fever, epidemic influenza, whooping-cough, diphtheria, etc. A warm, sunny climate, inland or seashore, where the patient can live out of doors, protected from wind, and can bathe in the sunshine. Atlantic City, Old Point Comfort, Lakewood, are examples.

Many other diseases and conditions are amenable to climatic treatment with more or less success, and in selecting a health resort for them the writer cannot do better than to repeat for the guidance of the practitioner the three principles enunciated in the previous edition of this HANDBOOK by the accomplished author of the articles upon health resorts: "1. A thoughtful, conscientious, and painstaking consideration of the precise pathological condition of the individual patient, and of his constitutional peculiarities. 2. A careful study of the effects produced upon the human organism, both in health and disease, by variations in each and all of the meteorological factors of climate. 3. The detailed study of these factors as they exist in the climate of each place which experience has proved to be, or analogy has led us to regard as likely to be, well suited for use as a health resort"; and, to this may be added the statement with which Solly wisely concludes his article upon "Climate" in "Hare's System of Practical Therapeutics": "In selecting a climate for an invalid let us above all remember to examine not only the suitable application of the climatic factors to the disease, but also into the peculiarities of the individual and his attendant circumstances."

A word in conclusion regarding home climates. It is true with climates as with other things, that familiarity often breeds contempt. In looking for a health resort we too often forget the possibilities of our own home climate. In the treatment of phthisis as well as other diseases we can, not infrequently, obtain surprising results by a painstaking utilization of the favorable climatic conditions existing in the patient's own locality.

A judicious arrangement of rooms and verandas so as to obtain the utmost possible sunshine and out-of-door life, ingenuity in providing shelter from the wind, ample ventilation, and an equal attention to the hygienic-dietetic *régime* which we would give in a health resort, with the same assiduous devotion to getting well, may produce as happy results as those obtained in many well-known health resorts.

Therefore the physician or his patient should not give up hope by any manner of means, if the conditions preclude a change of climate. "I can cure consumption in any climate," said Dettweiler. *Edward O. Otis.*

HEALTH, STATE BOARDS OF*.—The recognition of the necessity of general or central boards of health or sanitary organizations in each of the States may be said to date from the middle of the nineteenth century. A resolve of the Massachusetts Legislature of 1849 authorized the governor to appoint a commission whose duty it was to make a sanitary survey of the State and to report upon the same. This extremely thorough and comprehensive document presented a plan of organization for a general or state board of health, and although it was nearly twenty years before such a board was organized, the plan laid down in that report was very closely followed in the act of 1869 which authorized the establishment of a state board of health.

The first three state boards of health were organized in three widely separated States, Louisiana,† Massachusetts, and California, in the order named, and these were followed by the establishment of similar general boards in Virginia, Minnesota, and Michigan. The States and Territories which have thus far established state boards of health, with the dates of their organization, are given in the following list:

Louisiana, 1855.
Massachusetts, June, 1869.
California, March, 1870.
Virginia, February, 1872.
Minnesota, March, 1872.
Michigan, 1873.
Maryland, April, 1874.
Alabama, January, 1875.
Georgia, June, 1875.
Colorado, February, 1876.
Wisconsin, March, 1876.
Mississippi, February, 1877.
New Jersey, March, 1877.
Tennessee, March, 1877.
Illinois, May, 1877.
Connecticut, January, 1878.
Kentucky, March, 1878.
Rhode Island, April, 1878.
South Carolina, December, 1878.
Delaware, 1879.
North Carolina, 1879.
Iowa, March, 1880.
New York, May, 1880.
Arkansas, March, 1881.
Indiana, March, 1881.
West Virginia, March, 1881.
New Hampshire, August, 1881.
Missouri, March, 1883.
Maine, February, 1885.
Kansas, March, 1885.
Pennsylvania, June, 1885.
Ohio, April, 1886.
Vermont, November, 1886.
Florida, February, 1889.
North Dakota, 1889.
Nebraska, March, 1891.
Washington, March, 1891.
Oklahoma, March, 1891.
South Dakota, March, 1891.
Nevada, March, 1893.
New Mexico, February, 1895.
Utah, February, 1898.

In general, it may be said that the work of state boards of health has not been largely of an executive character, but has been eminently didactic, and much good has been accomplished by the publication and distribution of tracts, circulars, and pamphlets, relating to the various departments of sanitary work, and by the holding of frequent conventions or assemblies for the free discussion of sanitary subjects.

As a general rule, state boards do not have authority over local boards in sanitary matters, but in some instances they are authorized to exercise co-ordinate power with local boards in preventing the spread of infectious diseases, either within the limits of municipalities or along the border of other States and countries.

The most important duty of sanitary authorities is the management and control of infectious diseases, and while the state boards of health are, from their essential composition, not so closely in touch with the people as municipal boards, yet they are capable of doing excellent service in educating the people in this important sanitary question. In those States which are the most densely settled, and are of comparatively small area, it has been possible for the general boards to perform a considerable amount of executive work, and to carry out the provisions of such laws as have given them authority to act for the protection of the public health.

In several of the States, notably those of the western part of the Union, the function of regulating the practice of medicine has been added to the more distincive duties of public sanitation.

A valuable summary of the powers and duties of state boards of health as they existed in 1879 may be found in Dr. Billings' Introduction to the volumes on "Hygiene" published in New York by Dr. A. H. Buck. In this summary Dr. Billings says: "The state board of health should be the central supervising authority, having much the same relation to local boards that the local board has to the households. Its functions may be classed as follows: (1) To promote the organization of local and municipal boards; (2) to obtain medical and vital statistics; (3) to investigate the causes of undue sickness and mortality; (4) the removal of these causes, acting as far as possible through the local sanitary authorities; (5) the supervision of the hygiene of state institutions; (6) the supervision of quarantine."

ANNUAL PER CAPITA EXPENDITURE OF STATE BOARDS OF HEALTH IN THE YEAR 1898.

(Population Estimated to 1898.)

Groups.	States and Territories.	Fraction of dollar.	Groups.	States and Territories.	Fraction of dollar.
Over 2 cents	Florida	.0866	Less than 2 mills	West Virginia	.0017
	Vermont	.0301		Missouri	.0016
	Massachusetts	.0236		Kansas	.0015
1 cent to 2 cents	Rhode Island	.0167		Nevada	.0015
	Texas	.0144		Kentucky	.0012
	Mississippi	.0141		South Carolina	.0012—
	Maine	.0112		North Carolina	.0011
	New Hampshire	.0106		Virginia	.0011
	Minnesota	.0105		Pennsylvania	.0010

*Condensed from article in "Past and Present Condition of Public Hygiene and State Medicine in the United States," 1900.

†The Louisiana board created in 1855 could hardly be classed as a state board of health, though so named in its organic act, since it was created almost entirely for the purpose of maintaining a quarantine to protect the city of New Orleans.

ANNUAL PER CAPITA EXPENDITURE OF STATE BOARDS OF HEALTH IN THE YEAR 1898.—*Continued.*

(Population Estimated to 1898.)

Groups.	States and Territories.	Fraction of dollar.	Groups.	States and Territories.	Fraction of dollar.
5 mills to 1 cent	Utah	.0098	Less than 2 mills	South Dakota	.0010—
	Connecticut	.0092		Washington	.0007—
	New Jersey	.0089		Nebraska	.0001
	Delaware	.0070		Arizona	.0000
	New Mexico	.0055		Georgia	.0000
	New York	.0052		Idaho	.0000
	Maryland	.0049	0	Montana	.0000
	Colorado	.0042		Oregon	.0000
	North Dakota	.0040		Wyoming	.0000
	Ohio	.0040			
	Louisiana	.0040			
	Arkansas	.0036			
2 mills to 5 mills.	Michigan	.0035			
	Oklahoma	.0032			
	Tennessee	.0029			
	Wisconsin	.0028			
	California	.0027			
	Iowa	.0023			
	Indiana	.0021 +			
	Illinois	.0021			
	Alabama	.0020			

The preceding table presents the per capita expenditure of each state board of health in 1898, upon an estimated population for that year. The comparatively high expenditure of the Gulf States of Florida, Texas, and Mississippi was employed chiefly for the maintenance of quarantine in preventing the introduction of yellow fever from other States and countries.

Samuel W. Abbott.

HEART.—The heart is a four-chambered hollow muscle, divisible functionally into two parts, each consisting of two chambers, an auricle and a ventricle. The right half of the heart comprises the right auricle which receives the venous blood from the body general through the venæ cavæ, and the right ventricle which receives the blood from the auricle through the auriculo-ventricular orifice, and sends it by the pulmonary artery to the lungs. From the lungs the aërated blood is received by the left auricle through the pulmonary veins, and by it transmitted to the left ventricle through the left auriculo-ventricular orifice, the left ventricle in turn pumping the blood by way of the aorta back again to the body. This pump is supplied with appropriate valves to determine the direction of the blood stream (see *Circulation of the Blood*, Fig. 1328).

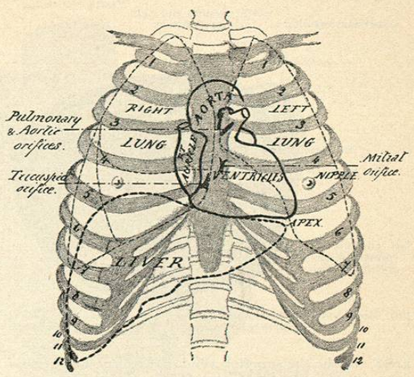

FIG. 2546.—Outline of Heart, Lungs, and Liver to Show their Relations to Each Other and to the Chest Wall. Heusman and Fisher's "Anatomical Outlines."

If the heart be removed from a cadaver that has been preserved by injection with a solution of formalin, which so hardens the tissues that they preserve after removal

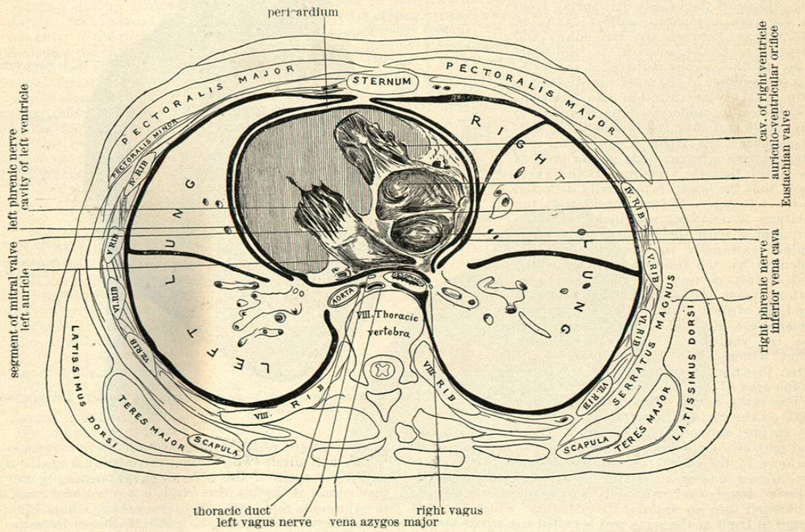

FIG. 2547.—Cross Section of Thorax at Level of Eighth Thoracic Vertebra. (Braune.)

the form they had *in situ*, it is seen to be not so much a conical as a distinctly six-sided organ; the sixth side or upper surface being, however, obscured by the fact that it is almost entirely occupied by the openings of three

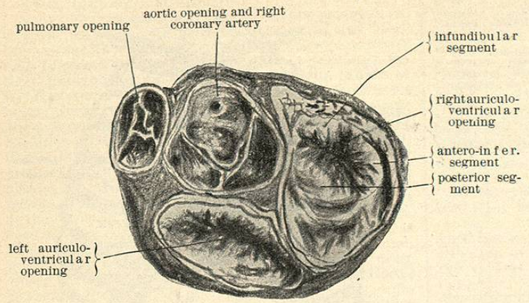

FIG. 2548.—View of Ventricular Orifices, the Auricles and Arteries being Removed Close to the Ventricles. W. Keiller ad naturam del.

great vessels, the superior vena cava, aorta, and pulmonary artery (Fig. 2548 and 2553). Two well-marked grooves are distinguishable on the surface of the organ (Figs. 2549 and 2553): the *auriculo-ventricular groove* which marks the separation of the auricles from the ventricles and lodges the main trunks of the cardiac vessels and corresponding nervous plexuses; and the *interventricular groove* seen on the anterior and inferior surfaces of the heart, which marks the separation of the two ventricles and larger branches of the cardiac vessels. A considerable amount of fat in which the vessels are embedded fills up these grooves and obscures them till dissection makes them more prominent. The heart, with the orifices of the vessels that spring from it, occupies a separate serous cavity in the thorax between the two lungs and pleuræ, called the *pericardium*, the heart with its fibro-serous pericardial sac forming the contents of the middle mediastinum (Fig. 2547). Its situation and relations will be readily understood by reference to Figs. 2546 and 2547, the former being self-explanatory, the latter a horizontal section through a frozen body at the level of the eighth thoracic vertebra. Both figures show that the organ is markedly deflected to the left side. Before considering the relations in detail we will make ourselves acquainted with the excised heart. Examined externally the *auricles* are conspicuous by the thinness of their walls, and mainly occupy the right and posterior aspects of the heart. The *ventricles* are thick-walled, form the greater part of its anterior, left and inferior aspects, and the left ventricle is drawn to a blunt point, which is the meeting place of the three just-named surfaces, and is known as the *apex* of the heart.

The *right auricle* (Figs. 2549, 2550, and 2554) on the surface presents a quadrangular outline, and occupies the whole right and part of the anterior, posterior, inferior, and superior surfaces of the heart. At its posterior inferior angle is the *inferior vena cava;* at its postero-superior angle the *superior vena cava;* while its antero-superior angle is prolonged into an angular diverticulum which extends round in front of the aorta and is called the *auricular appendix*. The anterior limits of the two cavæ are united by a groove on the surface of the auricle called the *sulcus terminalis* (Fig. 2549) which marks off the portion of the auricle formed by union of the two venæ cavæ from that portion which belongs to the primitive auricle. On opening the auricle (Fig. 2550) this latter portion is found to present on its inner surface a large number of branching muscular ridges united by a membrane so thin as to be translucent. Over the right wall of the auricle these ridges are fairly regular and nearly parallel. They extend from a prominent crest, the *crista terminalis* (which corresponds in position to the sulcus terminalis), to the region of the auriculo-ventricular groove and are called *musculi pectinati*. In the appendix they are much branched, and run vertically across its cavity.

The rest of the interior of the auricle is smooth and is called the *sinus venosus*. Its left wall in front is in close contact with the commencement of the aorta, and behind this is formed by the septum between the auricles. Here there is a circular depression where the septum is translucent. This is called the *fossa ovalis*, is about five-eighths of an inch in diameter, and is surrounded, except at its lower part, by a prominent muscular ridge, the *annulus ovalis*. The ridge is specially prominent above, and under it is a deep recess, closed after birth except for an occasional minute canal through which a probe can be passed, but open during fœtal life for the free passage of blood from the right to the left auricle. The opening in the fœtal condition is the *foramen ovale*. At the postero-superior angle of the cavity will be found the orifice of the superior vena cava, large enough to admit the little finger, and unguarded by any valve. At the posterior

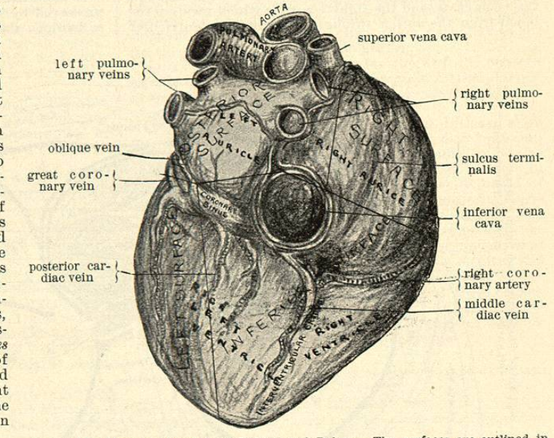

FIG. 2549.—View of Heart from Behind and Below. The surfaces are outlined in black lines. (His; two-thirds.) W. Keiller del.

inferior angle is the orifice of the inferior vena cava, which will admit two fingers. Stretching from the right anterior margin of the inferior caval opening to the anterior limb of the annulus ovalis is a prominent musculo-membranous ridge, the *Eustachian valve*, whose function in the fœtus is evidently to guide the blood from the inferior vena cava through the foramen ovale. Its prominence and constancy in the adult seem to show that though its fœtal function is lost, it still serves an important purpose in directing the intra-auricular blood currents. Its muscular portion consists of a strong bundle

forms the interventricular septum (Fig. 2551). The lower two-thirds of the posterior wall of the right ventricle is occupied by the large *auriculo-ventricular* orifice, the upper third tapering into the conus arteriosus and lying in

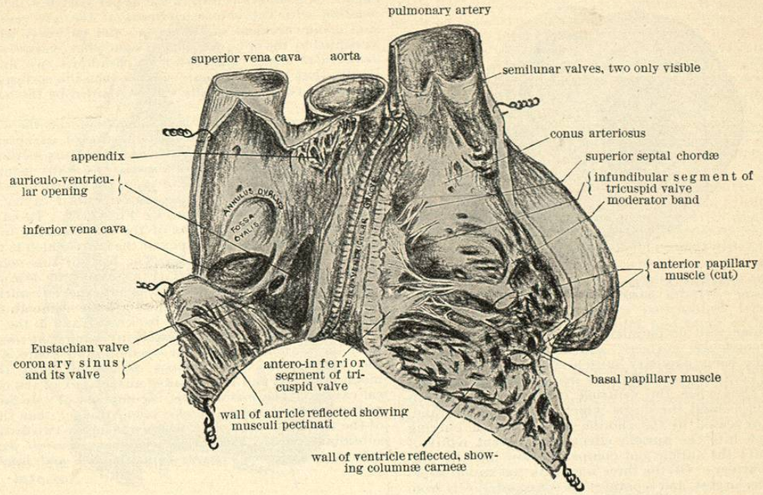

FIG. 2550.—Right Auricle and Ventricle Opened, Somewhat Stretched Out for Better Display. Drawn from nature by W. Keiller, 1901.

of fibres which surround the inferior cava and are attached to the septum, thus possibly constricting the caval opening during auricular systole. On the floor of the auricle, just in front and to the left of the inferior caval opening, is the orifice of the *coronary sinus*, guarded below by a delicate semicircular valve which is frequently fenestrated and is called the *valve of Thebesius*. The antero-inferior angle of the right auricle runs into a large funnel-shaped opening, the *auriculo-ventricular orifice* (Figs. 2548 and 2550). This opening is oval or triangular in shape, readily admits three fingers, and is guarded by the *tricuspid valve*. In addition to these openings there are scattered over the walls of the auricle numerous small pits and little openings called *foramina Thebesii*, some of which are blind depressions, while others are the orifices of small veins.

The *right ventricle* (Figs. 2550, 2553, 2557) occupies the greater part of the anterior surface, and about half the inferior surface of the heart. It practically forms the whole anterior inferior border, but stops short of the left inferior angle of the heart, the so-called apex. When opened it is seen to present a floor and three walls, anterior, left, and posterior, the three walls tapering upward to form a smooth funnel, the *conus arteriosus*, which leads into the pulmonary artery. This orifice is guarded by three semilunar flaps which together form the *pulmonary valve*. The left wall of this cavity is convex, owing to the great thickness of the wall of the left ventricle, and here the blending of the walls of the two ventricles close relation with the aorta. With the exception of the conus arteriosus, the walls of the ventricles are marked by an intricate network of muscular ridges and bands called *columnæ carneæ*, the ridges being mere thickenings of the wall, the bands attached at both extremities and free in the middle. A varying number of these fleshy columns, called *musculi papillares*, end in fibrous string-like bands, the *chordæ tendineæ*, which are attached to the segments of the tricuspid valve. The *tricuspid valve* (Figs. 2548 and 2550), which guards the auriculo-ventricular orifice, is composed of three triangular segments; consisting of fibrous tissue clothed with endocardium, thick at their bases where they are attached around the opening, and thinning off toward their free margins, which are trans-

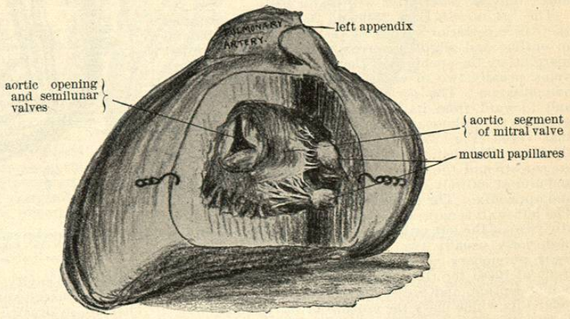

FIG. 2551.—View of Opened Left Ventricle, much Foreshortened. W. Keiller ad naturam del.

lucent and jagged. The extent to which the flaps are separated varies greatly, while sometimes there are small intermediate lobes between the main segments. Branched, thread-like chordæ tendineæ pass from the

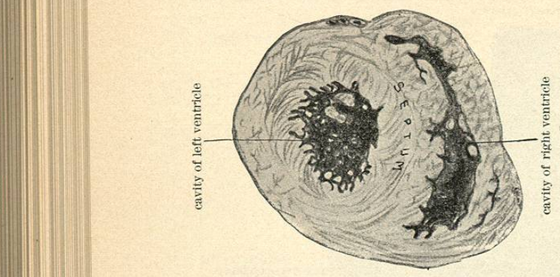

FIG. 2552.—Cross Section of Heart through Ventricles. W. Keiller, ad naturam del.

ventricular wall or papillary muscles to the free margins, ventricular surfaces, and attached bases of the segments, each papillary muscle or group of muscles sending cords to the contiguous margins of two separate flaps. Thus when the ventricle contracts the blood is forced in behind the cusps which come together and, being prevented by the chordæ tendineæ from bulging too much into the auricle, effectively prevent reflux of blood into the auricle and compel its flow into the pulmonary artery. Of the three segments the antero-superior is the largest, and separates the conus arteriosus from the auriculo-ventricular orifice. It is therefore called the infundibular segment. It is smooth on both its auricular and infundibular surfaces. The other segments are placed antero-inferiorly and posteriorly, and the last (being in contact with the septum) is called the septal segment. The *musculi papillares* in the right ventricle vary exceedingly. The best marked springs from the anterior wall and has usually a muscular band of varying thickness, called the *moderator band*, attaching its base to the ventricular septum. It sends chordæ to the infundibular and antero-inferior segments. A group of small papillary muscles occupies the floor and lower part of the septum and supplies chordæ to the contiguous margins of the antero-inferior and septal segments; while from the upper part of the septum, in the conus arteriosus, a few chordæ pass directly without a distinct papillary muscle to the contiguous margins of the infundibular and septal segments. The pulmonary valve is so similar to the aortic that one description will do for both.

The *left auricle* (Figs. 2549 and 2556), which occupies the whole posterior surface of the heart, is quadrilateral in outline and slightly convex. At its right and left margins are the openings of the *right and left pulmonary* veins, usually two of each. They vary greatly in size and situation. The *auricular appendix* extends upward and forward from its left superior angle and slightly overlaps the pulmonary artery in front and to the left of that vessel (Fig. 2553). The left auricle is somewhat thicker-walled than the right. On the interior the walls are smooth and the musculi pectinati are few and short and almost entirely confined to a small part of the roof and appendix. The posterior wall and floor are smooth. The left wall is narrow and presents the openings (usually two) of the left pulmonary veins; the right wall has posteriorly usually two, seldom three openings of the right pulmonary veins; none of these has valves. In front of these the right wall is formed by the interauricular septum, and presents superiorly one or two semilunar slits which mark the remains of the foramen ovale. They correspond in position to the upper part of the fossa ovalis and one of these may be still patulous. In five average specimens before me the foramen is not completely closed in any one, but an oblique slit varying from .01 to 1 cm. long occupies its place, and there is no evidence of the last having caused any cardiac embarrassment. The anterior wall in the upper part lies in close relation with the conus arteriosus of the left ventricle and commencement of the aorta; and its lower half is occupied by the obliquely placed somewhat oval *auriculo-ventricular orifice* (Fig. 2548) which admits two fingers easily, thus being distinctly smaller than the corresponding orifice on the right side. It is guarded by the *mitral valve.*

The *left ventricle* (Figs. 2555 and 2551) forms the whole left surface of the heart, a small portion of its anterior, and about half its inferior surfaces. On cross section its outline is seen to be almost circular, its walls being at least twice as thick as those of the right ventricle, which therefore moulds itself to the thicker-walled cavity and assumes a crescentic outline (see Fig. 2552). Its cavity is long and conical, the apex of the cone running to the extremity of the so-called apex of the heart which is thus formed by the left ventricle. The base of this conical cavity presents two orifices (Fig. 2551), the lower of which points backward and opens into the left auricle, and is guarded by the *mitral valve;* while a smooth funnel-like portion runs upward, backward, and to the left into the *aortic opening*, this last being somewhat smaller than the auriculo-ventricular opening, and guarded by the *aortic valve.* The *columnæ carneæ* are short, thin, much branched and best marked at the apex of the conical cavity. The *mitral valve* is composed of two large, well-marked segments, thicker and stronger than those of the tricuspid valve, and between them are two distinct subsidiary flaps. Two large prominent *musculi papillares,* springing respectively from the left and inferior

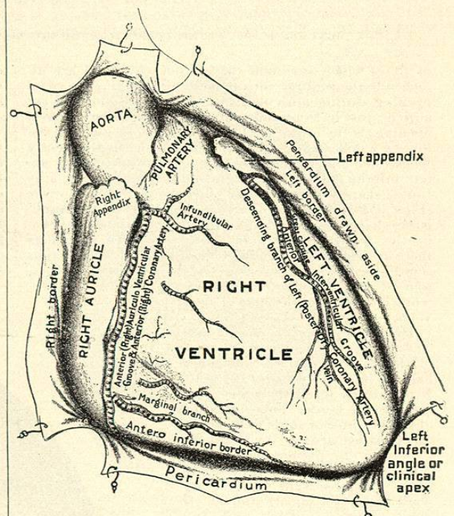

FIG. 2553.—Anterior Surface of the Heart, Pericardium Opened. W. Keiller ad naturam del.

walls of the cavity, send chordæ tendineæ to the upper and lower margins of the valvular segments respectively. They are so situated that when contracted with the ventricular systole they pull the margins of the segments together. Of these two segments, the anterior or *aortic*

segment separates the auriculo-ventricular from the aortic orifice (Fig. 2551), and is smooth on both its auricular and its ventricular surfaces, the chordæ being attached to its margins only. The *aortic valve* is composed of three

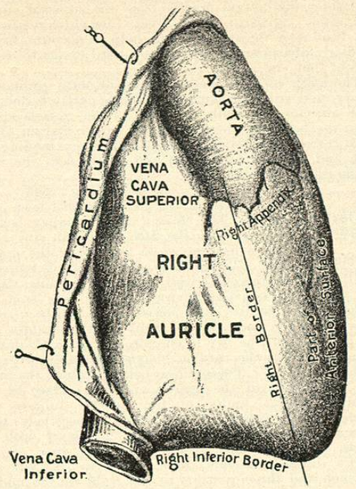

FIG. 2554.—Right Surface of the Heart. W. Keiller ad naturam del.

semicircular or semilunar folds of fibrous tissue lined below by the endocardium and above by the intima of the aorta. Their convex margins are attached to the ring round the aortic orifice, and their straight edges are free. Thus three pouches are formed open toward the aorta, into which the blood flows when the systole passes off, and thus brings the three segments together so as effectively to stop regurgitation of blood into the ventricle. The aortic wall bulges slightly at each pouch, and each bulging is named a *sinus of Valsalva.* These sinuses in the aorta are arranged, one anteriorly, two posteriorly, and from the anterior sinus springs the *right coronary artery* (Fig. 2548), while the *left coronary artery* springs from the left posterior sinus. Each segment of the valve has at the middle of its free edge a fibrous nodule, the *corpus or nodulus Arantii*, toward which the stronger fibres radiate so as to leave an exceedingly thin, sometimes fenestrated lunated margin on either side of it, called the *lunula.* The free margin of the valve is strengthened by a fibrous band. The portion of the ventricle which leads up to the aortic orifice is so strengthened by fibrous or fibro-cartilaginous tissue as to remain uncollapsed during diastole. The septum between the ventricles is thick and muscular, except for a small area where the aorta springs from the septum. This is the *pars membranacea* of the septum, and here a congenital defect in the septum may cause an abnormal communication between the ventricles.

Relations and Surfaces of the Heart.—As has been already pointed out, the heart is a six-sided or cuboidal body, presenting anterior, right, left, posterior, inferior, and superior surfaces. The *anterior* surface (Fig. 2553) is the first which meets the eye when the thorax is opened. It is triangular in shape, the apex of the triangle being completed by the merging of its upper limit into the aorta and pulmonary artery. It is slightly convex and is directed forward and a little upward, being in sagittal mesial section parallel with the sternum. In it are included the greater part of the right ventricle and portions of the left ventricle, left auricular appendix, right appendix, and part of the right auricle. It is bounded below by the sharp, almost straight *antero-inferior* border (*margo acutus*, inferior border of clinicians), on the right by the nearly vertical and convex *right anterior* border (right border of clinicians), and on the left by the oblique, convex, and slightly rounded *left anterior border* (left border of clinicians). Its left inferior angle forms the *clinical apex. Relations:* Separated from it by the pericardium (Fig. 2547) are the margins of the lungs and pleuræ, sterno-pericardial ligaments, triangularis sterni, internal mammary vessels and sternum, with the fourth, fifth, and sixth left costal cartilages.

The *right surface* (Fig. 2554) is markedly convex, four-sided, lies almost vertically, and is directed toward the right. It is composed of the greater part of the right auricle. Its anterior, posterior, and inferior borders are only slightly rounded and are therefore well defined. At its superior extremity the surface blends with the wall of the vena cava superior and its posterior inferior angle is similarly related to the vena cava inferior. *Relations* (Fig. 2547): It is separated by pericardium from the phrenic nerve and vessels, pleura, and inner surface of right lung.

The *left surface* (Fig. 2555) is a convex triangular area directed mainly upward and toward the left. It includes about one-half of the free surface of the left ventricle and left auricular appendix. It is separated from the anterior surface by the left anterior border; from the

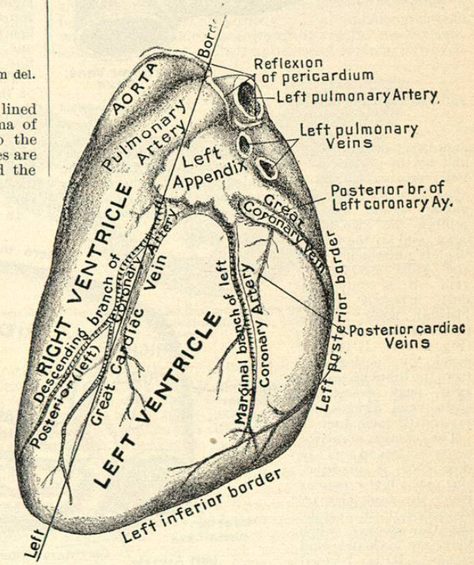

FIG. 2555.—Left Surface of the Heart. W. Keiller ad naturam del.

inferior surface by a rather sharp left inferior border; and behind it is bounded by the left pulmonary veins and left auriculo-ventricular groove, with the great coronary vein embedded therein. *Relations* (Fig. 2547): It is separated by the pericardium from the left phrenic

nerve and vessels, left pleura, and inner surface of left lung.

The *posterior surface* (Fig. 2556) is called the base in text-book descriptions. It is four-sided, convex, vertical,

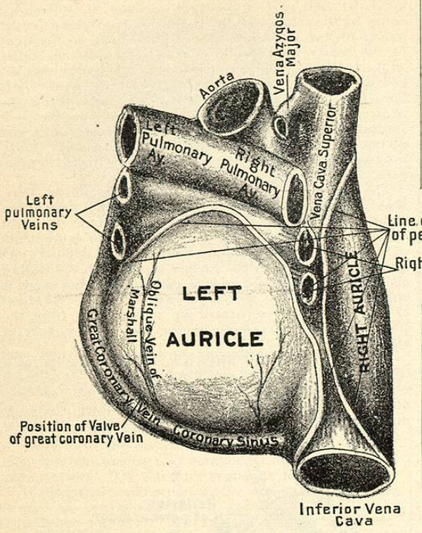

FIG. 2556.—Posterior Surface of the Heart. W. Keiller ad naturam del.

and directed backward. It is formed by the left auricle, and by the portion of the right auricle which joins the two venæ cavæ, and is bounded below by the inferior vena cava and coronary sinus, above by the right pulmonary artery, on the right by a fairly defined border joining the two venæ cavæ, and on the left by the left pulmonary veins and great coronary vein. It is only partially invested by the visceral layer of the pericardium. *Relations* (Fig. 2547): It is separated by pericardium from the bronchi, œsophagus, vagi, descending aorta, vena azygos major and thoracic duct.

The *inferior, diaphragmatic surface or true base* (Fig. 2557) is quadrilateral, slightly convex when the ventricles are distended or in systole, slightly concave when they are relaxed and empty. It is directed downward and a little backward and toward the right, and is bounded by rather sharp and well-defined borders. It includes a small portion of the right auricle and opening of the inferior vena cava, the rest of the surface being about equally divided between the right and left ventricles.

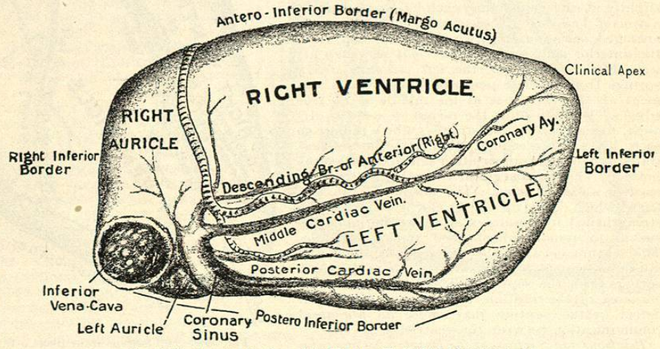

FIG. 2557.—Inferior Surface of the Heart. W. Keiller ad naturam del.

Behind the inferior vena cava is seen a small portion of the left auricle. It presents the inferior extremities of the right and left auriculo-ventricular grooves, and the inferior interventricular groove. *Relations* (Fig. 2546): It is separated by the central tendon of the diaphragm and some diaphragm muscle from the superior surface (impressio cardiaca) of the liver. Its close relation to the fundus of the stomach will help to account for the cardiac embarrassment apt to be caused by acute distention of that viscus.

The *upper surface* gives origin to the aorta, pulmonary artery, and superior vena cava, and is partly formed by both auricles, especially the left. These vessels spring from the heart on a level with the upper margin of the third costosternal articulation, along a line extending one inch and one-half to the left and one inch to the right of the middle line.

Superficial indications (Fig. 2546): The *upper limit* of the heart has just been indicated. The *clinical apex*, or apex beat, is felt between the fifth and sixth ribs, three and a half inches to the left of the middle line. The *antero-inferior border* is indicated on the chest wall by an oblique line, slightly convex downward, extending from the clinical apex on the left, across and slightly upward to a point one inch to the right of the middle line at the level of the sixth chondro-sternal articulation. Along this line the cardiac blends insensibly with the hepatic dulness. These lines being drawn, the *right and left borders* of the heart's anterior surface or the absolute lateral limits of the heart's dulness will be defined by convex lines joining respectively their right and left extremities. Thus, on a level with the fourth chondrosternal articulations, the area of the heart's dulness extends three inches to the left and one inch and three-quarters to the right of the middle line.

The *pulmonary* and *aortic valves* lie behind the left half of the sternum on a level with the lower border of the third costal cartilage. The *right auriculo-ventricular* opening lies behind the sternum on a level with the fourth intercostal space and fifth cartilage. The *left opening* is a little higher and more to the left. (Compare Figs. 2546 and 2548, it being remembered that the surface represented in Fig. 2548 lies obliquely so as to point very decidedly toward the right).

In children the heart is relatively broader and projects more to the left than in the adult, and the apex beat may be in line with the nipple or external to it.

Structure of the Heart.—The heart is invested externally by a fibro-serous membrane, the *epicardium*, under which

lies, especially along the interventricular and auriculo-ventricular grooves, a variable amount of fat with the main trunks of the cardiac vessels embedded therein. Its cavities are lined internally by a smooth endothelial lining, supported by a delicate fibrous membrane (the *endocardium*); the main substance of the heart is composed of muscular tissue (*myocardium*), the intricate arrangement of whose fibres will be found described under the heading *Circulation of the Blood* (Vol. III., p. 105). The valves are avascular and composed of fibrous tissue with an endocardial lining; while in the region of the ventricular orifices are fibrous rings, and between the aorta and auriculo-ventricular orifices there is a central fibro-cartilage.

Blood-Vessels of the Heart.—The *right coronary artery* (Figs. 2548, 2553, and 2557) arises from the anterior sinus of Valsalva, passes forward between the pulmonary artery and right appendix, and follows the right auriculo-ventricular groove till it reaches the inferior interventricular groove where it divides into two branches, of which the smaller *transverse* or *auriculo-ventricular* branch continues in the left auriculo-ventricular groove for some little distance, and the larger *descending* (or better, *interventricular*) branch follows the inferior interventricular groove, supplying both ventricles and the septum. This vessel in its course supplies the right auricle and ventricle, aorta and pulmonary artery. Besides the terminals it gives off two named branches, an *infundibular* branch to the front of the right conus arteriosus, and a *marginal* branch which follows the antero-inferior border to the apex. The *left coronary artery* (Figs. 2553 and 2555) arises from the left sinus of Valsalva, passes behind and then to the left of the pulmonary artery, and appears between that vessel and the left auricular appendix. Here it divides into two branches, the *anterior descending* or *interventricular* branch following the anterior interventricular groove to the apex of the heart; the *transverse* or *auriculo-ventricular* branch following the left auriculo-ventricular groove. A considerable marginal branch follows the left anterior border of the heart. It supplies the aorta, pulmonary artery, left auricle, and ventricle. The two vessels anastomose minutely with each other on the heart and with the pericardial and bronchial vessels on the walls of the aorta and pulmonary artery.

The great cardiac or coronary vein, commencing near the apex of the heart (Fig. 2553), accompanies the interventricular branch of the left coronary artery in the anterior interventricular groove; beneath the left appendix it curves backward in the auriculo-ventricular groove and joins the left end of the coronary sinus (Fig. 2556) where its opening is guarded by a valve. Three or four veins, called *posterior cardiac*, but better called left and inferior cardiac veins, course over the left and inferior surfaces of the left ventricle, joining the great coronary vein and coronary sinus. The *middle cardiac vein* (Fig. 2557), commences at the apex of the heart and follows the inferior interventricular groove with the descending (interventricular) branch of the right coronary artery. It joins the right extremity of the coronary sinus. The *small* or *right coronary vein* (Fig. 2557) runs toward the left in the right auriculo-ventricular groove to join the right end of the coronary sinus. The *coronary sinus*, about one inch in length, occupies the inferior extremity of the left auriculo-ventricular groove (Fig. 2557). It receives the veins above mentioned, all of which are guarded by valves where they join the sinus; and empties into the right auricle in front of the inferior canal opening. Its opening is guarded by the valve of Thebesius (Fig. 2550). In addition to the above a small vein, the *oblique vein* of Marshall, runs downward and over the back of the left ventricle to join the coronary sinus (Fig. 2556). This vein is interesting inasmuch as it, with the coronary sinus, represents the left superior cava of the embryo.

The *anterior cardiac veins* are two or three small veins which pass from the anterior surface of the right ventricle directly into the right auricle. They have no valves. Minute veins (the *venæ cordis minimæ*) open directly into the auricle and ventricles.

Lymphatics.—The cardiac lymphatics, found in great number beneath the lining membranes, open into both the right lymphatic and the thoracic ducts. The former are interrupted in a gland which lies between the aorta and the trachea.

The cardiac nerves are described in the article on the *Circulation of the Blood* (Vol. III., p. 113).

William Keiller.

HEART, DEVELOPMENT OF THE.—The vertebrate heart arises in two distinct ways, each of which is intimately associated with the origin of the blood-vessels in general. In the lower vertebrates its first appearance is in the form of a single tube on the ventral median line of the embryo, quite near the head. Fig. 2558 is a section of a salamander embryo in which the heart is just beginning to form. The body cavity, *lh*, is composed of two lateral halves (see *Cœlom*) separated from each other by a median septum. It is in this septum that the heart first makes its appearance. The two layers which contain this septum become separated, and the opening soon becomes lined with a layer of cells, *end*, the endocardium. The cells of the septum surrounding the opening give rise to the muscle walls of the heart.

In higher vertebrates the heart is first formed by the union of two tubes arising from what may be called the outside of the body. Fig. 2559 is a surface view of a young rabbit embryo in which the heart is beginning to form on either side of the body. The omphalomesenteric veins on either side run toward the ventral median line, and later on unite. Their appearance is such, however,

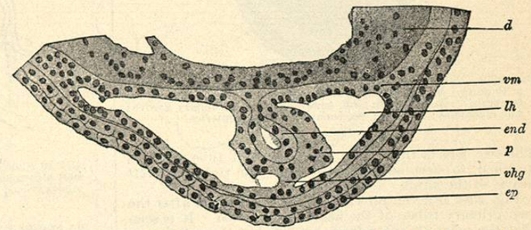

FIG. 2558.—Section through a Salamander Embryo, to Show the Origin of the Heart. (From Hertwig, after Rabl.) *d*, Yolk; *vm*, pericardium; *lh*, body cavity; *end*, endocardium; *p*, muscle layer of the heart; *ep*, epidermis.

that before they are united they may be spoken of as two hearts. Fig. 2560 is from a section through an embryo of the same stage as that pictured in Fig. 2559. The neural canal, *rf*, is just beginning to close, and in the splanchnopleure on either side there is a large fold, *ahh*, which already contains the endothelial tube coming from the omphalomesenteric vein. The tubes grow toward the median lines, but before they unite each has its descending aorta, as shown in Fig. 2561. The rudimentary hearts are formed between the splanchnopleure and entoderm, and as the former surrounds the heart to form its muscular layer the heart protrudes into the cœlomic cavity (Fig. 2560), much as does the single heart of lower vertebrates (Fig. 2558). Soon the two halves unite as indicated in Fig. 2561, and then we have a single heart with two veins entering from behind and two arteries, aortæ, leaving from in front. Although this primary division has nothing whatever to do with the later separation of the heart into its two halves, yet before the two primary hearts are united into a single tube the position