median surface of the hemispheres as far as the supercallosal fissure. There may be a slight interval between the frontal set and the others, or a smaller vein may here occur; otherwise they are all fairly equidistant. There are usually six to eight large trunks on each side. These veins tend to empty into the sinus in pairs. This is less marked in the frontal set. It is most easily demonstrable in the fœtus, owing to the absence of Pacchionian bodies, or thickening, adhesions, etc., at the border of the convexity. The last pair ends in the sinus some 3 to 5 cm. before the torcular. The second or third pair from the last may be somewhat larger than the others, and then represent the so-called anastomotic vein, though its size is quite as much due to the greater width of the brain in this part. Although Labbé says this vein runs along the postcentral fissure, it is probably identical with Krause's fetal *vena sulci centralis*. Moreover, each supercerebral vein is double, also best seen in the fœtus.

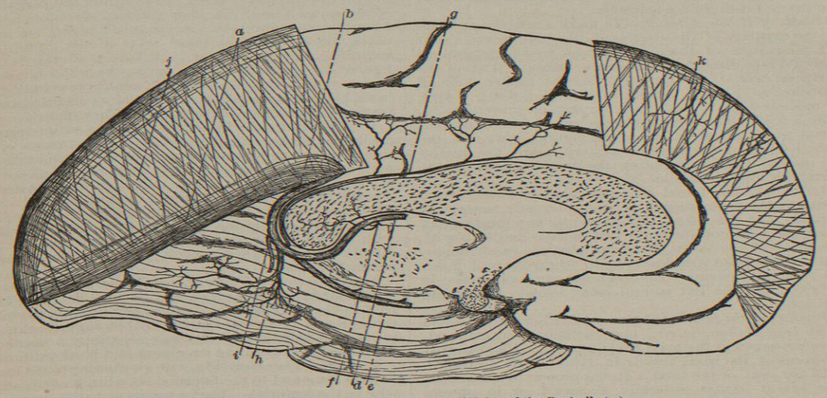

FIG. 819.—The Vena Galeni. (From the author's "Veins of the Brain," etc.)

The two constituent veins are of unequal size, the larger external one coming from the convexity, the smaller inner one coming from the median surface (of hemisphere). They may soon unite to one trunk, but generally, in their further course to the sinus, they lie side by side within a common sheath, and do not lose their integrity as independent conduits until about to open into the sinus. Commonly some of the paired, as well as their constituent double veins, are wanting to complete the diagram.

The frontal set take a course very nearly at right angles to the sinus, or the first of them may even run caudad along the sinus before discharging. They usually spring over to the dura a couple of centimetres away from the sinus. This point has since been more carefully gone over by Mittenzweig. In 200 cases he found 59 in which the presupracerebals (to only 9 in which the postsupracerebrals) jumped over from the piarachnoid to the dura at 3 to 4 cm. from the long sinus —thus favoring their rupture, as he thinks. Farther along the sinus the veins take a more and more oblique course until they at last run forward a distance of 3 or 4 cm., to discharge against the current. At the border of the convexity, or farther out in the pia, the vein makes the necessary bend to approach the sinus as described. It then runs a short distance in the pia, becomes in the fœtus a free trunk for a further short length, and finishes its course in the dura.

Again, the frontal set open at the lateral angle of the sinus, while the others open more and more at the side, and the last quite at the bottom of the sinus, even coming up a distance through the falx.

Toward their field of derivation these trunks pursue an indifferently parallel course. In general, over the cortical area the finest veinlets are richly distributed everywhere, from the bottom of the fissures to the crest of the convolutions.

B. *The Internal System, Tributary to the Tentorial Sinus.*—Along its course this mesal sinus receives only unimportant, mostly dural, veinlets. At its commencement there may be two affluents: (*a*) the falcial sinus: (*b*) the vena Galeni.

(*a*) The inconstant *falcial sinus* also receives only dural twigs in its course, but at its commencement—opposite the frontal border of middle third of callosum—*may* take up a small vein or veins coming from the frontal third of the callosum, and from the bordering convolutions.

Labbé calls this the *interhemispheric vein*, and says that the 1 to 2 cm. long veinule bifurcates, sending one branch to either side. A parallel term, *mesolobica*, was given by Breschet to the precerebral vein.

(*b*) *Vena Galeni*. This discharges through a slit in the basal wall of the sinus, just caudad of the free border of the tentorium. The name is now limited to the short (1 cm. long, 6 mm. broad) trunk from the union of the velar veins to the sinus. Within, it is often divided by a longitudinal septum.

The course of Galen's vein and that of the adjacent portion of the velars is very peculiar. The vessels sink a little after crossing the optic lobes, then encircle the splenium, and become subtentorial before ending in the sinus. The latter bears the relation thereto of a tangent to a circle (*vide* Fig. 819).

Galen's vein does not usually receive any lateral affluents. It arises from the union of the right and left *velar veins*. Each of these consists of two portions, a terminal bent part (*portio curvata*, Fig. 820, *c c*) from the conarium to the vena Galeni, and a peripheral, or cœlian, straight part (*portio recta*) from the origin of these veins, opposite the foramen of Monro. The two curved portions start and end together, but midway diverge 0.5 cm.; they receive laterally many large branches. The straight portions run parallel and adjacent, but receive only few and small additions.

The affluents to the portio curvata are largely of cortical origin; (1) v. suboccipitalis; (2) v. supercerebellaris;

(3) v. callosalis; (4) v. subcerebralis; (5) vv. optici et conarialis; (6) v. postcornualis.

1. The *Suboccipital* vein (Fig. 819, *b*) comes from the collateral fissure and median portion of the suboccipital surface of the cerebrum.

2. The *Supercerebellar* vein (Fig. 819, *h*), oftener a single trunk, but occasionally bilateral, empties into the main vein near its termination, or even directly into the sinus tentorialis. It starts from many little branches over the dorsal surface of the cerebellum, the supervermis, and in its further course takes up small veins from the crura cerebri, and at times also from the optic lobes.

3. The *Callosal* vein (Figs. 819 and 820, *g*) (first mentioned by Labbé, 1879, then independently described by the writer in 1884) may be either single or bilateral. It is a small but long vessel, and the only one emptying on the concave side of the portio curvata. Its origin is near the middle of the callosum, and dorsad as far as the callosal fissure. It runs caudad at the bottom of the longitudinal fissure, and curves around the splenium close to Galen's vein. In animals (sheep) its size almost equals that of Galen's vein.

4. The *Subcerebral* (Fig. 819, *e*) is a large vein, though its derivative territory is very variable. It forms by the union of many branches—collectively termed *Prebasal Veins*—opposite the preperforated space. The prebasilars include the first five next following:

(1) The *Precerebral* vein takes nearly the same path, but is too small and uncertain to be well compared to the precerebral artery. Its derivative area is very much less. It comes around the genu to the base, where it passes before the chiasm to the subcerebral vein. The right and left are usually of unequal size, but communicate, though by an insignificant branch compared to the arterial precommunicant. The two veins may also unite before the chiasm and pass to one of the subcerebrals, in which case there are one or more slight connections in front of the chiasm with the other subcerebral vein. This vein receives branches from the genu and adjacent median frontal surface.

(2) The *Olfactory* is a tiny veinule, very constant, and demonstrable as far as the olfactory bulb.

(3) *Subfrontals*. One of these is frequently more developed, and may empty instead directly into the Sylvian or the medicerebral vein.

(4) The *Sylvian* vein, as shown by the writer, is distinct from and a variable complement of the medicerebral vein (*vide infra*). *It lies at the bottom of the basi-Sylvian fissure*, covered up, except near its termination, by the tip of the temporal lobe. It arises in the region of the insula from a great number of radicles. When the medicerebral is poorly represented, the Sylvian may take up twigs from the surface of the temporal and frontal lobes; some of the venæ perforantes pass, as a rule, to this vein. There is here often a group of perforantes, separated from the others and coming from the brain substance caudad of the veins.

(5) The *Venæ Preperforantes* are small, very variable in number, and take a straight course for a short distance before splitting up. They come from the striate nuclei and adjacent frontal albalis. Their radicles approximate those of the precornual veins, yet without observable anastomoses.

(6) The subcerebral vein receives, in its course obliquely across the optic tracts and crura cerebri, several small veinules from the chiasm, infundibulum, mammillary bodies, crura, etc. These anastomose freely with one another, and with those of the other side, thus making an outstretched network over these parts which connect on the one hand with a small network before the chiasm, and on the other with that across the pons. This corresponds in general to what Labbé terms the inferior interhemispheric veins. Frequently there are accessory veinules from the basal temporal surface.

(7) The *Subcornual* vein, in that it comes from the end of the middle horn, is comparable to the prechoroid artery. It is very constant in occurrence, but not in size. Though connected with the choroid plexus of the medicornu, it originates in the cerebral substance, sometimes even from the lateral wall of the postcornu, oftener opposite the caudad border of the thalamus, where branches are received from the albalis lateral to the thalamus or from other directions. In its course along the lateral wall of the horn it receives many accessions, notably from the cornu Ammonis, and as it curves around the end of the horn several twigs from the albalis of the temporal apex.

(8) *Postperforant*, at least one considerable veinule. The post-perforating veins come, according to Hédon, from the cinerea of the walls of the diacœle, and even from the mesal surface of the thalamus. He also claims that in the striate nuclei the perforating veins anastomose with those going toward the cavities and Galen's system. He further recognizes the communications in the medicornu between the choroidal and the infracornual veins.

(9) *Crural* branches, one in particular, can be followed along the crus to the cerebellum.

5. The fine *Conarial* vein and variable *Optic* twigs often end in the supercerebellar vein instead of directly in the velar. They originate in a fine venous plexus over the optic lobes and conarium, which appears to be connected across the crura cerebri with the basal network described above.

6. The *Postcornual* vein is variable, complementary in derivation to the subcornual. It may arise in the albalis near the tip of the occipital lobe, and then runs subependymal along the cornual wall. The parathalamic branches above ascribed to the subcornual, and some from the Ammon's horn, pass often in part to the postcornual. The radiate radicles of this vein are traceable through the albalis nearly to the cortex (Fig. 820, *q*, *q*).

There is frequently another vein intermediary between (7) and 6, emptying into either the subcerebral or the postcornual.

The straight portion of the velar vein in its course through the velum receives the following, all at right angles:

1. The *Splenial* veins (Fig. 819, *f*) are very small, and but two or three in number as they come out through the fornix. They often combine with thalamic radicles and empty as one trunk into the velar.

2. The *Thalamo-Crural* vein, usually one on each side, but sometimes multiple (Fig. 820, *m*, *m*). This begins about the cerebral crus, makes its way dorsad and mesad through the thalamus, and joins the portio recta at about its middle point. It approaches the ventral side of the velar, and hence is but too easily overseen. Neither 1 nor 2 runs any length in the velum.

3. The *Thalamic* veinules are very variable in size, number, and position. They may even be entirely wanting, or run to neighboring veins, *e.g.*, the postcornual. These arise only to a limited extent in the thalamus; they come chiefly from the albalis beyond, running across or a trifle embedded in it. Where one of these is specially large it might be termed the *Transthalamic*.

Opposite or toward the apex of the thalamus, the velar vein is formed by the immediate or mediate union of several small trunks. Most of these are in a cluster coming in laterally between thalamus and striatum; the latter nucleus appears much richer in veins than the former. Of all but the first, the intracœlial course of these veins is subependymal.

1. The *Medicornual* vein (Fig. 820, *l*) takes a sinuous course in the outer edge of the choroid plexus, of about double the actual distance. Its membranous envelopment makes it a counterpart of the pia veins, and hence the actual continuation of the velar, as held by Bell. It begins in the middle horn, where it is said to anastomose with the subcornual. It comes out of the horn with the plexus, bends to follow the lateral thalamic border, and ends in any one of the veins near the commencement of the velar. Meanwhile it receives a multitude of radicles from the plexus, and some that seem to come from the surface of the thalamus.

2. The *Tænial* vein comes from the thalamo-striatal

groove, beneath the tænia. Nevertheless it has few tributaries from the thalamus. This short trunk is made up by three sets of veinules: (*a*) *Striatal*. Of these

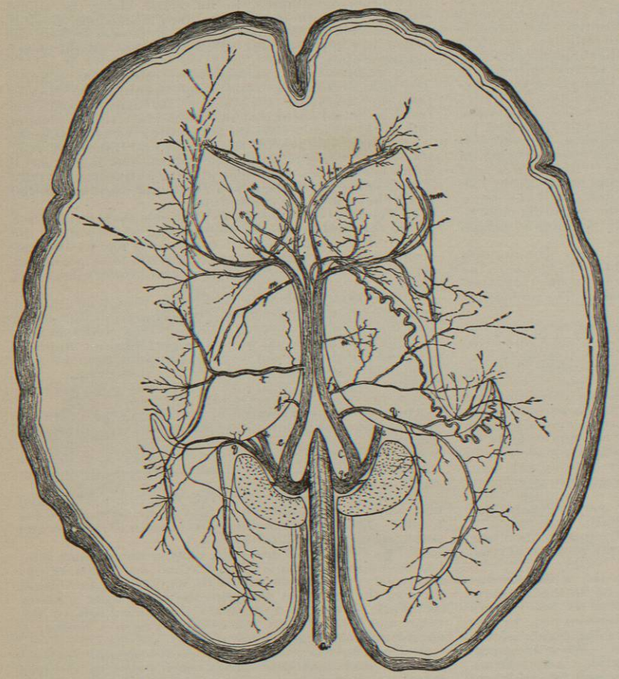

FIG. 820.—The Cœlian Veins. (From the author's "Veins of the Brain," etc.)

there are usually two or three larger and several smaller branches, coming from the substance and surface of the caudate, and passing to the tænial trunk or to either of the following: (*b*) A prealbal trend of veinules, passing along the outer cœlian border toward the precornu, and thence largely to the albalis of the frontal lobe. (*c*) An opposite trend, directly caudad, a short distance along the outer cœlian wall, and coming from the lenticular nucleus, the internal and external capsules, and the superimposed portion of the centrum semiovale. Many of these various albal radicles can be followed almost to the cortex; their angles of union are acute.

3. The *Paraseptal* trunk (Fig. 820, *o*, *o*). This short vessel, with its two constituent *Precornual* veins, is the most direct continuation of the velar. Laterally it receives small *Septal* and *Genual* accessions. There are usually two parallel precornuals (*p*, *p*). They come from the extremity of the horn and follow its contour around to the septum, or run in the adjacent border of the caudate, though they take up no important radicles from that nucleus. Their multitude of radicles come from the albalis in the basal portion of the frontal lobe, also demonstrable nearly to the cortex.

4. The *Superalbals* (Fig. 820, *n*, *n*) are commonly two small trunks that appear at the outer border of the cœle, opposite the body of the caudate, cross the latter, and empty through the tænial or paraseptal trunk. They come from the cœlian roof, and the frontal and parietal albalis dorsad of those previously described.

C. *Basal Veins* (Fig. 821).—These do not constitute a system in the sense of having a common point of discharge—in fact, they have already been described in part under Subcerebral Vein. Although they are quite irregular in termination—small veins seem occasionally to end at any point in the basal sinuses—still there are four frequent points of discharge: (1) Cavernous and (sphenoidal) sinus; (2) superpetrosal sinus; (3) middle of lateral sinus; (4) some sinus about the foramen magnum.

1. Some small veins from the pituitary body and other structures about the sella turcica have been described as tributary to the vene circle of Ridley. But the largest vein discharging at this point is the *Medicerebral*, a superficial vessel following the Sylvian fissure. This should be distinguished from the smaller though complementary Sylvian vein coursing at the bottom of the fissure. The medicerebral is inclined to be double, *i.e.*, there are then two parallel adjacent veins, one taking up frontal branches, the other only temporal. In this case one vein may receive some of the prebasals above described and empty into the sphenoidal or the cavernous sinus, while the other runs meso-caudad in the dura across the temporal fossa to the middle of the superpetrosal sinus. This latter is the course that the whole medicerebral vein takes in many cases, as Trolard rightly says; the dural portion may be termed the *Temporal Sinus*; by one or two lateral orifices it communicates with the medidural veins which it crosses.

2. The discharge of the subcerebral vein through the vein of Galen, as given above, holds for about one-half the cases—not always alike on the two sides. The main trunk may be diminished by the termination of some of its usual prebasal constituents in the cavernous sinus or medicerebral vein. Whether larger or smaller, the trunk as often passes to a basal sinus (superpetrosal) by turning ventrad instead of dorsad on reaching the cerebral crus.

One or more *Precerebellar Veins* from the flocculus region (*Floccular Vein*) pass to the superpetrosal sinus, with the subcerebral vein, when this terminates at the base; otherwise they seem to connect with this by veinules along the lateral surface of the cerebral crus. Among the cerebellar veins Hédon, referring to Merkel, mentions one that "comes from the flocculus and empties into the superpetrosal sinus. An important branch of this vein rises from the interior of the cerebellum in the region of the dentatum, receives also veins from the cerebellar medipeduncle, and emerges with the peduncle under the flocculus. The main trunk can acquire a very considerable size when it receives a branch of the basilar vein" (precerebellar vein, Fig. 821).

3. The *Postcerebral Veins* (Fig. 821, *M*) usually unite into one trunk just at the point where, turning caudad, they form an ampulla in the dura and enter the sinus. This is at the lateral border of the occipital lobe, opposite the exoccipital fissure. These veins come in part from the convexity, in part from the basal surface of the occipital lobe. The latter may be single or multiple; their derivative area is lateral to that of the suboccipital vein. The former is represented by one large trunk from the direction of the Sylvian fissure; it receives varying temporal branches and larger ones from the external occipital surface. The *Paracerebellar Veins* are smaller than the postcerebrals, but often empty opposite them, though, of course, subtentorial in origin. They come from the lateral portion of the cerebellum. The very inconstant *Postcerebellar Veins*, one or more in number, terminate in the lateral sinus near the torcular, or even in the tentorial.

4. The *Subcerebellar Veins* include any small vessels at the bottom of the posterior fossa discharging into the occipital sinus.

The cerebellar veins,—supra-, pre-, para-, post-, and sub-.—are but partially distinct from the cerebral veins.

Oblongata Region.—The ventro-mesal chain of myelic veins (see Fig. 821, *o*) is continued cephalad on the ventral surface of the oblongata to the furrow between this and the pons, there connecting with a fine venous network over the surface of the latter (Kadyi). This plexus in turn also connects with the veins of the cerebellum and of the base forward.

Besides irregular smaller ones, there are in particular two constant and considerable veins passing from this plexus, one on either side along the trigeminal nerve to the sinus petrosus (or cavernosus).

From the above-mentioned chain on the ventral surface of the oblongata, between the pyramids, there frequently arises a little trunk (up to 0.5 mm. or more thick) that joins one of the hypoglossal root bundles and passes out with it through the precondyloid foramen—doubtless a part of Luschka's plexus venosus hypoglossi.

The dorso-myelic chain of veins is continued cephalad over the oblongata. From a constant mesal vein here a small veinule traverses the arachnoid, covering the cisterna magna. Sometimes this adjoins the accessory nerve, and Kadyi thinks it probably empties into the sinus plexus about the foramen magnum.

GENERAL FEATURES OF THE INTRINSIC VEINS. — *Communications.*—In this regard the pia veins must be distinguished from those of the brain substance. In contrast to the arteries, the pia veins communicate freely, not only indirectly through the sinuses, but everywhere on the surface by a network of small vessels, as well as frequently by anastomoses between larger trunks. The veins of the convexity might almost be said to radiate from the Sylvian fissure (horizontal Sylvian). At least several of the larger ones connect toward the middle of the convexity. Of these, four may be specified: (1) One of the frontal supercerebrals (fronto-dorsad); (2) the second or third from the last supercerebral (caudo-dorsad); (3) the external trunk of the postcerebral (caudo-ventrad); 4, the medicerebral (fronto-ventrad). Or any two of these trunks may communicate independently, *e.g.*, the medi- and postcerebral veins by a large anastomosis directly across the temporal lobe (intrapial, of course). There are many other connecting veins, not as markedly bridging the fissures, however. The great anastomotic vein of Trolard is No. (4) (medicerebral) when continuous with No. (2). Labbé's illustration includes also No. (3). Trolard says it "sometimes takes origin at the side of the longitudinal sinus, but oftener it forms by the union of veins anastomosing at the middle part of the convexity." He encountered it twenty-five times in thirty subjects. According to Labbé this anastomosis, instead of being with the medicerebral, may, in its absence, be with the deeper Sylvian vein. Practically these various anastomoses present a collateral path in the pia, between longitudinal, lateral, and cavernous (sphenoidal or superpetrosal) sinuses. The basal veins, excepting the perforants and the cerebellars, have ample though smaller anastomoses, including an indifferent counterpart of the circle of Willis. It is evident that the derivative area of the pia veins can never be closely defined.

The internal system must be separated into those veins uniting in the curved portion of the velar, and those tributary to the straight portion. The former, as the writer has elsewhere shown, have the following sets of

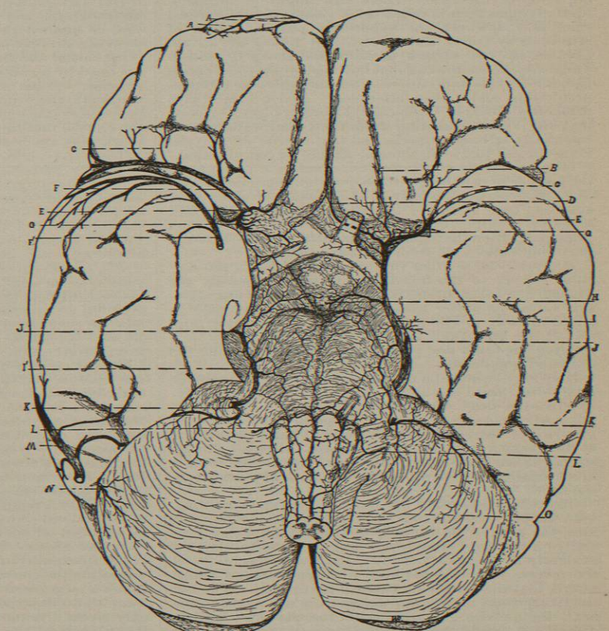

FIG. 821.—Veins of the Base (¾ natural size). The two sides represent respectively the more common arrangements of these veins. Those of the myel and oblongata are largely after Kadyi. A, A, Supracerebrals; B, ramus to olfactory bulb; C, C, subfrontals; D, precerebral; E, E, Sylvian or insular; F, medicerebral (to cavernous sinus); F', postmedicerebral (per temporal sinus to superpetrosal); G, G, preperforantes; H, postperforantes; I, subcerebral (to Galen's vein); I', subcerebral (when emptying at base); J, J, subcornuals; K, K, precerebellars and flocculars; L, L, hypoglossals (to precondyloid emissary); M, postcerebral (to lateral sinus); N, paracerebellar (to lateral sinus); O, ventromyelic (anterior spinal).

anastomoses: (1) Between the callosal vein—including practically the rare interhemispheric vein—and the median branches of the supercerebrals, across the callosal fissure; (2) between the suboccipital vein and the basal branches of the postcerebral; (3) between the supercerebellar and other cerebellar veins; (4) between the subcerebral vein—when, as in about one-half the cases, this discharges into the velar—and the many veins adjacent to its derivative area. These communications are all in the pia; from clinical cases we know that these may suffice to compensate fairly when *only* the tentorial sinus and the short common vein of Galen are closed. They do not suffice, however, when there is any impediment to this collateral discharge, and possibly not when the subcerebral vein ends elsewhere. Of the veins passing to the portio recta of the velar vein, only one, the medicornual, has superficial anastomoses. As this is a long, tortuous vessel, and connects with the subcornual only by small and questionable anastomoses, it is of itself entirely unable to compensate when the portio curvata becomes occluded. We have, remaining, the various cœlian veins coming directly from the brain substance, to which the postcornual may also be added. Neither between these nor between their subdivisions short of the ultimate capillaries did the writer succeed in finding any anastomoses. The same holds true for the perforating veins of the base. There still might be intrasubstantial connections between these vessels and the cortical veinules. However, the apparently positive results of injections by Duret, and especially by Labbé, are all explicable by the surface anastomoses above described. There may be such occasional but inadequate connections paralleled by the rare ones between the otherwise terminal perforating and cœlian arterioles. Hédon (1888) says that a few do exist. Clinical evidence also goes to show that the veins emanating from the cœlial walls are all essentially terminal vessels, and that closure of the velar vein—unless just at its mouth—cannot be compensated.

Cortical Veinules.—Duret found only six or eight in the section of a medium-sized convolution, one or two emanating perpendicularly at the dorsum of the gyrus, and from four to six by the sides. However, they had a diameter triple that of the arterioles. They start principally from the capillary transition plexus—between gray and white—and from the deeper albalis.

Developmental.—From various peculiarities in the vascular supply of the human brain, more especially the caudad displacement peripherally of the postsupracerebral veins, the writer has adduced evidence favorable in a general way to Hill's theory of a developmental rotation of the brain, and showing further that in any such rotation the brain and pia have glided caudad under the dura and brain case.

Here may be added a casual observation of a persistent fetal form, made at the autopsy of a child of twenty-two months, dead of tubercular meningitis. The large left medicerebral vein took the temporal course in a deep groove (per temporal sinus, intradural), and passed out at the foramen jugulare spurium instead of passing to the suprapetrosal sinus, first, however, connecting with a much smaller prepetrosal sinus. No such appearance on the right.

General Relations of the Veins and Arteries.—In the pia, over the convexity and on the median surface, the arteries lie beneath the veins (Labbé), as generally in the body elsewhere. But over the insula, and evidently in the sulci generally, the writer has observed the reverse; while of the finer pial arborizations Labbé asserts that the venous lie beneath the arterial. Though the larger veins often jump across from one gyrus to the next, the arteries go down with the pia more or less deeply into the fissures, to come up near or distant over the next gyrus.

Only by a forced comparison can any of these veins be said to accompany the arteries. By contrast, the dural vessels conform in their general bearing to those elsewhere; they have abundant collateral anastomoses, most of the arterial branches are accompanied by two veins, etc.

Dwight quotes the suggestion that, as the blood in the internal jugular and carotid flows in opposite directions, the arterial pulsations might interfere with the venous discharge, if both lay in a common canal. Trolard drew a strong analogy between the vertebral artery, surrounded by the vertebral vein and plexus, and the carotid through the cavernous sinus. "The supply arteries of the encephalon bathe (?) in venous blood; the carotids from the moment they enter the carotid canal; the vertebrals from the moment they penetrate the vertebral canal." This point has been elaborated by Rüdinger (*vide* abstract in Boston *Medical and Surgical Journal*, 1888, ii., 323). He shows that by this cushioning the pulsatory movements of the arterics are not abolished as they would be if they filled the bony canals. The diameter of the carotid canal he gives as 5–7 mm.; that of the artery, 3–4.3 mm. In the cavernous sinus the artery, though situated at one side of the cavity, is not in contact with either the bone or the dura.

The various retarding bends and angles in both classes of vessels can only be referred to. They affect very unequally the circulation in the different parts. The existence in the pia of vessels larger than capillaries, connecting the arteries with the veins, has been many times asserted and denied—the last investigator, Labbé, contriving to do both. This point still awaits final settlement.

III. The Dural Sinuses.—The encranial sinuses are all intradural, and all except the tentorial (with the falcial) lie against the cranial wall. They do not collapse on being slit open, nor do they admit of much distention—the falcial and the parasinual spaces excepted. They are lined by a continuation of the inner membrane of the jugular. Allen counts 16 sinuses—10 paired (symmetrical), and 6 unpaired (azygous). But their number depends so much on the way they are divided as to cause the remark that the easiest piece of anatomical work was to describe a new sinus.

They have been variously classified: (*a*) In two reciprocally perpendicular planes, the vertical plane including the longitudinal and tentorial (plus falcial), the horizontal including the remaining; or (*b*) in three horizontal planes; or (*c*) as connecting at three points, viz., the torcular and the two cavernous sinuses (to which Trolard sought to add a precondyloid confluens); or (*d*) according to the area drained.

The Longitudinal Sinus.—This, the longest sinus, runs parallel to the sagittal suture, slightly grooving the bone in a curved line from near the crista galli to the internal occipital protuberance. It lies between the folds of the falx, as they diverge to continue as the parietal dura. Its section presents a rounded triangle, increasing in size from the accession of large veins. Its lumen toward the bottom is crossed by numerous irregular strands (trabeculæ, chordæ Willisii). The openings from the supercerebral veins are usually larger than those from the parasinual spaces (and dural veins). The sini subalterni of Malacarne are often seen in the falx just beneath the sinus, and present more or less developed parallel narrow passages freely connecting with the main vessel. At the torcular this sinus more often turns into the right lateral. Rarely it, or its tributaries, drops down through the falx to the falcial sinus, or just before the torcular to the tentorial, or even divides, following the lambda sutures to each lateral sinus. The whole longitudinal sinus may be occluded without causing disastrous results.

Falcial Sinus.—This may run along about two-thirds of the free border of the falx or near the border, and then represents the continuation of the tentorial sinus. It is rather a large dural vein than a sinus. At its commencement the occasional interhemispheric veins empty. Its only lateral tributaries are usually small dural veinules, though part of the supercerebral veins or of the longitudinal sinus have in rare instances been seen to turn this way. On the contrary, Knott once saw the falcial pass to the longitudinal, and some connection between the two is not uncommon.

But, as stated by Luschka, this sinus is very variable in size and occurrence. In a series of adult subjects the

writer found that its average occurrence was only one in six; in the fœtus it was never present. Trolard's attempt at presenting this as an important anastomosis between the dorsal and internal systems, or as a safety diverticle of the latter, was quite overdrawn.

Tentorial Sinus.—This lies at the junction of the falx and tentorium (Figs. 819 and 820, *a*). It extends in full size from the torcular to the intersection of the free falcial and tentorial borders opposite the point where it receives its main tributary, the vein of Galen. Its section is a triangle with narrow base resting on the tentorium. Laterally it takes up small dural radicles, and often a supercerebellar vein. It is straight, lies in the median line, and is directed caudad. "It opens into the lateral sinus by an oval mouth formed by strong pillars of fibres."

Torticular.—A *confluens sinuum* in the sense of the old writers does not exist. "The right lateral sinus for the most part begins higher than the left, and may be considered as the continuation of the longitudinal. In some subjects the right or left lateral sinus begins from the longitudinal one, while that of the other side is continuous from the tentorial; and then the lateral sinuses are separated at their origin by a membranous isthmus" (Charles Bell, 1827). Rüdinger speaks of a "valvular arrangement" separating the two currents. In 26 out of Knott's 44 cases, the tentorial opened into the left lateral sinus, in 6 into the right, in 12 mesially. The statistics given below, on the larger jugular canal, bear on this question. This peculiarity of the paths at the torcular tends to prevent a reflux of blood from one into the other, or any interference of the currents.

However, in a considerable minority of cases the currents must intermingle. From the arrangements of the sinuses at the torcular, thrombosis of the longitudinal and right lateral is more often associated than of the longitudinal and left. A comparison of the few casual cases at hand shows 6 of the former to 2 (or possibly 3) of the latter. Of course, much more frequently—in 12—all three sinuses were involved.

Lateral Sinus.—This runs from the torcular, at first in the attached tentorial border, then curves (*flexura sigmoidea*) to follow the groove in the mastoid and gains the jugular canal. It has been seen to take a more basal course, running first in the cerebellar falx, then beside the foramen magnum to its usual exit. From the extensive investigations of Hartmann, Rüdinger, Bezold, and Politzer, it appears that frequently the sigmoid portion approaches within a few millimetres of the posterior wall of the auditory meatus. The one into which the longitudinal sinus turns, usually the right, is double the size of the other, and also a trifle longer. Rarely, one lateral is minimal in size or even absent. It receives laterally the postcerebral and paracerebellar veins and superpetrosal sinus, and gives off two inconstant emissaries.

Körner (1889) has shown that intracranial disease from caries of the petrous is more frequent on the right, and from a study of 449 skulls he attributes this to the fact that the lateral sinus at its sigmoid flexure enters deeper into the mastoid and the petrous pyramid on the right than on the left, and thus on the right approaches nearer the primary focus of disease. In 22 cases on the right and 8 on the left, there were gaps in the bony partition. He also holds that in the brachycephali the sigmoid excavation goes lower and deeper than in the dolichocephali, and that hence in the former such encranial sequelæ follow more readily; but this has been disputed by Schülzke.

Birmingham, of Dublin (*Brit. Med. Journ.*, 1890, ii., 683), from an examination of 100 recent dry specimens, points out that the relations of the lateral sinus to the surface are extremely uncertain, owing both to variations in the sinus curves and to irregularities in the bones. It begins opposite the external occipital protuberance in 50 per cent.; lower (by never more than one-half inch) in 33 per cent.; and higher in 17 per cent. It does not run forward horizontally, but is distinctly arched. The bend of the sinus where it turns down at the asterion may vary, within wide limits, from a gentle to a very sharp curve. It then runs down in front of the postmastoid margin, about one-half inch behind the meatus, and turns into the jugular foramen about one-quarter inch below the level of the meatus floor. Occasionally the sinus is only one-twelfth of an inch from the surface.

Cavernous Sinus (Plate XVIII., Fig. 1), distinguished by its irregular outline and cellular or reticulated appearance from intercrossing fibrous bands. It represents a colossal perivascular structure about the carotid, in a way similar to that established by Braune and his school for certain lymphatics accompanying veins. The late von Langer, in one of his last publications, based on corrosion and other preparations from infantile subjects, showed that the cavernous sinus is originally a plexiform network of veins, which, by fusion of its channels, takes on its later characteristics. The wall resorption goes on to old age, when villous offshoots of the remaining trabeculæ are often seen to project into its cavity. It is traversed by the carotid (cavernous portion). All the orbital nerves except the optic pass near or through its outer wall. Besides veins and emissaries, it is the communicating centre for all the prebasal sinuses. Frontad it tapers to the ophthalmic vein—the swollen end of which has been dubbed *Sinus Ophthalmicus*.

Laterally, the cavernous receives the *Sphenoidal Sinus*. This runs out along the dependent side of the lesser sphenoidal wing. Knott notes great variability in its size, though never complete absence, a small vein at least being found. Peripherally it receives or connects with a medidural vein, and also a diploic canal, and may take up the medicerebral or connect with ophthalmodural veins.

The *Subsphenoidal Sinus*, on the great wing of the bone, was found by Knott fourteen times on the right and nine on the left side.

Mesad, the cavernosi connect by the two *Transverse Sinuses*—which alone deserve to be called transverse. These follow the walls of the sella turcica, curve slightly to enclose the pituitary body, and complete the so-called vene-circle of Ridley (Plate XVIII., Fig. 1).

Sinus Præpetrosus (jugularis spurius of Luschka, petroso-squamosus of Hyrtl, petrosus anterior of Bell). This occasional sinus, at the bottom of the temporal fossa, describes a curve along the petro-squamous suture, from the spinous foramen—connecting with the medidural vein and also with the cavernous sinus—to either (or both) the emissarium temporale or the petrous portion of the lateral sinus (often by perforating the prominent petrous ridge). Its physiological interest arises from the prominent part which it plays in the fœtus. Zuckerkandl (1873) found this sinus 22 times in 280 skulls. Knott, 4 times in 44, found what appears to have been a continuation of this sinus to the sphenoidal; in 7 of 44 subjects he found the prepetrosal on both sides, in 19 on one side only.

Caudad, the cavernous empties into the oblique super- and sub-petrosal sinuses, but principally the former. The *Superpetrosal Sinus* starts from the cavernous, runs in the prolonged attached border of the tentorium along the dorsal ridge of the petrous bone, and enters the lateral sinus against the current at the beginning of its sigmoid flexure. It alone offers a direct encranial connection between the prebasal and lateral sinuses. The temporal sinus (medicerebral or anastomotic vein) and the subcerebral vein discharge into this in nearly one-half the cases, the precerebellar vein more constantly. As a consequence, its size varies considerably, though it is usually small. The vestibular and even tympanic veins of the ear pass to the superpetrosal sinus, either directly or by a dural vein. In his forty-four subjects, Knott notes its absence twice on the right and once on the left.

The shorter *Subpetrosal Sinus* runs in the petro-occipital groove, from the cavernous sinus to the subpetrosal vein, which, by bending before its discharge into the jugular vein, secures an unimpeded outlet for this sinus (for connections, *vide infra*, Vena Subpetrosa).

Occipito-Basilar Plexus.—In the occipital fossa are several sinus canals that vary much in size and distribution. The *Occipital Sinus*, usually bilateral, runs along the cerebellar falx and connects with the lateral sinuses by small mouths beside the torcular. Pre-, trans-, and post-occipitals have been made out. The so-called circular sinus of the foramen magnum is more often incomplete dorsad of the hole. The basilar sinuses over the like-named process connect with the preceding and with the prebasal sinuses. Langer has shown that, like the cavernous sinus, all of these are the persistent channels of what originally, in the fœtus, was a vein plexus; and he has also corroborated Virchow's description of their enlargement in the aged.

Parasinual Spaces.—These areolar venous pockets or derivative reservoirs (lacunæ, *recessus laterales*), though described with increasing definiteness by a long series of observers, find but little mention in the text-books. Their principal development is opposite the middle of the longitudinal sinus (bilateral). As numerous minute spaces they further occur along nearly the whole length of the said sinus, and also (Langer) beneath it in the falx, beside the lateral sinuses, on both sides of the tentorial sinus, and it is said even about the cavernosi. The dilated intradural termination of the postcerebral and paracerebellar veins has also been thus classed. They all occupy the attenuated space between the dural layers lateral to the sinuses, and hence are very shallow and of irregular outline. They have a lining membrane, also many intercrossing fibrous filaments, and are injectable from or with the sinuses. In position and characteristics they are intermediary between dural veins and sinuses. Where present they receive most if not all the dural veins. The larger spaces are traversed by incoming pia veins with which they connect by one or more openings. They increase in size as life advances, and then have intimate relations with the Pacchionian granulations—so much so that they have even been termed Pacchionian blood cavities. The circulation in their interior is not believed to be very active and the spaces have repeatedly been found thrombosed.

On opening a sinus or the jugular canal blood usually flows out in a more or less pulsatory stream showing that the ruling interior pressure is positive. In the cases of operative perforation of a lateral sinus (Jacoby, Knapp, Benton, Guye, Owen, Reeve, von Baracz, and others, usually ending in recovery) there is no record of air being aspirated. But in one case of opening of the longitudinal (Genzmer, 1877) so much air was aspirated as to prove quickly fatal, and Francois-Franck (1881) has endeavored by experiments to show that aspiration can be communicated through the vertebral veins to the diploic canals of the occiput.

Occlusion.—Blocking of any single sinus is not necessarily dangerous, though occlusion of a cavernous or the tentorial is always a serious matter.

By experimental blocking of the dural sinuses in the dog, Ferrari (1888) has shown that a large part of the whole sinus system, *e.g.*, all the sinuses of the calvarium, may be rendered impermeable without injury to the functions of the brain. However, occlusion of the collective blood efferents from the skull is of course quickly fatal, being usually preceded by an epileptic attack. But all this and more had been already determined by clinical experience in man.

IV. Venous Openings through the Skull (Emissaria, etc.).—From their number and pathological importance, and for clearness of description, these passages ought to constitute a separate class. Each of the cranial bones (except the ethmoid) has a foramen permitting direct communication between the dural sinuses and veins and the exterior veins: still these are of very unequal size, and in part disappear in the adult. There is but little topographical correspondence between the position of these exits and the area drained through them; nor is the area in any case closely definable. They may all act as efferent vessels, although the ophthalmic veins are usually afferent—partially so, says Sesemann, 1869; largely so, Gurwitsch, 1883, and Merkel—and certain of the others may conduct either way according to circumstances. Only Nos. 2, 6, 7, and 8 are superficial, while 7, 8, 11, and perhaps 4, belong rather to the dural and diploic system. Nearly all the blood normally passes out through the two postlacerated foramina with their four canals. But any one of the exits and, so far as known, any two—or, in case of the smaller emissaria, several—may be permanently closed without causing serious harm. Both internal jugulars have been tied in the same subject (Pilger, 1880) without other evil consequences than a temporary headache.

1. *Jugular Canal.*—In the lateral part of the postlacerated foramen. This, by far the largest of all the exits, leads from the sigmoid flexure of the lateral sinus to the bulb or gulf of the internal jugular vein. Its path through the foramen is often more or less separated from the passing nerves, etc., by a bony septum, thus forming a true jugular foramen. Rarely it is very small on one side, or even absent (four or five known cases).

By adding the series of 159 skulls examined by Dwight to the 100 by Rüdinger, we have 259. In 173 of these the right jugular foramen was larger than the left (*i.e.*, about two-thirds), in 65 the reverse (one-quarter), and in 21 the two were equal (one-twelfth). This harmonizes with what was said above (*sub* Torcular).

2. *Emissarium Mastoideum*, of most importance in fetal life. It arises directly from the lateral sinus, and empties usually into the occipital vein (extracranial), sometimes into the postauricular, or even directly into the external jugular. In the 16 perfect skulls examined by Green (*American Journal of Otology*, vol. iii.), it was absent on both sides in 1, and on one side in 1. It was always just behind the posterior limit of the mastoid process. The external opening was opposite the meatus (at about the middle of the perpendicular height of the mastoid) in 20, above this in 2, below in 6, and directly on the base of the skull in 1. Its diameter measured 5 mm. in 1, 4 mm. in 4, 3 mm. in 10, 2 mm. in 10, and 0.5 mm. in 4.

3. *Emissarium Postcondyloideum* (postjugular vein), passing from the lateral sinus near its termination to the upper cervical or vertebral veins. In 44 skulls, Knott found this on both sides in only 13, on the right in 21, and on the left in 10. In Dwight's series of 142 skulls, with unequal jugular foramina, the postcondyloid foramen was larger on the same side as the larger jugular in 53, on the other side in 37, and equal or absent in 52 (this foramen being wholly for the transit of the emissary).

4. *Emissarium Præcondyloideum*, connecting with the occipital sinus or its basal prolongation, taking up a diploic vein, and passing in part to the prepetrosal vein, in part to the plexus about the vertebral. As plexus venosus hypoglossi, Luschka described a cluster of veins about the hypoglossal bundles as they unite in the inner portion of the foramen, from which two veins passed dowr. the canal. Trolard says that externally the precondyloid foramen presents a deep cavity in which is lodged a true venous confluens. Ventrad its wall is hidden by the external part of the atlo-occipital ligament. He says that this confluens receives five veins: (1) Ventrad and mesad, the medilacerate; (2) latero-ventrad, a connection with the subpetrosal vein; (3) dorsad, a precondyloid vein; (4) latero-dorsad, an inconstant vertebral vein (passing between atlas and occiput, behind the internal jugular, sometimes in a bony canal); (5) a little vein on the preatlo-occipital ligament, communicating across with the intraspinal sinuses.

Dwight, in the same series of 142 skulls, found the precondyloid foramen larger on the same side as the jugular in 16, on the other side in 11, the two sides equal in 115. "There does not appear to be any definite relation between their size and that of the postcondyloids."

5. Small uncertain veins through the *foramen magnum* or beside the vertebral arteries, connecting some marginal sinus or vein with the vertebral and spinal vessels. The fine veins in the spinal cord also connect with intraspinal substantial ones above.

EXPLANATION OF
PLATE XVIII.