is the cytometer of Thoma-Zeiss. The directions for its use appended are essentially those of Zeiss—the maker.



ILLUSTRATING DIFFERENT FORMS OF THE MALARIAL ORGANISMS WITH THEIR STAGES OF DEVELOPMENT.—(*From Tyson's "Practice of Medicine."*)

A_1, A_2, A_3, A_4. Sporulation stage. B_1, B_2. Sporules separating. C_1, C_2. Free sporules. D_1, D_2. Epi-corpuscular forms. E_1, E_2, E_3, E_4. Intra-corpuscular forms. F_1, F_2. The large extra-corpuscular body. G_1, G_2. The flagellate forms. H_1, H_2, H_3, H_4, H_5, H_6. The crescent-shaped parasite and its developmental changes in shape.

The apparatus consists of the following parts:

(1) A graduated pipette with india-rubber tubing and mouth-piece. (Fig. 41.)

(2) A divided cell upon an oblong slip. (Fig. 42.)

(3) A cover-glass with plane-ground surfaces.

(4) A diluting fluid. Numerous diluting fluids have been suggested. A very convenient one is a .8 per cent. solution of common salt filtered. Gowers' fluid is a very good one. It consists of sulphate of soda, 6.3 gm.; acetic acid, 3.6 gm.; distilled water, 117.0 gm.*

In order to count the *red corpuscles* of human blood, the tip of any finger, or, better, the lobe of the ear, is cleaned with water and alcohol, and then rubbed between the fingers of the other hand. A slight arterial hyperæmia will arise, so that a fairly deep puncture with a lancet-like needle is sufficient to cause a drop of blood to appear. The point of the pipette is quickly placed into it and the blood sucked in up to division 1. Then the point of the pipette is cleaned from the blood sticking to it by a cloth kept ready for the purpose, and plunged into the diluting fluid, which is sucked up into the spherical

* Toison's fluid may be used. It has the advantage of staining the white corpuscles, but it is more difficult to cleanse a tube stained with it. It is made as follows:

Distilled water,	160 c.c.
Neutral glycerine,	30 c.c.
Sodium sulphate pur.,	8 gm.
Sodium chloride,	1 gm.
Methyl-violet, 5 B,	0.025 gm.

Mix and filter before using.

enlargement of the pipette. As soon as the sphere is filled up to division 101, the sucking is discontinued and the mouth-piece of the india-rubber tube closed by putting the finger upon it. The contents of the spherical enlargement are now to be mixed by thorough shaking. Thus in this sphere 99 parts by volume of the solution are mixed with one part by volume of blood, or 100 parts by volume of the mixture contain one part by volume of blood, for the fluid in the capillary tube does not enter into the mixture.

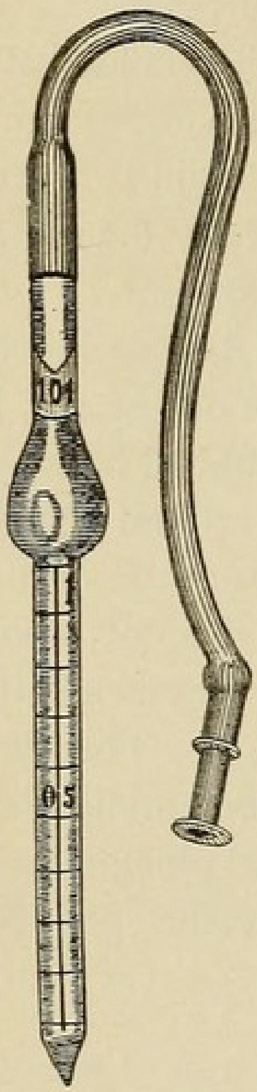


FIG. 41.—HÆMOCYTOMETER PIPETTE.—(*Thoma-Zeiss.*)

If the blood is drawn in up to a lower division, say 0.5, instead of division 1, then with the same mode of proceeding another dilution is obtained, viz., 1 : 200.

Afterward, by blowing air into the india-rubber tubing, the diluting solution is removed from the capillary part of the tube. The next drop of the mixture is emptied upon the middle of the bottom of the divided cell, after the latter has been carefully cleansed. The cover-glass is immediately placed over it, and the apparatus is transferred to the horizontal stage of the microscope and left standing quietly for some minutes, so that the blood corpuscles may settle down.

It is necessary for a successful enumeration that the divided cell and cover-glass should be thoroughly cleaned. If this is done properly the Newtonian rings will be perceived along the edge of the cover-glass as far as it rests upon the wall of the cell, and this indicates that the cover-glass lies well upon it. At the same time it must be seen that no fluid enters between the cover-glass and the wall of the cell. On the contrary, the drop of blood should be placed in the centre of the cell, and spread thence to fill up the space between the

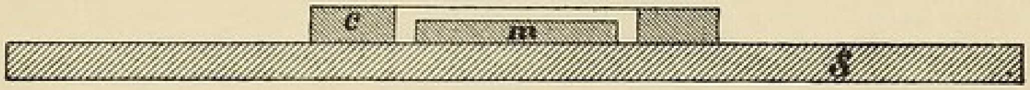


FIG. 42.—THOMA-ZEISS COUNTING SLIDE.
s. Slide *m.* Platform. *c.* Wall of trench.

cover-glass and the bottom of the cell for some square millimeters.

Special care should be taken to keep the pipette in clean condition. Every time after use it should be rinsed with (1) the diluting fluid, (2) distilled water, (3) absolute alcohol, and (4) ether. If dust or co. gulated blood should still stick to the pipette, it should be removed with strong acids or alkalies by repeated rinsings, assisted, if necessary, by a bristle.

The corpuscles may be counted by any object glass magnifying about 300 diameters.

Every fifth square of each horizontal and vertical row of squares is crossed by an additional line to facilitate the counting. Each square occupies an area of $\frac{1}{400}$

sq. mm., and above each square there is a space of $\frac{1}{4000}$ c. mm., since the distance of the bottom of the cell from the lower surface of the cover-glass amounts exactly to $\frac{1}{10}$ mm. The corpuscles which first were suspended in this space have now settled and are lying on the bottom of the cell, where they may be counted The corpuscles lying upon the lines should be counted, but, of course, only once. Thus, all corpuscles lying on the

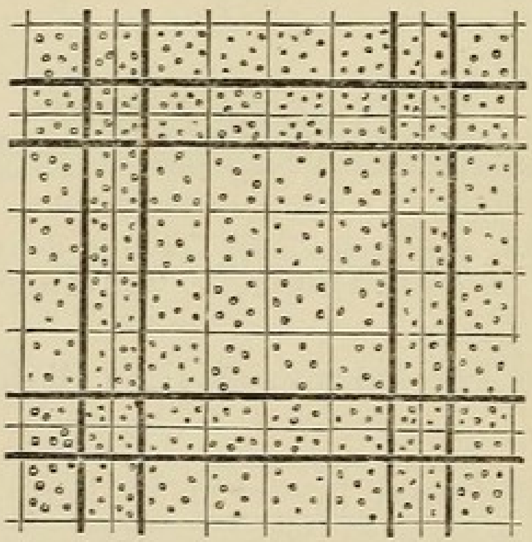


FIG. 43.—GROUP OF 16 SMALL SQUARES, each of a capacity of $\frac{1}{4000}$ c. mm. making one large square of the Thoma-Zeiss cytometer, magnified.

horizontal lines should be counted in the squares above them, and all corpuscles lying on the vertical lines should be counted in the squares to the right of them.

The calculation is as follows: If by a dilution of the blood in the proportion of 1 : *a*, *z* corpuscles have been counted in *n* squares, then

$$1 \text{ c. mm. of undiluted blood} = 4000 \times \frac{a \times z}{n} \text{ blood corpuscles.}$$

If, for example, by a dilution of the blood in the proportion of 1 : 100, as we supposed above, in 200 squares altogether 2570 red blood corpuscles were found, then the calculation will give for 1 c. mm. of blood—

$$\frac{4000 \times 100 \times 2570}{200} = 5,140,000 \text{ blood corpuscles.}$$

For counting the *white blood corpuscles* a pipette should be used which allows a dilution in the propor-

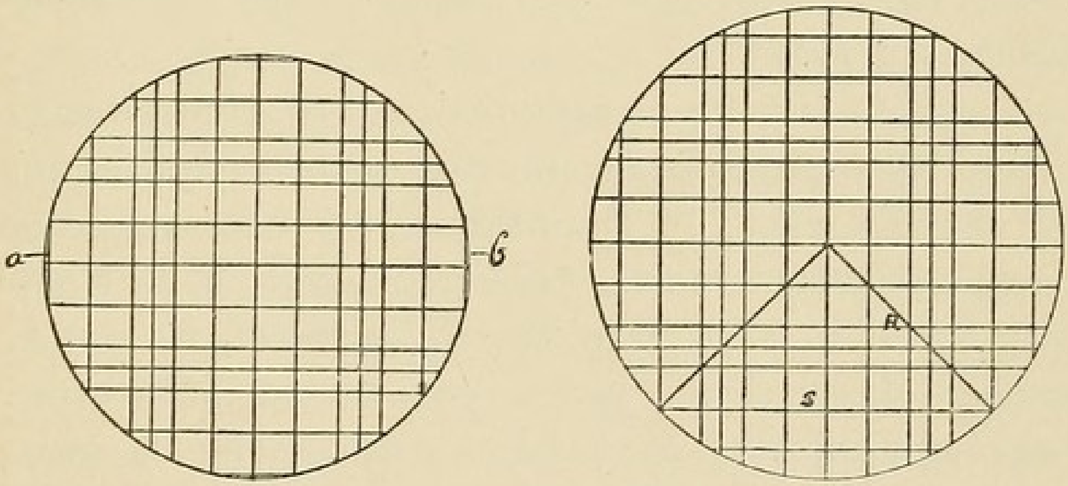


FIG. 44.—THOMA-ZEISS RULED SLIDE, focussed for 10 and 12 squares to cover exactly the field of view of the microscope.

tion of 1 : 10, or 1 : 20, and instead of the salt solution an aqueous .5 per cent. solution of acetic acid, to which may be added a little methyl-violet, should be chosen for diluting. The red corpuscles will disappear in this fluid, but the white ones will remain and are easily counted. The easiest method of calculation is to determine the cubic contents of the space covered by the field of the microscope and to count the leucocytes in a large number of such fields. Move the tube of the microscope up and down until one of the parallel lines of the ruled slide corresponds with the edge of the circular field of vision, as at *a*, *b* (Fig. 44). Then, as each square is $\frac{1}{20}$ mm. wide, the whole diameter of the field equals $\frac{1}{20}$ multiplied by the number of squares included between the parallel lines. Thus if the number be 10, the diameter is $\frac{10}{20}$ or $\frac{1}{2}$ mm., the radius $\frac{1}{4}$, and the area of the circle $(\frac{1}{4})^2 \times 3.1416$; the cubic contents $(\frac{1}{4})^2$ or $\frac{1}{16} \times 3.1416 \times \frac{1}{10}$, ($\frac{1}{10}$ mm., being the depth of the space); *i. e.*, $\frac{3.1416}{160} = \frac{1}{51}$ c. mm. = the capacity of the field of vision.

A number of fields are connted, say 10, containing in all 200 leucocytes, making the average of each field 20. But as the capacity of one field is $\frac{1}{51}$ c. mm., an entire c. mm. would contain $10 \times 51 = 510$. Now, as the blood is supposed to have been diluted 20 times, the actual number of leucocytes per c. mm. would be 10,200. Hence, for a field of 10 squares, 10 fields being counted, we need simply to multiply the average of one field by 51 and 20, or 1020. Calculations for fields of five, six, or any convenient number of squares may be made.

Studies by Thoma and others, with a view to determining possible errors with the instrument whose use has thus been described, go to show the constant errors to be insignificant, less than one per cent., while the accidental and variable errors, which are unavoidable, diminish with the number of corpuscles counted. Thus, by counting 200 red corpuscles they amount to five per cent. of the total result, by counting—

1,250	corpuscles	amount to	2	per cent.	of	the	total.
5,000	"	"	1	"	"	"	"
20,000	"	"	½	"	"	"	"

At least four sets of 16, or 64 squares, should be counted in estimating red corpuscles. To count the whole 256 such squares takes about one-half hour, and usually means from 1200 to 1500 corpuscles.

Estimating the Corpuscles by the Centrifuge.

In 1885, Professor Blix, of Upsala, Sweden, suggested the use of centrifugal force in estimating the volume of red blood corpuscles, and Dr. S. G. Heden has devised an instrument called the *hæmatokrit* for this purpose. Dr. Judson Daland has further improved this instrument so that after the blood, diluted with an equal bulk of a 2.5 per cent. solution of bichromate of potash, has received the requisite amount of rotation, the percentage *volume* of red corpuscles may be read off from the cylindrical tubes in which the blood is placed, and from this deduced the *number* in each cubic millimeter by simply adding five ciphers to the reading.

Dr. Daland regards the hæmatokrit as both more speedy and more accurate than the cytometer, basing his conclusions on a very large number of comparative observations. He used also a great variety of fluids for dilution, and concluded that the 2.5 per cent. solution of bichromate of potash is, for many reasons, the best. The hæmatokrit also enables one to measure the volume of colorless blood corpuscles, but no method has yet been devised for calculating their number.

TO MEASURE HÆMOGLOBIN.

Such estimation is, of course, approximate. The best instrument for this purpose is the hæmoglobinometer

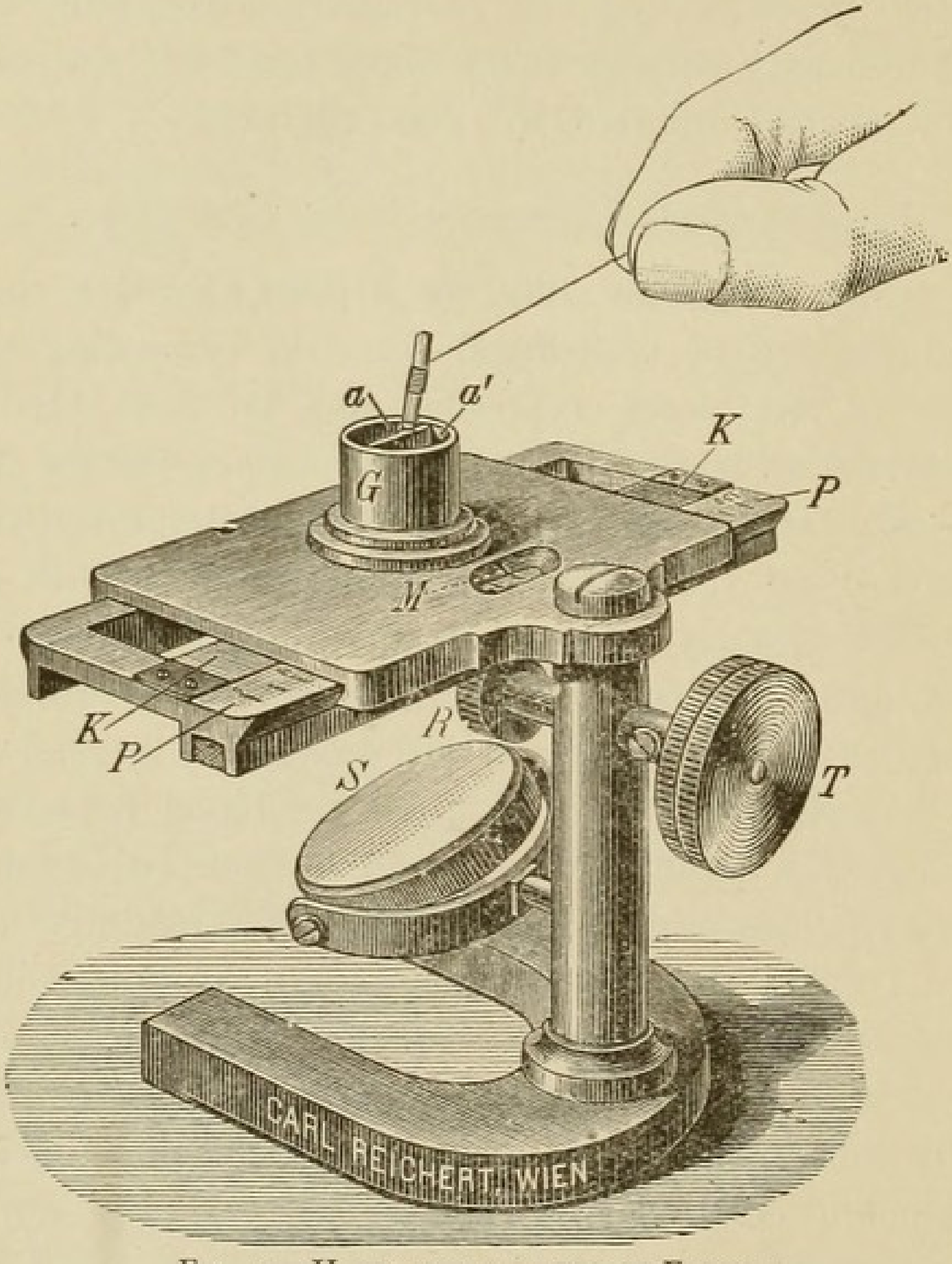


FIG. 45.—HÆMOGLOBINOMETER OF FLEISCHL.

of Fleischl. It consists of a stage perforated by a central opening, below which is a gypsum reflector, *S*, by which the light from a candle may be thrown directly into the opening. Into the latter is fitted a cylinder, *G*, divided by a partition into two equal parts, one-half *a*, being over the unobstructed opening, the other, *a'*, over a wedge-shaped piece of glass interposed between it and the opening. The glass is colored with Cassius' gold purple, and presents, of course, a gradually increasing depth of color in passing from the thinner to the thicker end. The wedge of glass is movable by a rack and pinion alongside of a scale graduated in 100 equal parts, of which the figure 100 corresponds with the depth of color of a mixture of normal blood, and lower figures correspond with that of thinner blood. The examination should be made in a cool, dark room.

To use the instrument each demi-cylinder is filled with water, and into the one *a*, opposite the *unobstructed* opening is put a quantity of blood, measured in the little cylinder shown in the cut. In order to prevent oxidation, the mixing vessel should be covered with the round cover-glass supplied with the hæmometer. It should be applied from that side containing the water. If applied from the other side some of the blood might be carried into the clear water and thus spoil the examination. The wedge of glass is then moved along by the milled head, *T*, until the color of the blood solution exactly coincides with the color of the opposite half cylinder containing water only, but placed over the colored glass. The figure attained on the scale when the shades are identical indicates the percentage of hæmoglobin. In point of fact, it rarely happens that a normal blood exceeds ninety per cent., a fact which should be borne in mind.

Dr. Daland has suggested covering the entire cylinder when ready for use by a cap containing a central slit ¼ inch (6 mm.) wide over the centre, through which the examination can be made with greater facility than with the entire cylinder exposed.

PREPARATION OF STAINED FILMS.

The staining of the blood preparations for clinical purposes may be rapidly performed by the following methods:

Blood films are prepared by cleansing the finger or the lobe of the ear carefully with alcohol; pricking it gently, wiping away the first few drops that emerge, and then touching the top of a small drop with a clean cover-glass, placing upon another equally clean cover-glass and sliding the two apart. The film dries in the air quickly and may be kept indefinitely. Fixation may be accomplished by immersing the cover-glass in a mixture of equal parts of absolute alcohol and ether, for from three minutes to one-half hour. In rapid clinical work staining with eosin and hæmatoxylin gives satisfactory pictures of the morphology of the corpuscles. The cover-glass fixed and dried is stained with a one per cent. solution of eosin (soluble in water) in sixty per cent. alcohol for one or two minutes. It is then counter-

FIG. 1.

Fig. 1.—Normal Blood. Fixed by heating, stained with Erlich's triple stain.

a. Normal polymorphous leucocytes.
b. Lymphocyte.
c. Large mononuclear leucocyte.
d. Eosinophile.
e. Red Corpuscles.

FIG. 2.

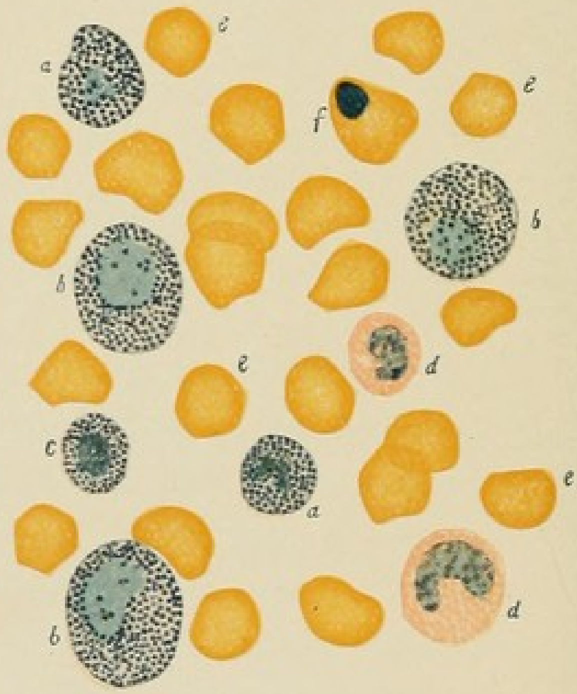


Fig. 2.—Lieno Medullary Leukæmia. Fixed by heating, stained with Erlich's acid fuchsin, methyl green, orange G mixture.

a. Normal polymorphous leucocytes.
b. Erlich's myelocyte, neutrophilic.
c. Small myelocyte.
d. Eosinophile.
e. Red Corpuscles.
f. Nucleated red corpuscle.

FIG. 3.

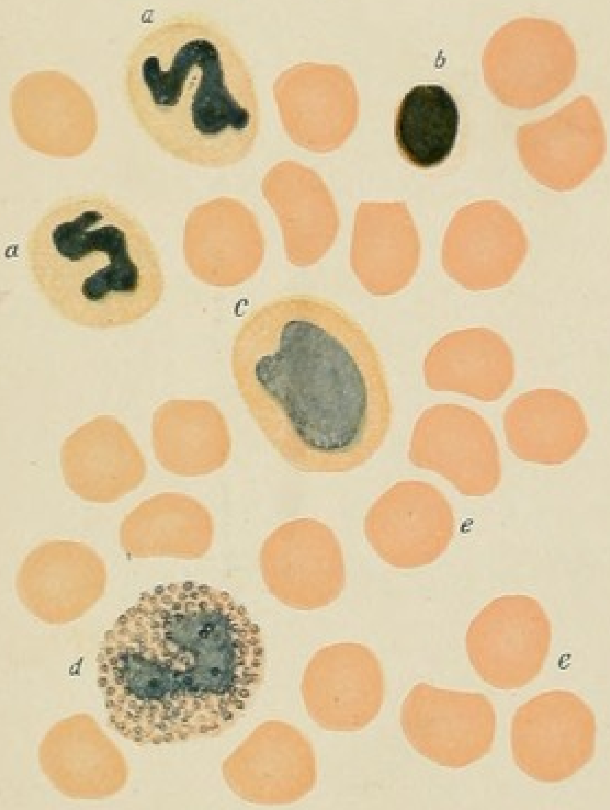


Fig. 3.—Normal Blood. Fixed in absolute alcohol-ether, stained with Eosin and Hematoxylin.

a. Polymorphous leucocytes.
b. Lymphocyte.
c. Large mononuclear leucocyte.
d. Eosinophile.
e. Red Corpuscles.

stained with Delafield's * hæmatoxylin for from one-half to one minute. The specimen is then washed, dried, and mounted. The red corpuscles take the eosin (pink) as do also the eosinophile granules, but nuclei of the white corpuscles are stained blue with the hæmatoxylin.

Simultaneous staining and counterstaining may be obtained by Gollasch's mixture:

Eosin,	0.5
Hæmatoxylin,	2.0
Glycerine,	
Distilled water,	
Absolute alcohol, of each,	100.0
Glacial acetic acid,	10.0
Alum—slight excess.	

This solution requires several weeks for ripening. The blood films after fixation are stained for several minutes and then washed, dried, and mounted.

For the demonstration of the eosinophilic and

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* *Delafield's Hæmatoxylin* is made of hæmatoxylin crystals, 4 grams; 95 per cent. alcohol, 25 c. c.; saturated aqueous solution of ammonia alum, 400 c. c.

Add the hæmatoxylin dissolved in the alcohol to the alum solution, and expose the mixture in an unstoppered bottle to the light and air for from three to four days. Filter and add glycerine, 100 c. c.; 95 per cent. alcohol, 100 c. c.

Allow the solution to stand in the light until sufficiently dark, then filter and keep in a tightly stoppered bottle. It keeps well and maintains a purplish tinge as long as it is good.

neutrophilic granulations as well as the general morphology, Ehrlich's triple stain is used. This consists of—

Saturated aqueous solution			orange G., . .	120 to 135
"	"	"	acid fuchsin, .	80 to 165
"	"	"	methyl-green,	125

Add—

Water, ...	300
Absolute alcohol, ...	200
Glycerine, ...	100

Frequently a little more methyl-green is required, and the solution must generally be tested and corrected by the addition of one or other stain after each preparation.

Staining with the triple stain is most satisfactory after previous heating of the blood films for fixation; they may be baked in a hot oven at 110° or 120° C. for an hour, or with some experience the heating is readily carried out by passing the specimen through the flame, as in staining sputum.

The Widal Test for Typhoid Fever.—This depends on the power inherent in the serum of a person who has had typhoid fever a variable but generally short time, of causing living typhoid bacilli to cease their active movements, and to form clumps. These changes take place in from a few minutes to an hour after the contact has been brought about.

The test is practised as follows: The finger or ear lobe is thoroughly sterilized and punctured with a sterile lancet, and the blood drawn into a sterilized pipette, which is then sealed up. A drop of dilute bouillon culture of typhoid bacilli, not more than twenty-four hours old, is placed on a sterilized slide. To this add a minute quantity of the serum from the pipette, mix rapidly, apply the sterilized cover-glass and press it gently to obtain a uniform film, and examine with a power of 300 to 400 diameters. Uninfluenced by the specific serum the bacilli maintain active movement for a long time—days if the specimen be properly prepared—and exhibit no tendency to form clumps. Under the influence of the typhoid serum the movement promptly ceases and the clump formation takes place. The reaction is more frequent after the first week, but may take place as early as the third or fourth day.

Instead of the serum a drop of dried blood may be mixed with distilled water and used instead of serum with the same result. The bacillus culture is commonly obtained from the spleen of one dead of typhoid.

EXAMINATION OF SPUTUM.

The coarse examination of sputum includes the coarser examination for quantity, color, consistence, shape, and odor. The minute examination seeks bacilli, cellular elements, including blood and eosinophile cells, elastic fibres, Curschmann's spirals, and Charcot-Leyden crystals.

The *eosinophile cells* are large and contain numerous fine granules stainable with eosin. They are often found in asthma, where they may be associated with Charcot-Leyden crystals, minute acicular or spindle-shaped bodies.

Curschmann's spirals also occur in the sputum of asthma. They are large enough to be seen by the naked eye, looking like sago grains. When unrolled they appear as convoluted threads which may be an inch long. Under the microscope they are found made of a central thread, about which clings a coating of tough mucus containing mucous corpuscles.

Previous to the discovery of the tubercle bacillus, *elastic fibres* were the most distinctive objects found in sputum. They are found where there has been breaking down of the lung from gangrene, tuberculosis, or abscess. They are best sought by boiling suspected sputum with several times its bulk of liquor sodæ, or potassæ, by which the former is thinned and the fibres fall to the bottom of the test-tube or conical glass, whence they may be raised with a pipette. Good examples furnish circular forms derived from the alveoli of the lungs.

STAINING OF TUBERCLE BACILLI.

Of the various methods of staining tubercle bacilli that by the *carbol fuchsin* solution of Ziehl-Neelsen, with or without *Gabbett's* counter-stain of methyl blue, appears to stand the test of time as well, if not better than any other. By this method the bacillus takes a bright red color from the fuchsin, the mordant being carbolic acid.

The *carbol-fuchsin solution* is made as follows:

Powdered fuchsin, ...	1 part
Alcohol, ...	10 parts
Five per cent. solution carbolic acid, . . .	100 parts

Mix and filter.

The *older* the solution the better.

Two methods are practised with this staining fluid, a rapid and a slow, the former being more commonly practised for diagnostic purposes.

1. *The rapid method with carbol-fuchsin without or with counter-stain by methylene blue.* A very small clump of the moist solid part of the sputum mass is selected and brought with forceps or platinum loop on a clean cover-glass. Upon this another cover-glass is superimposed and the two are pressed and rubbed over each other until the specimen is thoroughly smeared over both. They are then separated and two specimens are thus obtained. When dry, one of these covers is passed, specimen side up, three times slowly over the flame of a spirit lamp or Bunsen burner, by which the albumin

is coagulated and the specimen fixed. The specimen is then completely covered with the staining fluid and held over the flame until the solution begins to vaporize, care being taken to keep all parts of the glass thoroughly covered with the stain, but not allowed to boil. This is kept up for one minute, when it is washed in water for two or three seconds. It is then decolorized in acidulated alcohol, eight or ten drops of HCl or five drops HNO_3 to a watch crystal of alcohol, and examined in the latter solution, by a one-twelfth oil-immersion and Abbé's condenser, although a little experience with a dry lens of 350 diameters or higher will soon lead to the recognition of the bacilli, which are stained a handsome red.

The preparation is more brilliant and its study rather less trying to the eyes if *counter-stained* by Gabbett's acid blue, composed of—

Methylene blue, ...	2 parts
Twenty-five per cent. solution sulphuric acid,	100 parts

After being washed in water, the specimen is immersed for about thirty seconds in the acid blue, washed off in water, dried between filtering paper, and examined in water.

2. *Slower method with carbol-fuchsin, and counter-stain with Gabbett's acid blue.* This slower method is always more satisfactory if time permits, and should alone be used for permanent preparations.

The steps are the same until the staining stage is reached, when the cover-glasses containing the specimen are placed in the carbol-fuchsin solution, say at five or six o'clock in the evening, and allowed to remain until next morning. They are then washed in water, counter-stained by Gabbett's acid-blue solution, again washed in water, dried between filtering paper, and studied in water, or if it is desired to mount the specimen permanently, it is passed through alcohol or xylol into Canada balsam. Oil of cloves should not be used for clearing, as it sometimes declorizes the stained specimen. Nor should specimens stained in aniline colors be mounted in glycerin, as this gradually withdraws the stain.

The bacillus may be stained by Gram's method. *Sections* are treated similarly by the slow method and mounted in balsam.

Dr. C. W. Purdy has devised a "beater" with which to beat up the sputum mixed in a two-ounce glass graduate with equal parts of a three per cent. salt solution for a moment or two, after which he puts the fluid into the centrifuge. The sediment thus obtained is then stained and studied.

THE PNEUMOCOCCUS.

The *micrococcus lanceolatus* or *diplococcus pneumoniæ*, the true bacillus of pneumonia, was discovered independently by Surgeon General Sternberg, U. S. A., in 1881, and by Pasteur somewhat later. The latter was the first to publish an account of it. Neither appreciated its relation to croupous pneumonia. This Talamon first asserted in 1883. The subject was first satisfactorily cleared up by Fraenkel and Weichselbaum in 1886, whence it is also associated with their names.

The *pneumococcus* is characterized by its lance-shape and capsulation as found in tissues and sputum. In cultures it is without capsule. Found most frequently in the lung in croupous pneumonia, it also occurs in the sputum of pneumonia, in fresh endocardial vegetations, and the pus of cerebro-spinal meningitis. It usually occurs in pairs—diplococci—sometimes in filaments of three or four elements.

The simplest extemporaneous stain is the carbol-fuchsin solution (p. 227). An immersion of a few minutes usually suffices, when the coccus itself will have become intensely red, while the capsule has assumed a light reddish tint. The capsule may also be stained in the same way as that of Friedländer's bacillus described below.

The *diplococcus pneumoniæ may also be stained by Gram's method*, as follows:

1. The cover-glass preparation is placed for from two to five minutes in warm *Ehrlich-Weigert's* saturated aniline solution of gentian violet.*

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* Aniline oil, ... 4 parts
Distilled water, ... 100 parts
Shake, filter through moist filter and then add—Saturated alcoholic solution (stain, 10 grams; absolute alcohol, 40 grams), gentian violet, or methyl-blue, ... 11 parts
Filter.

2. Transfer directly without washing into Gram's solution (iodine, 1, iodide of potass. 2, water 300) for from two to three minutes, where it becomes quite black.

3. Wash in absolute alcohol until the primary black color becomes pale gray. All the cellular elements are decolorized except the micro-organism, which has assumed a deep blackish blue.

4. Mount in Canada balsam.

This method is particularly valuable in the differential diagnosis between the diplococcus and the—

Pneumo-bacillus of Friedländer.—This bacillus is oval, encapsulated, and occurs, also, in pairs, and is sometimes found in the lung of croupous pneumonia.

It is also stainable in aqueous staining solutions as the bacillus of Fraenkel-Weichselbaum, the capsule remaining unstained. *It cannot be stained by Gram's method.*

To stain the *capsule* in cover-glass preparations, Friedländer directs:

1. The prepared cover-glass, drawn three times through the flame, is placed in one per cent. acetic acid solution for two minutes.

2. Remove the acetic acid by blowing on the cover-glass through a pointed glass tube, and allow to dry in the air.

3. Stain for ten seconds in saturated aniline-water-gentian-violet solution.

4. Wash in water, dry between filter paper, mount in balsam.

For sections:

1. Stain for twenty-four hours in warmth in a solu-

tion composed of concentrated * alcoholic gentian-violet solution 50, distilled water 100, glacial acetic acid 10.

2. Wash in one per cent. acetic acid solution.

3. In alcohol to dehydrate.

4. Mount in balsam.

Bacillus of Diphtheria.—The short curved bacillus assigned by Löffler as the cause of diphtheria is well stained by Löffler's alkaline methylene blue solution of—

Concentrated alcoholic solution methyl-blue (1 : 40), ...	30 c. c.
Caustic potash (1 : 10,000), ...	100 c. c.

Another specimen should be stained by Neisser's method, which consists in staining for from one-half to one minute in a solution consisting of one gram of Grübler's methylene blue dissolved in 20 c. c. of 90 per cent. alcohol and then added to 960 c. c. of distilled water and 50 c. c. glacial acetic acid.

After staining in the blue mixture they are washed off in water, and are then stained for from three to five seconds in a solution consisting of two grams of vesuvin (Bismarck brown) dissolved in one litre of boiling distilled water and filtered. They are then again washed off in water and are ready for examination.

The object of these duplicate examinations is this: By the ordinary Löffler method of staining there are occasionally encountered micro-organisms that are mor-

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* Ten grams of the powdered dye, 40 grams absolute alcohol.

phologically strikingly suggestive of the diphtheria bacillus. When, however, these micro-organisms are subjected to the Neisser stain, the difference between them and the genuine diphtheria bacillus is, in the vast majority of instances, very manifest. This difference consists in the appearance in the true diphtheria bacillus of minute granules or spheres that take on the blue stain very heavily, looking almost black, and show very conspicuously in the brown counter-stain to which the micro-organisms have been subjected. These granules do not appear in the organisms that are not true diphtheria bacilli,—at least when they do, it is so rare as to be extremely exceptional. This method of duplicate preparation is greatly superior to the methods hitherto used, since the Neisser stain controls the ordinary examination with the Löffler stain.

The Löffler bacillus may also be stained by Gram's method (p. 230).

Slides made from the false membrane are seldom satisfactory, because it is seldom that a pure infection exists. Cultures should be made, which should be eight to fifteen hours old, and in order that the Neisser stain may give the best results, the culture should not be older nor younger than about fifteen hours, and should not have been cultivated at a greater temperature than 35° to 36° C.

The typhoid bacillus is stained by Löffler's solution. *It is not stainable by Gram's method.* It may be obtained from the spleen and from the blood in rose-colored spots.

The cholera bacillus is stained in the concentrated aqueous solutions of fuchsin ; sections by fuchsin solutions or methyl-blue. A flocculent mass from a stool is treated between glass covers and dried and fixed as in the case of sputum. *It is not stained by Gram's method.*

Bacillus of Syphilis.—*DeGiacomi's method.* The cover-glass preparations made from the pus are warmed for a few minutes in the aniline-water fuchsin solution, then washed in water to which a few drops of a chloride of iron solution have been added, and decolorized in a concentrated solution of chloride of iron. They are finally washed and studied in water. The syphilis bacillus remains red, while all other cells are decolorized. If desired to mount, dehydrate rapidly in absolute alcohol, clarify in xylol and mount in Canada balsam.

The gonococcus is very well stained by the carbol-fuchsin method already described for the tubercle bacil lus. The true gonococcus is not stained by Gram's method. It is thus distinguished from similar microbes.

CHEMICAL EXAMINATION OF GASTRIC CONTENTS.

A variety of test-meals has been suggested, the products of whose digestion are submitted to examination. The test breakfast of Ewald is usually preferred on account of its simplicity, convenience, comparative cleanliness, and easy manipulation. It consists of an ordinary dry roll,* weighing 35 grams (a little more than an ounce), and 300 c. c. (10 ounces) of either warm water or weak tea without milk or sugar. The Ewald meal contains no lactic acid, or, if any, so small a quantity that it does not respond to the ordinary tests. The meal is given after fasting all night, or after washing out the stomach. The stomach should be first washed out under any circumstances if there is reason to believe any residue is left from a previous meal. The Leube meal, which may be regarded as a full meal, the Ewald being a light meal, consists of soup-meat and bread, and contains considerable lactic acid.

One hour after the ingestion of the Ewald meal the product is removed by the flexible stomach tube. The tube is sufficiently lubricated by dipping it into warm water, after which it is introduced by carrying the end well back into the pharynx and directing the patient

* Such a roll containing about 35 per cent. of water, 7 per cent. of albumen, 5 per cent. of fat, 4 per cent. of sugar, 52.5 per cent. of non-nitrogenous extractive substances, and 1 per cent. of ash, includes, therefore, the usual elements of a mixed diet.

to swallow as it is gently pushed downward. The tube should be about 95 centimetres (37½ inches) long. From the fundus of the stomach to the incisor teeth is 60 to 65 centimetres (23.5 to 25.5 inches), and about this much should be taken up when the tube is well in place. The Ewald tube is usually marked at this place. A long tube allows the stomach to be emptied by siphonage after a little pressure on the abdomen has been exerted to start the motion of the contents; or they may be removed by aspiration. The amount withdrawn, which should be about 40 c. c., is first examined macroscopically as to quantity, color, and consistence, minutely for blood or other abnormal constituents, then filtered after previous thorough shaking, in order to diffuse uniformly the acid constituents.

In healthful conditions the gastric contents are acid in ten or fifteen minutes after food ingestion, the acidity depending on free acids or acid salts. The secretion of hydrochloric acid begins immediately, the first secreted combining with the native proteids and mineral salts, forming acid proteids and acid salts. The latter, chiefly acid phosphates (H_2KPO_4) form in the gastric contents by the action of HCl upon the phosphates (HK_2PO_4) contained in the food. As soon as the affinities of these substances are satisfied, free HCl makes its appearance. Free HCl appears in from 15 to 20 minutes after the ingestion of an Ewald meal; in from 25 to 30 minutes after ingestion of twice as much; in from 25 to 35 minutes after the ingestion of 60 gm. meat; 60 to 90 minutes after egg albumen; 45 minutes after a mixed meal of bread, meat, and vegetables. Fat and potato delay the appearance of HCl. It gradually increases in amount until at the acme of digestion the free HCl reaches, after a light meal, .05 to .19 per cent., and .2 to .33 per cent. after an abundant meal. The maximum is reached in one and a half to two hours after a light meal, and two to three hours after a full meal.

Lactic acid is not secreted by the stomach ; if present, it has either been introduced with food or is the result of abnormal fermentation of food ingested.

The procedure is as follows with the filtered fluid :

1. **Test reaction** with litmus or Congo red paper, the former being rendered red, the latter blue by acids.

2. **Test for free acid and acid salts qualitatively**. See also p. 246. This may be done roughly by means of the aniline dyes *Congo* red and *tropæoline oo*—*l'orange Poirier* of the French. A saturated watery or alcoholic solution is made, strips of filtered paper dipped into such solution, dried, and thus preserved for use. The paper is, however, less delicate than the solution, which in the case of Congo red, strikes a beautiful *sky-blue* reaction with a solution containing but 0.02 per 1000 of HCl. A *purple* color is produced by organic acids, and a *dull brown* with acid salts. Combined acids do not affect the color.

The tropæolin solution is dark yellowish red, and a solution of free acid, as HCl, 0.025 to 1000, changes it to a *deep dark brown*. It is slightly less delicate, therefore, than the Congo red. *Acid salts*, as acid sodium phosphate, *make it straw-yellow.* In all of these tests it is necessary to use an excess of the fluid to be tested. This is accomplished by placing five or ten *drops* of the reagent in a test glass or porcelain capsule and adding one to two *cubic centimetres* (15 to 30 *drops*) of the filtered contents. Tolerably delicate tests can thus be made, though their delicacy is affected by acid salts and albuminoids, especially albumose and peptones.

Leo's carbonate of calcium test is based upon the fact that $CaOCO_3$ in cold solution *neutralizes free acids only*, not reacting with acid salts. A strip of blue litmus paper having been previously moistened with the filtrate as a standard, a few drops of the latter are thoroughly mixed in a watch-glass with a small amount of *chemically pure* powdered calcium carbonate. After the complete neutralization of the free acids and disappearance of the separated CO_2, the reaction is tested with another piece of litmus and the result compared with the standard. If the litmus is no longer reddened the acidity was due to free acids only, while if there is still redness, but less in degree than that of the standard, there are both free acids and *acid salts*.

3. **Test for free Hydrochoric Acid**.—*Günzburg's* test is commonly used, or if the result is negative or doubtful with it, Boas's test.

Günzburg's solution is made as follows:

Phloroglucin, ...	2 parts (gr. xxx)
Vanillin, ...	1 part (gr. xv)
Absolute alcohol, ...	30 parts (f℥j)

The solution is pale yellow and has a decided odor of vanilla. On exposure to light it assumes a dark golden yellow, and it must therefore be kept in dark hued bottles or be freshly made as required.

A drop or two of the reagent is placed on a porcelain plate or capsule with an equal quantity of the gastric filtrate, and a *gentle* heat applied, not to boil, but simply to evaporate. Very soon a beautiful rose-red tinge will appear at the edge of the mixture,or red stripes will be observed. Blowing at the edge will favor the appearance of the red stripes. This test is unmistakable, and surpasses all others in delicacy, being available when HCl is present in the proportion of 1 to 20,000, or .05 per mille. Filtration of the gastric contents is not necessary.

Boas's test is based upon the fact that *resorcin* strikes a similar reaction with hydrochloric acid. The solution consists of—

Resublimed resorcin, ...	5 parts	(gr. lxxv)
White sugar, ...	3 "	(gr. xlv)
Dilute alcohol, ...	100 "	(f ℥ iiiss)

Three to five drops of the reagent are poured into a porcelain dish and an equal quantity of stomach contents added. Heat is applied as in Günzburg's test, and a purple-red color appears at the edge of the drop. It is said also to detect .05 per mille of HCl.

Neither of these tests responds to the organic acids or is interfered with by peptones or acid salts.

Töpfer's test consists in the addition of one drop of a half per cent. alcoholic solution of dimethyl-amido-azo-benzol to a portion of the contents in a test-tube. If HCl is present a carmine-red color results.

Free HCl may also be sought by Leo's test after extracting the fatty acids by heat and the lactic acid by ether, when the fre acid remaining will only be HCl, of which, according to Leo, .02 per 1000 may be detected if decided amounts of acid phosphates are not present, and even then .008 per cent.

4. **Test for Organic Acids**.—These include lactic acid and the true fatty acids, especially butyric. They are not normal *secretions*, but in the early stage of digestion are not necessarily abnormal constituents, as they may be ingested with food. This is especially true of lactic and acetic. Commonly, if detectable by the ordinary reagents, they are pathological. Abnormal lactic acid is formed by fermentation of carbohydrate foods by action of bacteria, probably more than one. Butyric acid is also formed from carbohydrate and milk foods by the action of bacilli. Acetic acid has a like origin through the action of the *mycoderma aceti*.

Uffelmann's Test.—Lactic acid is recognized by its effect upon a very dilute, *almost colorless*, solution of neutral ferric chloride, which is converted into a *canary-yellow* color by its action. This is Uffelmann's test. It is rendered more certain when a few drops of a neutral ferric chloride solution are mixed with one or two drops of pure carbolic acid, and adding water until the solution assumes an amethyst blue color. A few dops of even a .05 per mille solution of lactic acid (1 in 20,000) will change the blue to the distinctive yellow color.

There are, however, sources of error. The lactates cause the same reaction, but this matters not, because we desire to recognize the lactic acid, whether in combination or not. The reaction, however, takes place with alcohol, sugar, and certain salts, especially phosphates, which are often found in gastric contents. The color produced by phosphates is not identical, but if the filtrate operated with has a yellow tinge the resulting color may approximate very closely. Under these circumstances the lactic acid must be extracted with ether. To five c. c. of the stomach contents add two drops of strong hydrochloric acid. Heat the mixture to a syrupy consistence over a flame or water-bath. Shake the residue thoroughly with three or four times the amount of ether. The ether is allowed to rise on top, which it does rapidly, and is then poured off into a glass beaker. More ether is added and the washing repeated, until in all about 30 c. c. (f℥j) of ether have been used. The ether is then evaporated by placing the beaker, with its contents, in a vessel of hot water. The residue is redissolved in a few drops of water and *one or two* drops of Uffelmann's reagent allowed to fall from a pipette into the solution. Too much of the solution may mask the reaction. This test is much more delicate than tropæoline, which may fail to show a reaction for free acid because of its concealment by acid salts.

The *fatty* acids, especially *butyric*, strike a *tawny yellow color* with a reddish tinge with Uffelmann's chloride of iron solution, but .5 per 1000 or 1 in 2000 is required before the reaction occurs.

Fatty acids may also be detected by heating to the boiling point a few c. c. of the gastric filtrate in a test-tube, over the mouth of which a strip of moistened neutral or blue litmus paper is placed. On this the vaporized acid will produce the usual change.

The oily particles of pure *fat* may be recognized floating in the gastric contents or in the aqueous solution of the residue after evaporating the ethereal extract. Butyric acid may also be separated in the form of drops by adding small pieces of sodium chloride.

Acetic acid is easily recognized by its odor, but it may also be detected by neutralizing by sodium carbonate the watery residue after the removal of the ethereal extract; then adding a few drops of a ten per cent. neutral ferric chloride solution. A striking blood-red color is struck, also produced by formic acid, but this is never a constituent of gastric contents.

Alcohol, which is sometimes formed in the stomach in intense yeast fermentation, may be detected by Lieben's iodoform-test applied to the distillate of the stomach contents, as follows: To a portion of the distillate add a small quantity of liquor potassæ, then a few drops of a solution of iodine and iodide of potassium (1, 2, 50). If alcohol is present a yellowish precipitate of iodoform takes place slowly. The same precipitate occurs with acetone, but rapidly.

5. **To Determine the Total Acidity,** including Free and Combined Acids and Acid Salts.—A Mohr's

burette is filled with a decinormal * solution of caustic soda. Ten c. c. of the filtered solution are placed in a beaker and one or two drops of one per cent. alcoholic solution of phenolphthalein added as an indicator. The decinormal solution is then slowly dropped from the burette until the red color produced in the fluid by the action of the alkali on the phenolphthalein no longer disappears on shaking. As a rule, the total acidity of the gastric contents, an hour after such a meal, requires four to six c. c. of the decinormal solution to neutralize it in normal digestion. Figures above and below this are therefore abnormal. The acidity may be expressed by the number of c. c. required to neutralize one hundred c. c. of gastric contents; thus, if four c. c. were required to neutralize ten c. c., there would be forty per hundred, which is also spoken of as *degrees* of acidity; or, if six c. c., 60 per hundred total acidity. Again one cubic centimeter of the decinormal solution is equivalent to .00365 HCl. If, therefore, the number of cubic centimeters used to neutralize ten c. c. of the solution be multiplied by .00365 and again by ten, the result will be the percentage. Thus, if six c. c. of the decinormal solution be used, the percentage will be $6 \times .00365 \times 10 = .219$ per cent., within the normal range, which is from .14 to .24 per cent. in the filtrate; if four c. c. be used the HCl percentage will be

* Decinormal solution of soda $\frac{N}{10}$ NaHO = 4 grams NaHO dissolved in 1000 c. c. distilled water. Each c. c. of this solution exactly neutralizes 0.0036 gram HCl.

$4 \times .00365 \times 10 = .146$, or less than normal. The range of total acidity in the unfiltered contents is greater than in the filtrate, being .15 to .3 per cent. This is probably because of the large amount of combined acids in the unfiltered contents.

6. **To Determine Total Free HCl Quantitatively.**—(*a*) By Mintz's method: Ten c. c. of the stomach contents are titrated with the decinormal soda solution until a response with Günzburg's reagent no longer occurs, testing a drop or two of the partly neutralized gastric contents with the addition of each one-tenth c. c., or fraction thereof. Then, as one c. c. decinormal soda solution equals .0036 HClO, we have simply to multiply .00365 by the number of c. cs. used, this by 10, and the result will be the percentage required. The last reading before the disappearance of the reaction is taken as the measure of the HCl. Thus if the test responds after 5 c. c. of the decinormal solution have been added, and does not respond after 5.1 have been added, the HCl in 10 c. c. will be represented by $5 \times .00365$ gm.

(*b*) By Töpfer's method: To ten c. c. of the filtered contents add a few drops of a 5 per cent. alcoholic solution of dimethyl-amido azo-benzol. The mixture turns a bright red in the presence of free HCl. Titrate with the decinormal sodic solution until the red turns to a clear yellow. Calculate as above.

7. **To Determine Free HCl, Organic Acids, and Acid Salts.**—To ten c. c. of the gastric filtrate add a few drops of a one per cent. aqueous solution of alizarin

(alizarin monosulphonate of sodium) and titrate with the decinormal sodic solution until the mixture assumes a clear violet color. Combined acids have no effect. Alizarin responds to the alkalinity which succeeds the neutralization of the acidity due to free HCl, organic acids, and acid salts.

As the violet tint is more or less difficult for the unpractised eye to recognize, Töpfer recommends the following preliminary tests:

(*a*) To five c. c. of distilled water add two or three drops of the alizarin solution. A clear yellow color results.

(*b*) To five c. c. of a one per cent. solution of disodium phosphate add the alizarin solution as above. A reddish color with a slight tinge of violet results.

(*c*) Five c. c. of a one per cent. solution of sodium carbonate when treated with alizarin, as above, gives a clear violet tint, which is the tint to be reached in the titration. It should be used as a guide until the eye becomes sufficiently practised. Where there are no free organic acids the result of this test represents free HCl and acid salts.

8. **To determine the combined HCl**, subtract the acidity found by alizarin from that found by the phenolphthalein, *i. e.*, from (5) subtract (7).

9. **To determine the acidity due to organic acids and acid salts**, subtract the free HCl from that found by alizarin, *i. e.*, from (7) subtract (6).

10. **To determine total HCl**, free and combined, to (6) add (8). Where free HCl is present all the combined acid is HCl.

11. **To Determine Acid Salts.**—See also p. 237. This may also be done by Leo's method, which is based on the fact that when calcium carbonate is added as a fine powder to gastric contents, the free and combined HCl unite with the calcium carbonate, forming calcium chloride, a neutral salt, the acid salts being unaffected. Moreover, the calcium chloride thus formed reacts with the phosphates to form acid *calcium* phosphate, which requires twice the amount of *sodium* carbonate to neutralize it as the acid *sodium* phosphate. Hence it is necessary before each titration to add an excess of calcium chloride solution.

Method.—To fifteen c. c. of the gastric contents is added a small quantity of calcium carbonate, as much as will go on the end of a penknife, the mixture stirred and immediately filtered through a dry filter. The liberated carbonic acid is expelled from the filtrate by passing a current of air through it by means of a glass tube. Ten c. c. of this filtrate are then treated with five c. c. of a saturated solution of calcium chloride and titrated as before. The result divided by two represents the acid phosphates.

Examination of Products of Albumin Digestion.

The term *proteolysis* is applied to albumin digestion, in which all proteid substances are converted into peptone. It takes place partly in the stomach, but probably even to a greater degree in the small intestine. In this process the first step is the production of certain substances intermediate between albumin and peptone which are called *albumoses* or *proteoses*. Those which are of chief importance in the study of gastric digestion are syntonin or acid albumin, and propeptone or hemialbumose. In the ordinary process of digestion with a normal gastric juice some or all of these substances should be present in the stomach at the end of an hour. So far as they are the products of gastric digestion they may, therefore, be studied by the aid of a test-meal and removal of the gastric contents as already described.

This digestion is accomplished by the agency of the hydrochloric acid, a proteolytic ferment *pepsin*, and a coagulating ferment *rennin*, all three secreted by the glands of the stomach.

The secretion of HCl begins at once after the introduction of food. It unites at once with the native proteids of the food, forming acid proteids, and reacts with the neutral phosphates of the food, forming acid salts; also with the proenzyme pepsinogen, forming pepsin, and with the rennet zymogen, forming rennin. A part of the rennin is formed as such in the glands. The secretion of the gastric juice continues in health until all these affinities are supplied and a certain amount of HCl remains over as free acid. As soon as this appears the pepsin ferment begins to act on the proteids and to convert them into albumoses and peptones, while the rennet acts on the casein of the food, coagulating and converting it also into soluble proteid. Pepsin acts only in the presence of HCl, while rennin is active in acid, neutral, or even feebly alkaline solution.

Propeptone and Peptone.—Propeptone at the maximum of normal digestion should be present only in traces and must be removed before peptone is tested for, since it responds to the same test,—the biuret test.

To remove propeptone treat 2 or 3 c. c. of the stomach filtrate with an equal quantity of a saturated solution of chloride of sodium and then add one or two drops of strong acetic acid. Propeptone if present is thus precipitated and may be filtered out. To the filtrate add one c. c. of liquor potassæ, then a few drops of a one per cent. solution of sulphate of copper. A purple red color indicates the presence of peptone, and we may approximately estimate its amount by the intensity of the biuret reaction, provided we always use the same proportion of stomach contents, solution of potash, and cupric sulphate. Should it happen that a handsome biuret reaction is struck before removing the propeptone, and but a faint one or none afterward, the proportion of propeptone is large and of peptone small. Cahn has shown that in dogs, at least, the quantity of peptone remains at a certain percentage, being probably kept at that figure by constant removal. Hence the only index of the rapidity and amount of albumin transformation is the amount of propeptone formed or remaining. Finally, Ewald and Gumlich conclude that the formation of true peptone in the human *stomach* is slight, albumoses being mainly produced, the chief transformation of which is effected in the small intestine.

To Estimate the Activity of Proteolysis, or Albumin Digestion.—By Ewald's method, coagulated white of egg is cut into thin slices, and out of these small discs are cut by a cork-borer or similar instrument. These may be prepared in quantity and kept for use in glycerin, which should, however, be washed off before using the slices. An equal quantity of the filtered gastric fluid is placed in four small test-tubes and one or two discs of albumin put into each. To the first nothing else is added, to the second enough hydrochloric acid to make a solution of about * 0.3 to 0.5 per cent. This is accomplished by adding two drops of hydrochloric acid to five c. c. (90 minims) of stomach contents.

To the third is added a definite quantity of pepsin, about 0.2 to 0.5 gram [gr. iij to gr. viiss], to the fourth both hydrochloric acid and pepsin. The test-tubes are placed in an incubator at about 100° Fahr., and from time to time examined with a view to learning how far the liquefaction of the discs of albumin has proceeded. The rate of this will inform us whether digestion would have occurred without the addition of anything, or whether acid or pepsin or both were necessary. We will learn, also, whether by adding more hydrochloric acid we have made the acidity excessive.

It must be remembered, however, that after the peptone has reached a certain percentage, its further pro-

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* The difference between the strength of the acetic acid of the German Pharmacopœia (25 per cent. of the anhydrous acid), intended by Ewald, and that of the U. S. P. (32 per cent.) is not sufficient to necessitate a change of proportion.

duction is retarded, or even suspended, so that there may be an apparently slow reaction with even a very active gastric juice. Ewald happily reminds us that all laboratory attempts to imitate digestion are defective in the important respect that with our test-tubes and flasks we can neither imitate absorption on the one hand, nor, on the other, allow for the onward movement to the intestines of the gastric contents, two important functions by which the stomach strives to maintain a fairly uniform degree of concentration of its contents.

The Action of Rennet, the Milk-coagulating Element of the Natural Gastric Juice.—The simplest method of estimating the action of rennet is that of Leo. To ten c. c. of *raw* milk are added two to five drops of stomach contents. Raw milk is used because it coagulates ten times more rapidly than boiled milk, while neutralization is unnecessary because of the relatively small quantity of gastric juice used. The mixture is placed in the warm chamber at 100° F., and coagulation should take place in from one minute to several hours. The characteristic coagulation of rennet is a cake of casein floating in clear serum, while acids produce lumpy and flaky masses.

The rennet-ferment, or enzyme (lab ferment), does not exist primarily as such but as a rennet zymogen or proenzyme, which itself has no action on milk, but is converted into rennet by the action of any acid, as hydrochloric, or of warm chloride of calcium. This may be shown as follows: If the spontaneous coagulating action of gastric juice on milk be destroyed by neutralization by an alkaline carbonate, this property may be restored by digesting with dilute hydrochloric acid or by the addition of a five per cent. solution of calcium chloride. While fasting and at the beginning of digestion, zymogen only is present in the stomach, but later both it and the ferment are found. An acid reaction for the curdling action of rennet is not absolutely necessary.

Digestion of Starch and Sugar.—It is well known that during digestion starch is converted into grape sugar, and cane sugar is converted into *invert* sugar—a mixture of cane and grape sugar. This action, commenced in the mouth by the ptyalin of saliva, is continued to a less degree so long as the acidity is slight (.01 per cent. for HCl, .1 or .2 per cent. for lactic, .4 per cent. for butyric) in the stomach, and is finished in the small intestine by the trypsin of the pancreatic juice. As in albumin digestion there are intermediate substances between albumin and peptone, so between starch and grape sugar there are similar intermediate products. The order is as follows:

(1) Starch, (2) Dextrins (Erythrodextrin, Achroödextrin), (3) Maltose, (4) Dextrose = grape sugar.

Starch is recognized by the deep blue color struck with iodine or Lugol's solution (iodine 1, iodide of potassium 2, distilled water 200), and the reaction grows less vivid as the starch is converted. Of the dextrins, erythrodextrin strikes not a blue but a purple color, while solutions of achroödextrin, maltose, and grape sugar take on only the yellow color of the iodine solution. Where a mixture of these substances occurs, the first few drops of the iodine solution produce no color at all, or only a transitory one, being taken up by the dextrose and maltose, while the addition of more iodine strikes the purple of erythrodextrin or blue of starch.

If, therefore, amylaceous transformation has progressed normally in the mouth and stomach, so much starch should be changed into achroödextrin, maltose, or dextrose that the addition of small quantities of Lugol's solution does not strike the characteristic color. If, however, the blue or purple reactions appear, conversion has not been sufficiently rapid into maltose, the principal product of gastric conversion, the change into dextrose being completed in the small intestine. This may be due either to a deficiency of ptyalin or a too rapid production of acid in the stomach. From such event we might also infer a hyperacidity of the gastric juice.

To Determine the Rapidity of Absorption from the Stomach.—Penzoldt's method is that generally followed. A capsule containing iodide of potassium (.1 gram or gr. iss) is swallowed, being first carefully wiped to remove any adherent particles. The appearance of the iodide in the saliva indicates that absorption has taken place from the stomach. To determine this, starch paper is first prepared by moistening with starch-paste and drying. Then, after the salt is swallowed, a piece of the paper is moistened every five minutes with the saliva, and the moistened spot touched with fuming nitric acid. As soon as the iodine appears in the saliva the characteristic blue reaction is struck.

When absorption is normal this reaction usually takes place in ten or fifteen minutes, but where absorption is abnormally delayed, the reaction is also delayed half an hour or more, or it may not occur at all.

To Test the Motor Function of the Stomach.—Three methods are practised. First, remove the gastric contents six to seven hours after the ingestion of a large meal, or two and a half hours after an Ewald breakfast, and note the amount of solid substance remaining. The stomach should by this time be empty.

Second, salol is administered and the product of its lysis sought for in the urine. Third, a definite quantity of olive oil is introduced into the empty stomach and the remnant unabsorbed is withdrawn at the end of two hours. The second, though not without drawbacks, is preferred. Salol is composed of phenol and salicylic acid, into which it is broken up by the action of the pancreatic juice, but not by the acid gastric contents. Salicyluric acid, a product of decomposition of salicylic acid, appears in the urine forty to sixty, or at most seventy-five, minutes after taking one gram (15 grs.) of salol when gastric peristalsis is normal. Salicyluric acid is readily detected in the urine by the violet color produced on the addition of neutral ferric chloride solution. The method employed is to place a drop of urine on a piece of filter-paper and bring in contact with this a drop of a ten per cent. ferric chloride solution. The edge of the drop will strike a violet color in the presence of a mere trace of salicyluric acid.

The objection to the salol test is that the decomposition of the salol may be delayed by an undue acidity of the gastric contents discharged into the duodenum. But practically this is found not to be a serious drawback, tolerably constant results being obtained by Ewald and Sievers. To meet this objection, however, Huber suggested that the outside limit of excretion of salicyluric acid fails to appear in the urine after the ingestion of a gram (15 grs.) of salol. *This should be at the end of twenty-four or thirty hours.* If, therefore, it is continued after this, peristalsis must be slow.

In Klemperer's oil test 100 c. c. (3⅓ ozs.) of olive oil are introduced into the stomach by the stomach tube after the stomach is thoroughly washed out. Two hours later the stomach is aspirated, and if there is motor sufficiency the remnant of oil should be a minimum. If any decided quantity remains peristalsis is slow.

To Determine the Capacity of the Stomach.—The capacity of the stomach in health is from 1600 to 1700 c. c. (say from 3 to 3½ pints). Its normal limits and deviations therefrom can usually be determined by percussion. This is rendered easier by distending the stomach with gas or liquid, as by having the patient drink a glass of water just before the examination, or, as originally suggested by Frerichs, by taking in rapid succession the two portions of a Seidlitz powder—tartaric acid and sodium bicarbonate—or a glass of soda water. A better way is to inflate the stomach with air, as suggested by Runeberg, by means of the double bulb of a spray appratus. This should be done, if possible, in connection with the use of the tube for some other purpose, as removing the stomach contents after a test-meal. In fact, the simplest way is to fill the stomach with the washing-out fluid and measuring the quantity thus used. The air inflation is preferable to gas, because if any excess is introduced it passes out alongside of the tube, which is not the case with carbonic acid gas, which excites rather a spasmodic contraction of the cardiac orifice.

THE ROENTGEN RAY IN DIAGNOSIS.

The discovery in 1895 by Prof. Roentgen, of Würzburg, of the peculiar ray to which he gave the name of X-ray, at once gave promise of important possible results in diagnosis. These rays were believed to emanate from the cathode when induced electric currents were passed through a vacuum-tube (Crooke's tube). Recent studies by Prof. Trowbridge give reason to believe that such rays emanate from the anode as well, but are less powerful. Their potency is shown in their ability to pass through solid objects. They are not subject to reflection or refraction, and give rise to fluorescence and phosphoroscence. The latter is, of course, best seen in a dark room, while fluorescence ordinarily ceases to exhibit light in the dark.

The energy of the X-rays is, however, manifested in its penetrating power, since by their aid we can see through timbers a foot thick and see the beating of the human heart through the flesh.

The examination is accomplished as follows, in a dark room: The body is placed between a Crooke's tube and a photographic plate placed in a box, under which circumstances the soft parts appear dark on the negative and the denser parts appear light. The positives made from this exhibit the opposite, the bones being dark and the soft parts light. In lieu of the photographic plate the fluoroscope is used to study the effect of the rays. The advantages of the Roentgen rays have been greatest in connection with surgery, but they may also be applied to medical diagnosis.

In the *thorax*, it is especially in the diagnosis of enlargements of the heart, of pericarditis, and of aneurism of the aorta and calcareous blood-vessels that the apparatus is available. Emphysema of the lungs, tumors in their substance, pleuritic effusions, and calcareous plates may also be recognized. A striking demonstration is the motion of the heart and lungs.

In *abdominal organs* this mode of diagnosis has been of most service in recognizing stones in the kidney and ureters, although it has not always been successful. The same is true of biliary and vesical calculi. Not much help has as yet been secured in the diagnosis of diseases of the abdominal organs; the organs themselves cannot be differentiated. Those penetrable by metallic sounds, such as the œsophagus and stomach, may be more successfully explored. So, too, foreign

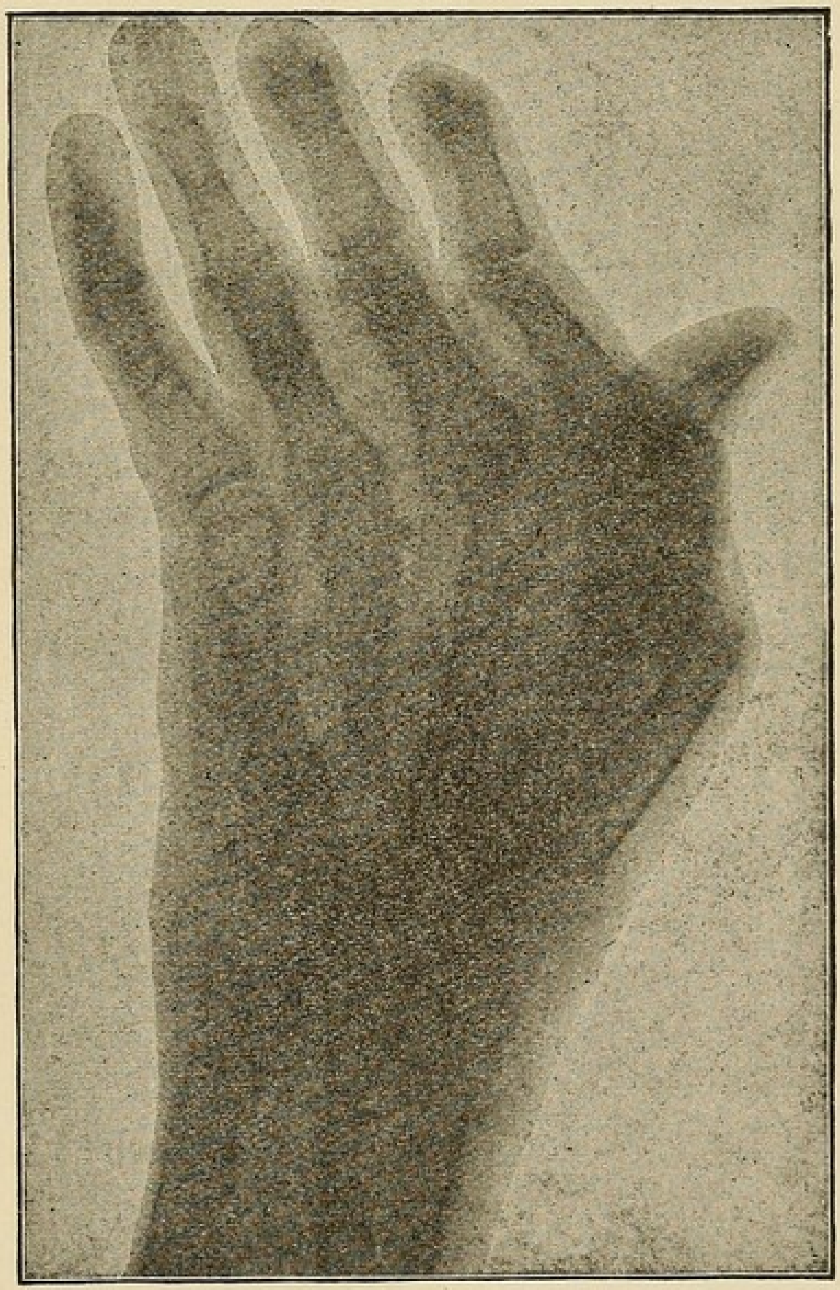

FIG. 46.—"SEAL FIN" DEFLEXION OF THE HAND IN A CASE OF PROTRACTED ARTHRITIS DEFORMANS.

From a photograph with the Roentgen ray, showing also erosion and dislocation of joints.

bodies accidentally introduced, such as coins, or jack-stones, have been well located.

Diseases of the bones and joints have been, after the last-named objects, most satisfactorily investigated. Bony outgrowths can be easily outlined. The appended figure shows fairly well the changes in a case of rheumatoid arthritis, which may, by this means, be differentiated from those of gout.

Caries of the vertebræ and the changes of *rickets* have been similarly recognized, and it is more than likely, as the subject is further developed, that important aids to diagnosis will be further added.

THE MAKING OF AN AUTOPSY.*

Previous to section a general survey of the body should be made with a view to noting marks, scars, state of the body as to obesity or emaciation, and degree of *rigor mortis*, post mortem lividity, and decomposition.

A position to the right of the body is usually more convenient for the right-handed examiner, while the left side is more convenient to one who is left-handed. To the ambidexter it is indifferent on which side he stands.

* The directions here given are for an autopsy for clinical purposes, and not for the medico-legal investigation, which is much more elaborate. The general plan adopted is that laid down by Virchow in his little book on "Post-mortem Examinations," which the writer has followed for many years with great satisfaction.

The appended directions imply that the knife is held in the right hand

The first incision is made with a strong, broad handled knife by a sweeping traction movement down the median line from the suprasternal notch to the symphysis pnbis, passing to the left of the umbilicus. Then the skin and adjacent muscles of the thorax are cut back and the section through the abdominal walls carefully completed, avoiding perforation of the intestines. The muscles are also separated from the edge of the thorax and the abdominal walls laid back, so as to expose as much as possible the abdominal viscera *before opening the thorax.* This is done in order to preserve the natural relations of the abdominal viscera to each other and to the diaphragm, relations which are altered as soon as the thorax is opened by the removal of the sternum and attached cartilages. An inspection of the abdominal contents is therefore first made, the absence or presence of fluid or abnormality noted, *without, however, as yet removing or making any section of the ograns.*

Next the cartilages are cut through near their junction with the ribs from the 2d downward; this is often done on each side by one sweep of the knife in the hands of the skilled sectionist, if the subject is not too old. If not complete, the section of the cartilages and muscular interspaces should then be thoroughly completed, by the bone forceps, if necessary. The clavicle and 1st rib should be disarticulated from the sternum, bearing in mind that the articulation is an oblique one, and that it can readily be found by grasping the clavicle and moving it. Or, if it is preferred, the knife may be drawn through the middle of the 2d cartilage, when it will strike the junction between the first and second bones of the sternum, leaving the manubrium, with the articulation of the clavicle and 1st rib, intact. This, however, restricts the space over the origin of the great vessels rather inconveniently, and the former method is to be preferred unless the latter is necessitated for some special reason. The sternum should be raised, beginning with the tip, and the muscles and other tissues shaved close to its under surface. This act uncovers the mediastinum and opens the two pleural sacs, without, however, incising the pericardium, if the section has been successful. The superfluous integument thus dissected off should be folded over the cut edges of the ribs to protect the hand against these rough edges.

The *pleural sacs* should now be examined by inserting the hand between the lungs and the ribs and the diaphragm, with a view of finding adhesions or fluid, and the latter, if present, should be removed and measured. Outgrowths or inequalities of the pleural surfaces, pulmonary, costal, and diaphragmatic, should be looked for. The lungs should, however, be left as yet *in situ*.

The *pericardium* should then be opened, and the position of the heart observed. If an abnormal amount of fluid is present in the sac, it should be removed and measured. The external appearance of the heart, its size, shape, and consistence, should be noted; also the state of fulness of the superficial vessels, the amount of superficial fat, adhesions, or other abnormality.

The heart should then be opened in situ, with the purpose of examining the quantity and quality of blood in the separate cavities and the size of the orifices. In thus opening the organ it is held in the left hand with the index finger pressed well under and against the base, so that the ventricles project laterally. It is then rotated to the left until the *right border* comes into view, being easily recognized by the relative thinness of the wall here as compared with that of the left ventricle on the other side of the septum. At the right border, close to the base, the knife is deeply thrust into the *right ventricle*, and drawn to the apex. With the heart still thus held, the *right auricle* is incised midway between the entrances of the two venæ cavæ. The blood is then removed from the right auricle, its quantity and quality observed. The index and middle fingers of the left hand are now passed from the auricle through the tricuspid orifice into the right ventricle. Then the blood is removed from the right ventricle. The right auriculo-ventricular orifice in the adult, if normal, should receive three fingers, the index and middle finger of the left hand so far separated that the index finger of the right may be passed up between them from the right ventricle.

To make *the openings for the left side*, the apex of the heart is drawn up to the left, and placed in the left hand in such a way that the fingers encircle it at the base. Pressure is now made so that the wall of the left ventricle bulges out a little and separates itself from the septum, when the incision is made behind the base through the middle of the external wall into the *left ventricle* and out at the apex. For the *left auricle* the incision begins at the left superior pulmonary vein, and ends in front of the base usually indicated by the coronary vein, which should not be injured.

The blood is now removed from the left cavities, and the size of the auriculo-ventricular orifice determined. Here we have to consider the contraction of the ventricle which closes the orifice, and we have to gradually overcome this contraction, when we may introduce the three fingers named with less facility than into the tricuspid orifice, the mitral being 4.5 cm. (1.8 in.) in diameter as against 5 cm. (2 in.) for the tricuspid. The fingers should be very carefully introduced and withdrawn, so that no abnormal vegetations or coagulæ are removed, for *the valves have not yet been examined.*

The next step is the *removal of the heart.* This is done by thrusting the index finger of the left hand into the left ventricle and the thumb into the right through the openings made. The heart is then raised and the venæ cavæ, the pulmonary artery, aorta, and pulmonary veins severed as far as possible from the heart.

The orifices of the aorta and pulmonary artery are then examined with a view to discovering changes in their walls or lumen. The *hydrostatic* test is then applied for the sufficiency of the aorta and pulmonary valves by pouring water into each vessel while the heart is freely suspended. Previously, however, all coagula should be carefully removed from the orifices and ventricles. The plane of the orifice should also be exactly horizontal, and for this two hands are necessary to accomplish the proper support, and the water must be poured in by a second person. The aorta should also be cut again, short enough to enable one to see from above the state of the valves. Care should be taken to avoid wounding the coronary arteries, for if this accident happens, the water may run off into them and give the impression of insufficiency when it does not exist.

There is no hydrostatic or other test available to show the sufficiency of the auriculo-ventricular valves.

We are next ready to open *the ventricles and explore the interior*, including the valves. The heart is placed on a board or table, as nearly as possible in its position in the body. A long pair of scissors is the most satisfactory instrument for this purpose. For the *right ventricle* one blade is introduced at the center of the right ventricular incision previously made and carried well over toward the left side between the left anterior and posterior leaflets of the pulmonary valve, care being taken to pass above the insertion of the anterior papillary muscle of the tricuspid valve with its chordæ tendineæ.

To display the *left ventricle* is more difficult. Introduce one blade of the scissors at the apex close to the septum, and while drawing the pulmonary artery to the right, cut close to the ventricular wall until the portion of the left dog's-ear which overlaps the ventricle is reached. If we pass too far to the left we will cut through the right border of the base of the *mitral* valve, *which corresponds* with the right border of the left auricle; if too far to the right we cross the pulmonary orifice and may cut through the valves of the pulmonary artery.

The *auricles* can be further opened by cutting with the scissors on the right between the openings of the venæ cavæ, and on the left between those of the pulmonary veins.

The adult heart *weighs* in health in the male fifty to sixty years old about 335 grams (11.8 oz., *avoirdupois*); in the female, 295 grams (10.44 oz.).

The average *thickness of the wall* of the left ventricle is 1.6 to 1.7 cm. (5/8 to 2/3 in.); of the right ventricle .4 to .6 cm. (1/6 to 1/4 in.)

The *lungs* are now removed, their surface examined for emphysematous distension or subpleural deposits, and then incised longitudinally with a view to the discovery in their interior of tubercular infiltration, cavities, changes in the bronchi, etc. The right lung can always be differentiated from the left by its three lobes.

The lungs weigh, in the male, the right, 859.5 grams (30.3 oz.); the left, 811.6 grams (28.6 oz.); in the female, the right, 552 grams (19.48 oz.); the left, 296 grams (10.2 oz.).

For the examination of the *pharynx*, *larynx*, *æosphagus*, and *thyroid gland*, the central incision should be carried up to an inch below the chin. The first three should be slit up with the enterotome, the last dissected off. The thyroid varies a good deal in weight, usually about 30 grams or 1⅛ oz. These organs and a portion or all of the tongue can be removed by dissecting up under the skin and then making a transverse cut, thns obviating opening the skin on the neck.

The abdominal organs are now examined in the following order:

1. The omentum.

2. The spleen, which is longitudinally incised. The organ in health weighs about 176 grams (6.23 oz.).

3. The left and right kidney, with their suprarenal capsules and ureters; the kidney being stripped of its capsule and longitudinally incised.

The adult kidney weight, in the male, 113.5 to 170 grams (4 to 6 oz.); in the female a little less, 113.5 to 156 grams (4 to 5½ oz.). The suprarenal capsules, 4 grams to 8 grams (60 to 120 grains).

4. The bladder, prostate gland, vesiculæ seminales, urethra. The prostate weighs in health about 31 grams (1¼ oz.).

5. Testicles, spermatic cord, and penis. The testis with the epididymis weighs about 24.5 grams (½ to ¾ oz.).

6. Vagina, uterus, Fallopian tubes, ovaries, parametria.

The weight of the uterus differs greatly at different ages. Thus, according to Robert Boyd's table, in 11 girls from fourteen to twenty, the minimum weight was 17.01 grams, the maximum 70.87 grams, average 29.48 grams (1.04 oz.); in 47 women between twenty and thirty, the minimum was 21.26 grams, the maximum

120.48 grams, average 49.04 grams (1.73 oz.); in 79 women between thirty and forty, the minimum was 14.17 grams, the maximum 127.57 grams, average 56.13 grams (1.98 oz.); of the ovaries 3.9 to 6.5 grams (60 to 100 grains).

7. The rectum.

8. The duodenum, portio intestinalis of the ductns communis choledochus.

9. Stomach. Capacity 1 to 1.5 litres (2 to 3 pints).

10. Hepato-duodenal ligament, gall-ducts, venæ portæ, gall-bladder, liver.

The *stomach* and *duodenum*, under ordinary circumstances, should be examined *in situ*. The duodenum should be opened first, its contents examined above and below the biliary papilla. The latter should be examined, its contents expressed, and its patulousness determined by pressing gently on the gall-bladder. Finally, the common bile duct should be slit up. The vena cava should be examined, and not until then should the liver be removed and examined. Sections should be made through the organ horizontally, from right to left, to display its interior. The gall-duct should not be probed, as a duct essentially closed may thus be opened.

The *liver* weighs in health from about 1247.4 grams (2¾ lbs.) in the female to 1569.7 grams (3½ lbs.).

11. The examination of the *pancreas* naturally follows the stomach and duodenum and liver, and after it the cœliac (semilunar) ganglia.

The organ weighs 70 to 108 grams (2⅓ to 3½ oz.).

12. *Mesentery* with glands, vessels.

13. *Small* and *large intestines.*- These, after the examination of the stomach and duodenum *in situ*, should be removed, placed on a board or in water, and laid open, care being taken on opening the small intestines to keep on the line of the mesentery. If possible, water should be allowed to run through the intestines before opening them. The solitary glands and glands of Peyer should be carefully examined.

14. Retro-peritoneal lymphatic glands, receptaculum chyli, aorta, vena cava inferior.

Examination of the brain.—The scalp is divided by an incision across the top of the head from ear to ear, and reflected backward and forward, noting the presence or absence of extravasated blood. The skull-cap is now sawn through, better by two angular cuts so as to remove a wedge-shaped piece, care being taken not to wound the dura mater. To this end the chisel and hammer are used to break through the internal table. But it is sometimes impossible to avoid injuring the dura, and it may even be necessary to cut it through in consequence of the difficulty in separating it from the skull-cap. The thickness of the cranial bones, their internal surfaces, and the condition of the diploë are examined; also the external surface of the dura mater and the state of the sinuses. The brain is then removed, severing the cord as low as possible through the foramen magnum, and effusion at the base of the cranium looked for. The dura is separated and the appearance of the arachnoid and pia noted. Also that of the large arteries at the base; atheroma is especially sought. In health the visceral arachnoid presents a faint, opalescent appearance, and any turbidity or opaqueness beyond this points to meningitis. The state of the blood-vessels in the pia is carefully examined, and the presence or absence of effusion noted. As the pia mater is drawn aside, the blood-vessels which dip down between the sulci into the fissure of Sylvius are examined, especially their sheaths.

The pia being removed, the surface of the brain is examined, the depth of the sulci, flattening of the convolutions, and any marked deviations in their arrangement noted.

The *dissection of the brain* is now commenced, beginning with the opening of the lateral ventricles. This is done after drawing apart the halves of the cerebrum, by an incision one millimetre ($\frac{1}{25}$ inch) on each side of the median line in the corpus callosum directly downward, when the middle portion of the lateral ventricle is reached at the depth of two or three millimetres ($\frac{1}{12}$ to $\frac{1}{8}$ inch). The anterior and posterior cornua of the lateral ventricle are then opened by horizontal incisions from this point into the anterior and posterior lobes of the brain. Thus the lateral ventricles are exposed throughout their extent, and their contents, the state of their walls, and the venous plexuses examined; also the septum lucidum, with its contained 5th ventricle.

The septum is then seized from behind the foramen of Monro and the scalpel pushed in front of the fingers through this foramen, and the corpus callosum cut through obliquely upward and forward, and then these parts (the corpus callosum, septum lucidum, and fornix) are carefully detached from the velum interpositum and choroid plexus, which are examined as to the state of their vessels and tissue.

The handle of the scalpel is then passed from the front under the velum, which is thus detached from the pineal body and corpora quadrigemina, which are examined. The 3d ventricle is then exposed. Finally, the corpora quadrigemina and the cerebellum are divided as far as the aqueduct of Sylvius and the 4th ventricle.

The hemispheres of the cerebrum and cerebellum are now sliced by *transverse* incisions rather than longitudinal ones, because in this way the parts can again be more easily united if desired, with a view to determine the relation of parts or the seat of lesions.

The optic thalami and corpora striata are cut by *fan*-shaped incisions radiating from the peduncle of the cerebrum.

The adult brain of the male weighs on an average about 1400 grams (49½ oz. avoird.), of the female 1245 grams (44½ oz. avoird.). The cerebrum alone weighs 1244 grams (43 oz. 15 dr.) in the male, and 1098 grams (38 oz. 12 dr.) in the female; the cerebellum 148⅔ grams (5 oz. 4 dr.) in the male, in the female 137 grams (4 oz. 12½ dr.). The pons and medulla oblongata weigh 28 grams (15¾ dr.) in the male, and in the female 28.8 grams (1 oz. ¼ dr.).

The removal of the *spinal cord* is a laborious operation. The spinal canal is opened, preferably from behind, by dissecting back the skin from the median line and sawing upon each side of the spines of the vertebræ, slanting the saw 30° from the median line at the side of the spinal canal, or by using a double saw. The cord when removed is carefully examined as to its membranes, and transverse incisions made at intervals of a half-inch or less, leaving the membrane intact at one spot, so that the pieces are all held together like the leaves of a book.

The spinal cord weighs 37.2 grams (1 oz. 5 dr.) in the male, and 35.43 grams (1 oz. 4 dr.) in the female.

The *Eye* is reached by chiseling off the roof of the orbit. The posterior half of the eye, which is commonly all that is needed, can be removed by seizing the sclera with forceps and cutting around the eyeball with sharp scissors. It should be done quickly, because in this way the retina can be kept from folding. The anterior half of the eyeball is to be held in place by a plug of cotton dipped in ink or other dark substance.

The Ear.—The *middle* ear can be exposed by chipping off the petrous portion of the temporal bone which covers it.

The *Nasopharynx* can be exposed by chiseling off that part of the base of the skull lying above it.

It is always desirable to take to an autopsy three or four wide-mouth bottles of about two ounce capacity containing preservative fluids in which to place small pieces of tissue intended for subsequent examination. In one of these should be placed 95 per cent. alcohol, in another 70 per cent. alcohol, in a third *Müller's fluid.* The fourth may be reserved for unexpected purposes. Müller's fluid is especially used for nervous tissues. It is composed of bichromate of potassium, 2.5 grams; sulphate of sodium, 1 gram; water, 100 c. c. If to this is added corrosive sublimate, 5 grams, and glacial acetic acid, 5 c. c., we have *Zenker's* fluid, which is even better.

ORDER OF EXAMINATION OF PATIENT.

Name, nativity, and residence.

Age.

Occupation. This is often carelessly stated, and should be carefully investigated, including changes of occupation and especially occupation just previous to illness.

Social condition [married or single].

Habits of patient [*i. e.*, as to mode of living, temperance in eating and drinking].

Family history.

Health of parents, brothers, sisters, and children.

History of previous illnesses.

The diseases experienced by the patient before the present illness [*i. e.*, diphtheria, scarlet fever, typhoid fever, rheumatism, malaria, pneumonia, pleurisy, venereal disease, etc.].

History of present illness or of previous attacks of same.

1. Ask how long patient has been sick. Ascertain this definitely by suitable questions.
2. Get the symptoms in regular order from the beginning to the present.

Condition on coming under treatment or admission to hospital,—that is, the symptoms of which the patient complains at such time.

Physical examination. [Patient stripped.]

1. General appearance of patient.
2. Chest: Inspection, palpation, mensuration, percussion, auscultation.
3. Abdomen.
4. Special parts.

METRIC OR FRENCH WEIGHTS.

	Gram.		Troy Grain.		Av. Ounce.		Av. Pound.
Milligram,	.001	=	.01543				
Centigram,	.01	=	.15433				
Decigram,	.1	=	1.5433				
Gram,	1	=	15.43316	=	.03528	=	.0022047
Decagram,	10			=	.3528	=	.022047
Hectogram,	100			=	3.52758	=	.2204737
Kilogram,	1000			=	35.2758	=	2.204737
Myriogram,	10000					=	22.04737
Quintal,	100000					=	220.4737

METRIC OR FRENCH LINEAL MEASURE.

	Meter.		U. S. Inch.		Feet.		Yard.		Mile.
Millimeter,*	.001	=	.03937	=	.00328				
Centimeter,†	.01	=	.3937	=	.03280				
Decimeter,	.1	=	3.937	=	.32807	=	.10936		
Meter,	1	=	39.3685	=	3.2807	=	1.0936		
Decameter,	10			=	32.807	=	10.936		
Hectometer,	100			=	328.07	=	109.26	=	.0621347
Kilometer,	1000			=	3280.7	=	1093.6	=	.6213466
Myriameter,	10000			=	32807	=	10936	=	6.213466

* Nearly $\frac{1}{25}$ inch. † Full $\frac{3}{8}$ inch.

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