it is also true that gastroptosis itself renders difficult and delayed the expulsion of food; hence distention and dilatation. Yet gastroptosis is frequent without dilatation, surprisingly frequent in young females without gastric symptoms or signs, and with no changes in the gastric secretion. Corsets are a common cause of this; kyphosis and scoliokyphosis have the same effect.

The more nearly vertical the stomach is, *i.e.*, the farther down the pylorus has descended, so much the more difficulty—as Kussmaul long ago pointed out and figured—has the stomach in emptying itself; and the fundus diminishes in capacity while the pyloric region increases. This leads to actual kinking in the lesser curvature and necessary retention, atony, and dilatation. Cases so extreme as that shown in Fig. 4553 are very rare. More common are the subvertical, or the loop-shaped displacements. All gradations occur, but never a descent of the entire organ, except in marked displacement downward of the entire diaphragm.

Etiology.—The very great variety of forms of displacement makes it very unlikely that one single cause accounts for all cases (as Glénard believed); and, what is more important, there are many cases of enteroptosis without any relaxation of the hepatico-colic ligament. Riegel believes that gastroptosis results from the stomach's accommodating itself to changes in the space conditions in the abdomen, by whatsoever process brought about.

Diagnosis.—The condition is far oftener overlooked than recognized, mainly because we emphasize chemical tests and the position of the lower border, neglecting the motor power and the *site of the pylorus and of the lesser curvature.* Palpation and percussion alone almost never give accurately a diagnosis of gastroptosis. Percussion, after the patient has drunk water, gives information concerning the lower border, but it is not sufficient for a diagnosis of either displacement or enlargement.

There is only one method which is accurate and easy of performance, and that is inspection, with perhaps palpation and percussion, after inflation.

Electric transillumination is more complex and offers no greater accuracy.

Gastroptosis promptly affects other organs, and first, as a rule, the right kidney. In wellnigh all marked cases of gastroptosis, of any standing, one can readily feel the moving kidney, either the rounded lower extremity leaving its normal position a trifle, or nearly the entire organ which one can grasp and control, or the whole kidney which one can seize and move over a large area. A freely movable kidney does not prove the presence of a mesonephron, for this latter is very rare, while the former is fairly common.

The liver, too, comes in for displacement, in the recognition of which one must pay particular attention to the upper border as in the case of the stomach.

The colon, particularly the transverse colon, is frequently found similarly displaced, as may be demonstrated by rectal injections of air or water.

The etiology is fully discussed in the article on *Enteroptosis*, in The Appendix.

Symptoms.—Kussmaul believed that the nervous manifestations produced the motor insufficiency, Glénard the reverse. Most authorities now hold that gastroptosis plays an important part in causing nervous symptoms. There remains the fact that in persons having gastroptosis and other displacements, symptoms of gastric distress, as well as nervous, hysterical, or neurasthenic symptoms, are frequent, though such symptoms occur without gastroptosis, and vice versa. Gastroptosis and these symptoms belong as a rule to women only. If such nervous symptoms depended on gastroptosis we would expect to find them in the few males who suffer from gastroptosis, but Bial found that of the males with the complaint, fifty per cent. had no subjective symptoms. For this reason Riegel believes that a suitable disposition on the part of the central nervous system is essential to the production of these symptoms.

Gastroptosis itself has a train of symptoms—*e.g.*, a sense of fulness and weight after meals, an increase of the length of time required for digestion, eructations of gas a long time after meals, borborygmi, especially on the left side, and generally relieved by removing tight clothing. It not uncommonly leads to motor insufficiency, while the chemistry in the stomach is likewise sometimes disturbed. The chemical changes, however, are not always directly due to the displacement. The motor insufficiency, however, does lead to retention, fermentation, and gas, all of which rarely irritates the mucous membrane and affects the secretion. Much oftener the altered secretion is a complication. This gastroptosis is accompanied sometimes by increased, sometimes by diminished secretion. So chlorosis often has with it hyperchlorhydria. But hyperchlorhydria and gastroptosis, though associated, are independent, and both or either may accompany chlorosis.

Treatment.—The treatment of this displacement is multiform. Those examples which are due to the wearing of constricting clothing are preventable. After parturition a great deal can be done by aiding the abdominal muscles, combating tympanites, opening the bowels regularly, keeping the patient supine till the abdominal muscles are fit to do their work. The treatment of the gastroptosis itself, as of nephroptosis, is largely mechanical, and a well-fitting belt or properly adjusted corset gives great comfort and distinct assistance. Some mild cases are cured by the horizontal position assumed in the treatment of some other complaint. The German "fat cures" do increase the fat, but aid more probably by the horizontal position being more frequently chosen. In acute cases, lying down with the clothes loosened may be definitely prescribed.

The diet is all-important and should be light and dry, given in small amounts, easily digested and nourishing; for example, eggs, milk, cocoa, junket, toast, meat in small quantity, and greatly restricted carbohydrates; but it should always be adapted to the gastric juice in the individual case, as made out by chemical examination.

Surgeons have obtained good results by folding and stitching the enlarged and displaced stomach, reefing it in as it were, but results are not as yet satisfactory enough to warrant operative procedure in all cases that give symptoms.

Charles F. Martin.
F. Morley Fry.

STOMACH, THE SHAPE, POSITION, AND MOVEMENTS OF.—The best method of studying the form and size of the stomach is to remove the organ as soon after death as possible, to inflate it with air, then to tie off both extremities and permit it to dry. By this method the stomach is usually slightly overdistended, and attains a size not quite reached during life. The usual form of the stomach is represented by Fig. 4554, and cannot easily be described by a phrase. The part to the left of the œsophageal orifice is called the fundus; that part which lies nearest the pylorus is called the antrum pylori. The right half of the stomach is called the pyloric half; that to the left the cardiac half. The stomach is exceedingly variable in shape. When empty it contracts, and after a prolonged fast of many hours it may be almost cylindrical in shape. This cylindrical appearance is most marked in the pyloric half, so that this portion of the stomach may markedly resemble the transverse colon in contour. The same condition of the pyloric half may be found at the autopsy if death has occurred during the height of digestion. It is not uncommon, under such circumstances, to find a constriction near the middle of the stomach, separating in a greater or less degree the cardiac from the pyloric half.

The measurement of about two hundred adult stomachs gives the following average dimensions: Length, 25.5 cm.; vertical diameter, 12.5 cm.; antero-posterior diameter, 11.9 cm.

The length is a trifle more than twice the height, or as 100 to 49; the height is to the antero-posterior diameter as 100 to 95. Berry and Crawford state that the antero-

posterior never exceeds the vertical diameter. I have found the antero-posterior diameter longer not infrequently, especially in very young children, and it may be that as the children grow older the vertical diameter develops more rapidly than the antero-posterior one.

The vertical diameter is subject to very marked variations; it may be so great as almost to

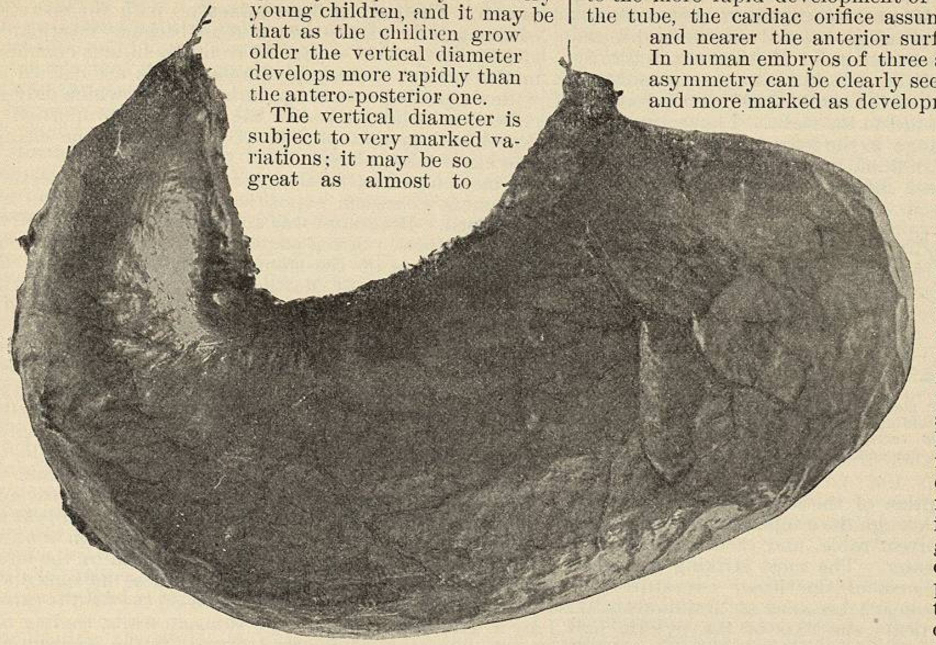


Fig. 4554.—Normal Adult Stomach.

equal the long diameter, or, on the other hand, it may be very short. The fundus also varies greatly. Nearly one-half of the stomach may lie to the left of the cardiac orifice; or the fundus may be altogether wanting. As an average the part to the left of the œsophagus is a little more than one-fourth of the total length of the stomach. This proportion holds true for all ages, from early fœtal life to old age. I have examined many fœtal and infantile stomachs, and cannot detect any peculiarities of outline belonging to any particular age. The fundus is developed very early in fœtal life, often as early as the third month of utero-gestation; and fœtal stomachs present as many variations of shape as do adult stomachs. If an inflated stomach is examined on its upper surface it will be noticed that the œsophagus does not enter the stomach at a point equidistant from its anterior and posterior surfaces. The cardiac orifice is invariably much nearer the anterior than the posterior wall of the stomach (see Fig. 4555). This asymmetry of insertion is constantly present, occurring in all the stomachs, both fœtal and adult, which I have examined; but it varies considerably in degree. In general it may be stated that about two-thirds of the antero-posterior diameter lies behind the cardiac orifice, and one-third in front. Rarely is the orifice very near the centre of the antero-posterior diameter; never at the centre or behind it.

An explanation of this anatomical peculiarity may be found by attention to the development of the stomach. Originally the stomach is a simple tubular prolongation of the œsophagus. In human embryos of the sixth week the form is no longer cylindrical. The posterior surface of the tube (that directed to the spinal column) bulges considerably (greater curvature); the anterior surface is slightly depressed (lesser curvature). During the third month the stomach undergoes decided change in position. In the first place it twists on its sagittal axis in such a manner that the long axis of the stomach instead of lying parallel with the spinal column thereafter lies obliquely, the fundus thereby moving to the left of the median line, the pylorus to the right.

In the second place, a twist occurs in the long axis of the stomach and lower part of the œsophagus in such a way that what was the left side becomes the anterior one; what was toward the right turns backward. Owing to the more rapid development of the posterior part of the tube, the cardiac orifice assumes a position nearer and nearer the anterior surface of the stomach. In human embryos of three and four months this asymmetry can be clearly seen, and becomes more and more marked as development progresses.

Position.—A simple way to study the position of the stomach is to make an œsophagotomy as soon after death as possible, to introduce a rubber tube through the orifice into the stomach, and then to fill the organ with water. When this method is employed the cardiac orifice is always found on the left side of the body in front of the tenth dorsal vertebra. It is there held firmly in position. The greater curvature ascending from this point rises as a rule to the upper border of the sixth rib in the anterior axillary line, sometimes so high as the fifth rib, causing the fundus to lie behind the heart. The greater curvature then sweeps around, descends vertically a short distance, then turns in its descent to the right, passing the free border of the ribs on about the level of the junction of the ninth and tenth ribs, runs from one to three inches above the umbilicus, and finally turns up and to the right to reach the pylorus.

The pylorus in the male lies as a rule on the body of the first lumbar vertebra, 4–6 cm. to the right of the median line. It is always more or less movable, usually not more than 2 cm. in any direction. The pylorus lies 6–8 cm. lower than the cardia, and about the same distance to the right of it. It is evident that the lesser curvature, which is the shortest line of the stomach connecting the cardia with the pylorus, must run, taking its course as a whole, downward and to the right. It would seem easy to describe the main axis of the stomach from these data, but matters are confused by the different degrees of distention in which the stomach is seen. I have called attention above to the contracted appearance of the stomach after a several days' fast. In these cases the long axis of the stomach runs directly from above and to the left, downward to the right, and the position of the stomach is unequivocally oblique.

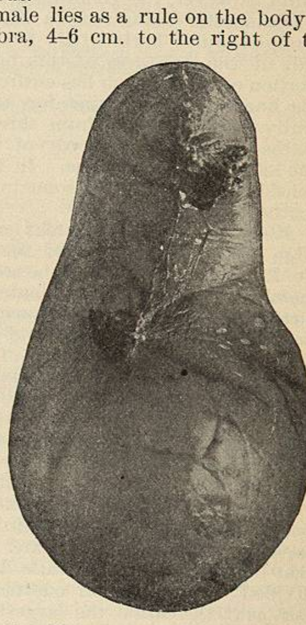
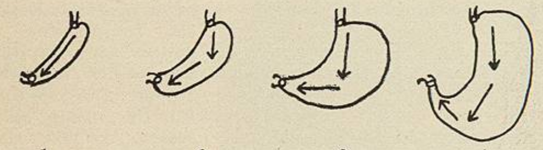


Fig. 4555.—Stomach of Three-Year-Old Male, seen from Above.

When the stomach fills it sinks slightly in the abdominal cavity, the greater curvature is rounded out, the lesser curvature becomes more acutely curved, and the long axis seems divided into two parts, the first part almost vertical, the second running obliquely downward to the right, and sometimes horizontal. If the stomach is fully distended the axis of the pyloric half runs upward and to the right, the axis of the cardiac half running at first vertical, then downward to the right. I have attempted to illustrate this change in the long axis of the stomach as the latter fills with fluid, by means of diagrammatic drawings made from life. Any one can verify the



1. 2. 3. 4.

FIG. 4556.—1, Contracted stomach; axis obliquely down and to the right; 2, stomach containing water; axis vertical, then oblique; 3, full stomach; axis vertical, then horizontal; 4, distended stomach; axis vertical, descending obliquely, ascending obliquely.

truth of this conception of the axis of the stomach by introducing a tube through the œsophagus into the stomach on the post-mortem table, and then watching the stomach fill with water. The most striking change is the increasing acuteness of the lesser curvature; the upper part of the stomach becomes at first doubtfully, then positively vertical; the axis of the pyloric half changes from obliquely descending to horizontal and finally to obliquely ascending (see Fig. 4556).

It is usually stated that the stomach in infants has a more vertical position than in adults. This is in the main true, but the bald statement is likely to give rise to misunderstanding. In a small proportion of infants the pylorus lies in the median line, or at least nearer the median line than in adults; but in the great majority of instances there is no decided difference. In young infants, however, the pyloric part of the stomach is relatively shorter than later in life, and it runs usually a straight course horizontally from left to right. As a result of the shortness of this horizontal part, the main portion of the stomach lies entirely to the left of the middle line, and appears therefore to be vertical. It is generally estimated that from three-fourths (Boas) to five-sixths (Hemmeter, Vierordt) of the adult stomach lies to the left of the middle line. In infants this proportion is considerably greater; in some instances so much as nine-tenths.

Movements.—The first great contribution to our knowledge of the movements of the stomach was made by Sir E. Home. He studied the stomachs of man and other mammals, and also experimented on dogs. His favorite method was to remove the stomach as soon after death as possible, turn it inside out, and thus gain an insight into the ante-mortem appearance of the stomach and of its mucous membrane. The following literal quotations from his writings will show how nearly his conclusions agree with those of later investigators. He says: "The true carnivorous stomach, as well as the human, which in its structure is closely allied to it, I found capable of dividing its cavity into two distinct portions by a transverse contraction of its coats, in which state the cardiac portion is, in length, two-thirds of the whole, but in capacity much greater." Later he writes: "I found also that the dog's stomach while digestion is going on was divided by a muscular contraction into two portions; that next the cardia the largest, and usually containing a quantity of liquid in which there was some solid food, but the other which extended to the pylorus being filled entirely with half-digested food of a uniform consistence."

"From these experiments the following facts are ascertained: That while the process of digestion is going on in the cavity of the stomach, it is divided by means of a muscular contraction of its coats into two portions; that the first receives the solids and fluids taken in by the mouth. The food is there mixed up with the secretion of the gastric glands and mucus, becomes coagulated, and by that means separated from the liquids contained in the cavity; these superfluous liquids are carried off without passing into the pyloric portion, which only receives the solid food with the necessary proportion of liquid, and in that portion of the stomach the change into chyle takes place."

Nineteen years after the appearance of Home's lectures Beaumont's classical exposition of gastric digestion was published. Beaumont was acquainted with the observations of Home. Seven pages of his treatise are devoted to the motions of the stomach. In his studies of the stomach of Alexis St. Martin he also clearly saw that the splenic and pyloric halves of the stomach had very different functions, and with great minuteness he described the mechanical processes in each part as he saw them. According to Beaumont there are two kinds of movement in the splenic half of the stomach, one causing the food to travel along a definite path, the other triturating or grinding the food and causing it to be intimately mixed. The food on entering the stomach turns to the left from the cardiac orifice, passes into the splenic extremity, follows the greater curvature to the pyloric end, and then returns along the lesser curvature to repeat the revolution again and again. Each revolution requires from one to three minutes and is produced by the circular muscles of the stomach. While these movements of the food are in progress trituration of the food is caused by a grinding motion of the stomach walls, leading to a perfect mixture of the food already in the stomach and the newly swallowed food. All of these movements are slow at first, but become more rapid as digestion progresses; the contractile force is increased in every direction, and the contained fluids are thereby given an impulse toward the pylorus. This is accomplished by the longitudinal fibres of the central and splenic parts of the stomach, aided by the circular fibres.

It is probable that, from the very moment food is received into the stomach, portions of chyme are constantly passing into the duodenum, slowly at first, more rapidly as digestion progresses. The pyloric end of the stomach can be shut off from the rest of the organ by the peculiar action of the transverse muscle, or rather of the *transverse band* (previously described, according to Beaumont, by Spallanzani, Haller, Cooper, Sir E. Home, and others). During digestion this band of circular muscle fibres alternately contracts and relaxes (at irregular intervals of from two to four or five minutes), temporarily dividing the cavity of the stomach into two parts, a cardiac half in which the food is being gently agitated and mixed, and a pyloric half which firmly presses upon the food, forcing it toward the pylorus. The action of the pyloric end can best be described in Beaumont's own words: "The longitudinal muscles of the whole stomach with the assistance of the transverse ones of the splenic and central portions carry the contents into the pyloric extremity. The circular or transverse muscles contract progressively from left to right. When the impulse arrives at the transverse band this is excited to a more forcible contraction, and, closing upon the alimentary matter and fluids contained in the pyloric end, prevents their regurgitation. The muscles of the pyloric end now contracting upon the contents detained there separate and expel some portion of the chyme. It appears that the crude food excites the contractile power of the pylorus so as to prevent its passage into the duodenum, while the thinner chymified portion is pressed through the valve into the intestine. After the contractile impulse is carried to the pyloric extremity the circular band and all the transverse muscles become relaxed and a contraction commences in a reverse direction from right to left, and carries the contents again to the splenic extremity to undergo similar revolutions."

Very little has our knowledge of the movements of the

stomach advanced since Beaumont's observations were published. During the past fifteen years numerous experiments have been made on dogs without bringing many facts to light. Examination with the *x*-ray has been an exceedingly valuable means of extending our knowledge, and Cannon's contribution has been the most notable one since Beaumont's on the subject of the movements of the stomach.

The more important of the observations on dogs are here briefly reviewed: Hofmeister and Schütz removed the stomachs from freshly killed dogs and noted two kinds of contraction: (1) Very slight peristaltic waves traversing the cardiac half and most pronounced at the beginning of the antrum pylori; (2) vigorous contractions of the pyloric half which becomes entirely shut off at the antrum pylori from the cardiac half. These contractions narrow and shorten the pyloric end and press the food against the pylorus, which closes tightly. Only when solid particles are pressed against the pylorus is there any real antiperistaltic wave in the sense of Beaumont (*vide supra*).

Rossbach observed on dogs that, during digestion, no peristaltic waves of any kind occur in the fundal portion of the stomach, which simply remains passively contracted upon its contents. Peristaltic movements always begin at about the middle of the stomach and take twenty seconds to extend from there to the pylorus. This contraction of the pyloric half is so violent that it completely obliterates the lumen of that portion of the stomach. Rossbach noted that the pylorus remains closed during the whole process of digestion (from four to eight hours), and then the food is propelled into the duodenum in little jets.

Von Mering also states that the stomach of the dog empties itself rhythmically, contractions occurring every twenty seconds.

Moritz made duodenal fistulæ in dogs. He observed that water begins to be forced into the duodenum almost immediately after its ingestion, and that all the water leaves the stomach at latest twenty to thirty minutes after it is swallowed, being squirted into the duodenum rhythmically. Moritz, by manometric observations in the human stomach, showed that no peristaltic contractions occur in the cardiac half, but that rhythmic waves occur in the pyloric extremity.

Roux and Balthazard by means of the *x*-ray studied the movements of the stomach in dogs and men. They noted that the stomach during digestion is divided into a splenic and a pyloric part; that peristaltic contractions occur almost immediately after food is swallowed; that peristaltic waves pass over the stomach in man from left to right, traversing the stomach in twenty seconds, and recurring with great regularity every fifteen to twenty seconds.

Cannon has published the most extensive and valuable observations with the *x*-ray. He experimented on cats. The cats were starved for twelve hours, and were then fed on dry bread made pulpy with milk or gravy or hot water, and mixed with varying proportions of bismuth subnitrate. Within five minutes after food is taken a few constriction waves pass over the extreme pyloric end of the stomach. Two to three minutes later the stomach begins to be constricted near the middle, and slight peristaltic waves originate there and pass to the pylorus. As digestion proceeds the antrum pylori elongates, the depressions grow deeper, the peristaltic waves recurring with almost clock-like precision every ten seconds, and requiring thirty-six seconds to travel from the middle of the stomach to the pylorus. During digestion the cardiac half of the stomach acts as an active reservoir; the walls contract as the food gradually passes on into the pyloric half. There are no currents of food in the fundus. The part of the stomach which narrows its calibre first is the middle of the stomach, the so-called preantral portion. To the left the contractions of the fundus force the food very sluggishly onward into the preantrum, which in turn contracts much more vigorously, squeezing the food into the antrum pylori. In the antrum the food is thoroughly triturated and mixed with the gastric secretions, and expelled thence into the duodenum with considerable power. Ten to fifteen minutes after peristalsis begins food enters the duodenum. It is often squirted with force 2–3 cm. beyond the pylorus. Not every constriction wave forces food into the duodenum, except toward the end of digestion. One hour after food was given Cannon noted that three waves in succession forced food through the pylorus; then no food passed during eight subsequent waves; the next wave again forced food through; the next two did not; the next four waves again expelled food; then followed three ineffectual waves, and thus the food was squirted into the duodenum at rather irregular intervals.

The pylorus usually though not always stops solid particles, and often these are shot back with considerable rapidity several centimetres along the antrum. Occasionally solid pellets enter the duodenum. There is no true antiperistalsis. The food in its path from fundus to pylorus is not moved progressively forward. It follows a zigzag course forward and backward, requiring in the cat nine to twelve minutes to reach the pylorus after having reached the zone where the peristaltic waves affect it.

During vomiting the pyloric antrum contracts violently, expelling its contents into the relaxed fundal half, from where it is forced by contraction of the abdominal muscles into the œsophagus.

Henry Wald Bettmann.

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STOMATITIS. See *Mouth, Diseases of,* in the APPENDIX.

STOOLS. See *Fæces.*

STORAX (*Styrax*, U. S. P., P. G.; *Styrax Præparatus*, B. P.; *Styrax liquide*, Cod. Med.) is a balsam prepared from the inner bark of *Liquidamber orientalis* Miller (fam. *Hamamelidaceæ*). This balsam is a disease product, resulting from wounds inflicted upon the bark of the medium-sized tree named above, which resembles the sweet-gum tree (*L. Styraciflua* L.) of the Eastern United States.

The styrax tree occupies a limited area in the south-western districts of Asia Minor, where it forms forests. It is collected by bruising, and after some time removing the outer bark, then scraping off and boiling the inner bark with sea water. The oleoresin thus melted out rises to the top and is skimmed off. By pressure, an additional amount can be obtained from the remaining bark.

Storax is a semi-liquid, gray, sticky, opaque mass, depositing, on standing, a heavier dark-brown stratum; transparent in thin layers, and having an agreeable odor and a balsamic taste. Insoluble in water, but completely soluble (with the exception of accidental impurities) in an equal weight of warm alcohol. If the alcoholic solution, which has an acid reaction, is cooled, filtered, and evaporated, it should leave not less than seventy per cent. of the original weight of the balsam, in the form of a brown, semi-liquid residue, almost completely soluble in ether and in carbon disulphide, but insoluble in benzin. When heated on a water-bath, storax becomes more fluid, and if it be then agitated with warm benzin, the supernatant liquid, on being decanted and allowed to cool, will be colorless, and will deposit white crystals of cinnamic acid and cinnamic ethers. This balsam consists principally of an amorphous substance named *storesin*. It also contains several *cinnamic ethers* and *cinnamate of cinnamyl* (styracin), which can be prepared in rectangular prisms, and *cinnamic acid* and *styrol*.

Storax goes principally to the East, very little being used in European pharmacy; in its action it varies very little from a number of other balsamic substances; internally it has been used in bronchitis and similar conditions with but moderate success. As an ingredient of liniments, ointments, etc., it is quite useful. The compound tincture of benzoin contains eight per cent. of storax. Dose of storax, from three to five drops.

ALLIED PLANTS.—The Sweet Gum Tree, *Liquidamber Styraciflua* L., resembles the above species and supplies a non-drying sticky balsam resembling storax in medicinal properties, although not in color or opacity.

Henry H. Rusby.

STORM LAKE MINERAL SPRING.—Buena Vista County, Iowa.

POST-OFFICE.—Storm Lake. Good hotel accommodations.

This spring is located one mile from the village of Storm Lake, at an elevation of 900 feet above the Mississippi River. The surrounding country is level, and not especially interesting. The temperature ranges from about 70° F. in summer (average) to zero in winter. The following analysis is by Walter L. Brown, analytical chemist, of Chicago: One United States gallon contains (solids): Sodium chloride, gr. 0.18; potassium sulphate, gr. 3.02; sodium sulphate gr. 3.22; calcium sulphate, gr. 35.12; magnesium sulphate, gr. 3.40; magnesium bicarbonate, gr. 10.78; silica, gr. 3.56; iron oxide and alumina, gr. 0.18; organic matter, a trace. Total, 59.46 grains. There is also present a large amount of free carbonic-acid gas. The water is said to be efficacious in diseases of the liver, bowels, and kidneys.

James K. Crook.

STRABISMUS, or **SQUINT,** is that condition in which the visual axes are not both directed toward the point looked at. It causes diplopia, and the eyes may be seen to be turned in different directions.

Diplopia arising from strabismus is binocular, and is noticed only when light from the object looked at forms a sensible image on each retina; and when the visual centres are so related to each other as to possess the power of binocular fusion.

Normally, when a certain point is looked at, its image in each eye falls on the fovea; and the two produce the idea of a single point. When, however, the point looked at makes its impression on the fovea in one eye, but on

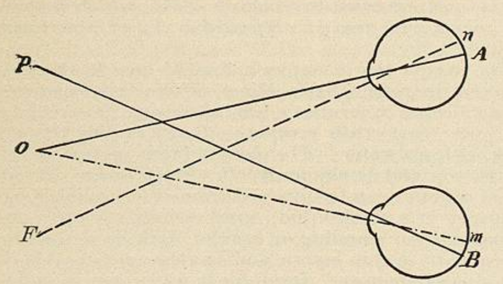

FIG. 4557.

some other portion of the retina in the other, it generates the idea of two distinct points some distance apart, the impression on the fovea being referred to a point directly in front of the eyes, while the impression on another part of the retina is referred in a different direction. Thus, in Fig. 4557, representing a case of convergent strabismus, the visual axis of the eye A being directed to the object O, the visual axis of the eye B is directed elsewhere, to P.

In the eye A the impression of the point O will be made at the fovea; but in the eye B the light from O, entering in the direction of the broken line $O\,m$, will make its im-

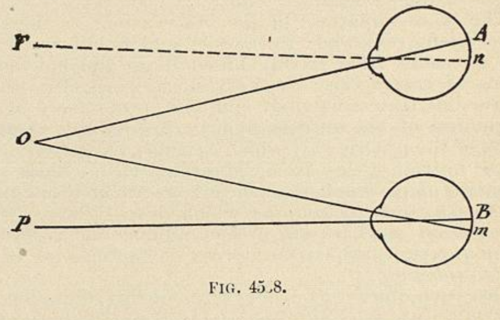

FIG. 45.8.

pression on the point m, some distance from the fovea. Since the impression is made on A at the fovea, it will be correctly referred to the object looked at. But in B the impression made at m will be referred to a point to one side of the object looked at; its position relative to O being in the direction $n\,F$, which makes the same angle with the visual axis of A as $O\,m$ makes with the visual axis of B. The image of the point received on A, and referred to its true position O, is called the *true image*. The image received at m, and referred to F, in the direction $n\,F$, is called the *false image*.

In Fig. 4558, representing what occurs in divergent squint, the eye A, turned toward the object O, receives on its fovea the true image, which is referred to its proper source; and the eye B receives at m the false image, which, with reference to the true image, is referred in the direction $n\,F$ to F.

In general, *in whichever direction the squinting eye deviates, its false image appears to be situated to the opposite side of the true one.* When the image on the right belongs to the right eye, it is called *homonymous diplopia*. It occurs when the visual axes are crossed as in Fig. 4557. When the image on the right belongs to the left eye and the image seen to the left belongs to the right eye, it is *crossed diplopia*. This is represented in Fig. 4558, and occurs in divergent squint. To determine which image belongs to the right eye, and which to the left, cover one eye and the image belonging to it will instantly disappear. Or place before one eye a piece of colored glass, when the image belonging to that eye will appear colored.

Objective Symptoms.—If the squint be well marked, inspection will reveal the defect, and show which eye deviates. But there is a possibility of error. We judge of the direction of the visual axis by the direction of the cornea. Usually the visual axis pierces the cornea near its centre. But sometimes the visual axis deviates, so that, when properly directed, the centre of the cornea will be turned considerably to one side, and the eye will appear to squint.

To determine whether the eye really does squint, direct the patient to gaze steadily at a certain object, and cover first one eye and then the other. If both eyes are properly directed, there will be no change of position when either one is covered. If one eye have its visual axis turned elsewhere, covering it will not cause any change of position; but covering the eye which has been directed toward the object will cause the eyes or head to be turned, so that the eye which had looked elsewhere may now fix on the object. If, however, both eyes have been fixed on the object, but only by an undue effort, the covered eye will deviate and take such position as can be preserved without the undue effort. The test should be repeated until the observer is satisfied as to the presence or absence of squint. Having ascertained that squint is

actually present, the first point to be settled is whether it is *comitant* (concomitant) or *paralytic*.

COMITANT STRABISMUS is a wrong, and usually variable, co-ordination of the movements of the eyes with reference to each other, without marked limitation of these movements in any particular direction. It commonly appears in early childhood; but may exist from birth, and more rarely begins during adult life.

Convergent squint is the most common form of comitant strabismus. In it the visual axes converge to a point nearer the eye than the one looked at, as in Fig. 4557. In it the diplopia is homonymous, and on covering the eye which is fixed on the object it turns in toward the nose, while the other turns from the nose and fixes the object.

Divergent squint comes next to the convergent in frequency. In this form the visual axes do not converge enough, either meeting at some point beyond the object looked at, or remaining parallel or even divergent. The diplopia is crossed. When the fixing eye is covered it turns out, and the other eye turns toward the nose and fixes the object. When the visual axes remain always divergent, the squint is said to be *absolutely divergent*. When the visual axes can be made to converge, but not enough, as in Fig. 4558, the squint is *relatively divergent*.

Parallel squint is applied to those cases in which the visual axes remain parallel when they should converge.

Vertical squint, in which one visual axis is directed more upward or more downward than the other, is rare, except as complicating one of the other forms of comitant squint.

Constant squint is always present, the visual axes never assuming normal relations. Opposed to it is *periodic* or *intermittent squint*, which is only present part of the time.

Periodic squint is apt to be most marked when the general tone of the nervous system is low, or at times of great excitement, or when the eyes are particularly taxed. A form of convergent squint, appearing only during strong effort of the accommodation, is called *accommodative squint*. Squint due to clonic spasm is *convulsive squint*. Closely allied to convulsive is *hysterical squint*.

Monolateral or *monocular squint* is the form in which it is always the same eye that fixes on the object looked at, while the other eye always deviates. If the fixing eye be covered it will deviate, while the ordinarily deviating eye fixes; but, upon uncovering, the deviation is soon transferred back to the eye which habitually presents it. The large majority of cases of comitant strabismus are in this sense monolateral. But it must not be supposed that only the deviating eye is at fault. The squint is a faulty co-ordination of the motions of the two eyes, and one eye deviates because the fixing eye has better vision, or sees with less effort.

Alternating squint is the variety in which the deviation is sometimes presented by one eye, and sometimes by the other; either of them becoming the fixing eye when the other is covered, and continuing to fix after the other is uncovered again.

Absence of Binocular Fusion.—Most persons with squint do not experience double vision. In some cases it is quite obvious why there is no diplopia, as where corneal opacity, or a high degree of ametropia, prevents the formation of a retinal image in the deviating eye. In other cases the reason is less obvious, yet not hard to understand; as here, although the deviating eye presents no abnormal appearance, the acuteness of vision is very low. But there is still another class of cases in which, although each eye is used, it is as an independent organ. What is called the power of binocular fusion or association is lacking.

Amblyopia with Squint.—In many cases of squint there is great defect of vision in one eye without any visible cause for it. This may be due to invisible defects in the cerebral connections of the eye, in which case it may be a cause of squint. It may also be due to failure to develop visual power through disuse, *amblyopia ex anopsia*. Or there may even have been deterioration of vision, by suppression, to prevent annoyance from diplopia.

Causes of Comitant Squint.—When binocular fusion is especially difficult or impossible, or the tendency to it unusually feeble, as where the vision of one or both eyes is very imperfect, the orbital muscles never attain that normal development which enables them to keep the visual axes properly directed to the point looked at. Anything which impairs the development of the visual centres or the acuteness of vision—as hereditary anomalies, convulsions, prolonged nutritive disorders, injury of the eyeball, keratitis, or high ametropia—becomes a cause of squint. But ametropia has an especial share in the causation of squint, as was first pointed out by Donders. Normally, the exertion of the power of accommodation is accompanied by convergence of the visual axes; the full power of the accommodation cannot be exerted without strong convergence. Hence in hyperopia, where the accommodation must be exerted more strongly, there is a special tendency to excessive convergence.

In myopia the need for complete relaxation of the accommodation, even when a near object is looked at, may lead to deficient convergence of the visual axes, or divergent squint. In myopia of high degree there is also antero-posterior elongation of the globe, which is often very marked. This makes the eyeball an oval, fitting in an oval socket, in which it cannot be turned without changing the shape or direction of the socket, by actual displacement of the orbital tissue. Hence convergence of the myopic eye requires excessive effort, while myopia, restricting the range of distinct vision, requires that the convergence should be especially great. In the highest degrees of myopia, the effort at convergence is abandoned, and a divergent strabismus permitted. This is at first relative and periodic, but, if associated with deficiencies of muscular development, is very likely to become absolute and constant.

Treatment of Comitant Squint.—The preventive treatment would include all measures favoring the normal development of the general nervous and muscular systems, or calculated to improve the acuteness of vision. Both to influence the acuteness of vision, and to give the normal accommodation and range of distinct vision, *errors of refraction are to be corrected.* In convergent squint with hyperopia, the convex lenses fully correcting the latter should be worn constantly. They should be carefully determined and put on at the earliest date possible. Children of two or three years will wear accurate correcting lenses with the greatest benefit. To make the necessary measurements for lenses, and to enforce their use, it is advisable to place the eyes under the influence of a *mydriatic*, as: Atropine sulphate, gr. i.; distilled water, ℥ ij.—one drop to be placed in each eye three times a day. This should be kept up for some time after the squint has disappeared, or for some weeks, until it is clearly demonstrated that the deviation is not being favorably influenced by it.

The mydriatic acts by paralyzing the accommodation, and so preventing any attempt to use it which may bring about excess of convergence. Care must be taken that the solution used is strong enough, and is efficiently applied. If only enough of the mydriatic is instilled to somewhat weaken the accommodation, the effect will be not to prevent, but to increase the accommodative effort, and therefore the accompanying convergence.

In myopia concave lenses, correcting it, may be used to prevent divergent squint; or, if the squint is already established, to bring about convergence.

As aiding in the proper development of the muscles concerned, what are called *orthoptic exercises* are recommended. They consist usually in looking through some form of stereoscope at lines, letters, or figures, a part of each being seen by one eye, and the remainder being presented to the other eye; by an effort these are to be fused into one picture. A reading bar or a ruler may be placed vertically between the page and the eye. The ruler cuts off a part of the page for each eye, but by using both eyes all parts may be seen. The reading of each line