1. It is a clear watery fluid, faintly alkaline, of low specific gravity, about 1.007.

2. It contains no fibrin and gives no precipitate (mucin) on adding acetic acid.

3. On boiling not more than a trace of turbidity (serum globulin) is observed.

4. It reduces Fehling's solution.

5. A reducing substance, obtained by evaporating to dryness an alcoholic extract of the fluid, is found in needle-like crystals having a pungent taste and an acid reaction, and resembling pyrocatechin. This reducing substance does not ferment with yeast, nor give the phenylhydrazin reaction, nor turn the polarization plane.

6. It contains a small proportion of proteids and generally no albumin.

Pathological and Clinical Considerations. — Since Quincke called attention to the value of puncture of the vertebral canal as a diagnostic and therapeutic measure, and to the ease with which it could be performed, resort to it has frequently been had.

The method of procedure is as follows:

The patient is preferably placed in the recumbent posture on the left side, with the body strongly flexed in the lumbar region. The puncture is made with a long aspirating needle between the second and third or the third and fourth lumbar vertebræ, a few millimetres outside the median line. In a child of about two years, the puncture should be opposite the mid-point between the lumbar spines, and at a depth of about 2 cm. the subarachnoid chamber will be reached. In the adult the puncture should be made at a point opposite the middle third of the lower border of the spine above, on account of the downward inclination of the spines, and the needle should slope toward the median line. If the puncture be made in the median line, it should be at the mid-point between the spines; and in children the needle should penetrate in a nearly horizontal direction, while in the adult it should slope upward parallel to the spines. Sahli[18] recommends that the puncture be made between the fifth lumbar and the base of the sacrum, especially if the morphological elements are to be sought for. Anæsthesia is, as a rule, unnecessary.

Where there are symptoms of intracranial pressure and only small amounts of fluid can be obtained by puncture, the cause will probably be an interruption of the connection between the encephalic and spinal spaces, due to exudate or tumor, especially of the cerebellum. It is possible, however, that the lack of fluid might be due to the closure of the aqueduct of Sylvius or the metapore. Small quantities of fluid exclude tuberculous meningitis, acute hydrocephalus, and tetanus.

The cerebro-spinal pressure can be judged by the strength of flow from the cannula, a strong spurt indicating an increased pressure, slow-coming drops a decreased pressure. It can be more accurately measured by attaching the cannula to a mercury, or, better, to a water manometer, the normal pressure being from 5 to 7.3 mm. mercury. When the pressure is much raised (15 to 60 mm. of mercury) meningitis or brain tumor is indicated. The specific gravity is somewhat variable, but an increased density points to meningitis, although this affection may exist with normal specific gravity.

Proteids may be found increased in tuberculous meningitis, decreased in brain tumors and serous meningitis. The variation in different cases of the same kind is so great that the proportion of proteids loses considerably in diagnostic significance. Lichtheim and Quincke claim to find sugar in most cases of brain tumor. This does not agree with the observations of Fürbringer, who found sugar only in cases of diabetes associated with tuberculosis.

Microscopic Examination.—A turbid appearance is due to leucocytes and indicates inflammation, but in tuberculous meningitis the fluid is clear.

In tuberculous meningitis, tumor, abscess, and chronic hydrocephalus only a few leucocytes and endothelial cells are to be found, while in acute meningitis the leucocytes are more plentiful, and in the purulent form they are very numerous. It is important, before advising operation in cases of abscess of brain and sinus thrombosis, to exclude purulent meningitis. This is often readily done by a microscopic examination of the puncture fluid.

Pure blood in the subarachnoid space indicates either extensive brain laceration or intraventricular hemorrhages. In subdural hemorrhages, a small amount of blood may be found; but in epidural hæmatoma, and in hemorrhagic pachymeningitis only very small quantities of blood are found. In severe traumatic cases the presence of nearly pure blood would indicate serious brain injury and contraindicate operation, and vice versa; the absence of blood might indicate the advisability of an operation. In non-inflammatory diseases of the brain, as tumors or abscess, no clotting occurs, except a slight one in tuberculous meningitis.

In cases in which tuberculous meningitis is suspected, some of the puncture fluid should be centrifugalized and examined for tubercle bacilli. Fürbringer has found the bacilli in thirty out of thirty-seven cases. Other organisms that have been found are the diplococcus intracellularis (Weichselbaum) in cases of epidemic cerebro-spinal meningitis, and the streptococcus and the diplococcus pneumoniæ in purulent meningitis secondary to otitis media. The staphylococcus pyogenes aureus and albus are also sometimes found.

St. Clair Thomson has collected from the literature nine cases of undoubted spontaneous flow of the cerebro-spinal fluid from the nose, and twelve probable cases. This condition he has named cerebro-spinal rhinorrhœa. It affects the sexes about equally, and is a disease of adult middle life, frequently presenting cerebral and eye symptoms. The flow is usually from the left side of the nose and is generally continuous day and night, but long or short periods of intermission may occur.

The method of escape of the fluid was found in one case to be through an aperture in the cribriform plate of the ethmoid. A possible explanation is that the lymph vessels of the nasal mucous membrane, which are in communication with the subarachnoid cavity, may furnish the exit. No efficient method of treatment has been found. One case of spontaneous flow from the ear is recorded in which the membrana tympani was intact and no evidence of injury or disease was present.

Harry B. Ferris.

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BRAIN, CIRCULATION OF.—All the larger intracranial vessels and most of their easily visible branches lie in the enveloping membranes—dura, pia, and their processes. Over the convexity only minute branches enter or leave the brain proper. The largest arterial twigs directly entering the cerebrum are those of the (basal) pre- and post-perforated spaces. The largest

EXPLANATION OF
PLATE XVI.

EXPLANATION OF PLATE XVI.

Fig. 1.—The arterial areas of the convexity

Fig. 2.—Those of the mesial surface. The area supplied by the precerebral is in brown, that by the medicerebral is in green, and that by the postcerebral is in blue. The main branches and their directions in each case are indicated by shades of the primary color.

The two figures on this plate were prepared especially for this work. They represent an average between the two sides of a brain examined by isolated injection of the individual arteries.

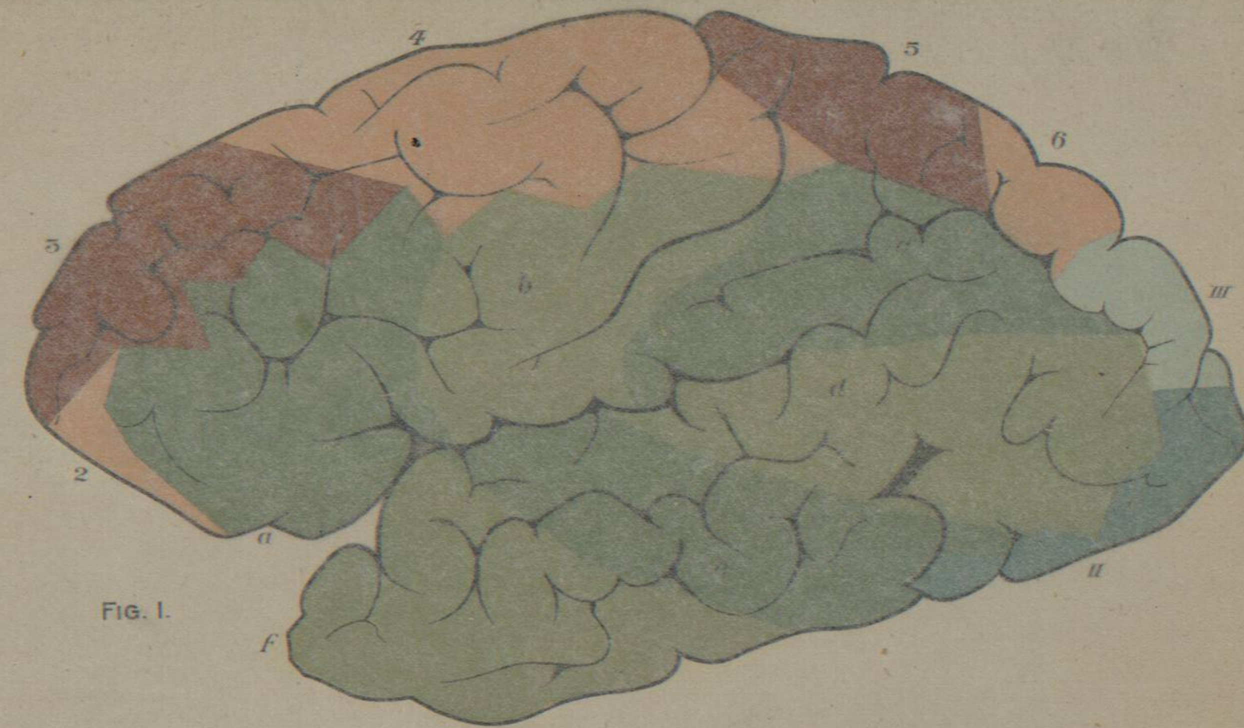

Fig. I.

Fig. 2.

Arterial Distribution over Convexity (Fig. 1) and Mesial Surface (Fig 2): Precerebral in Brown: Medicerebral in Green: Post-Cere-

EXPLANATION OF PLATE XVI.

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PLATE XVI.

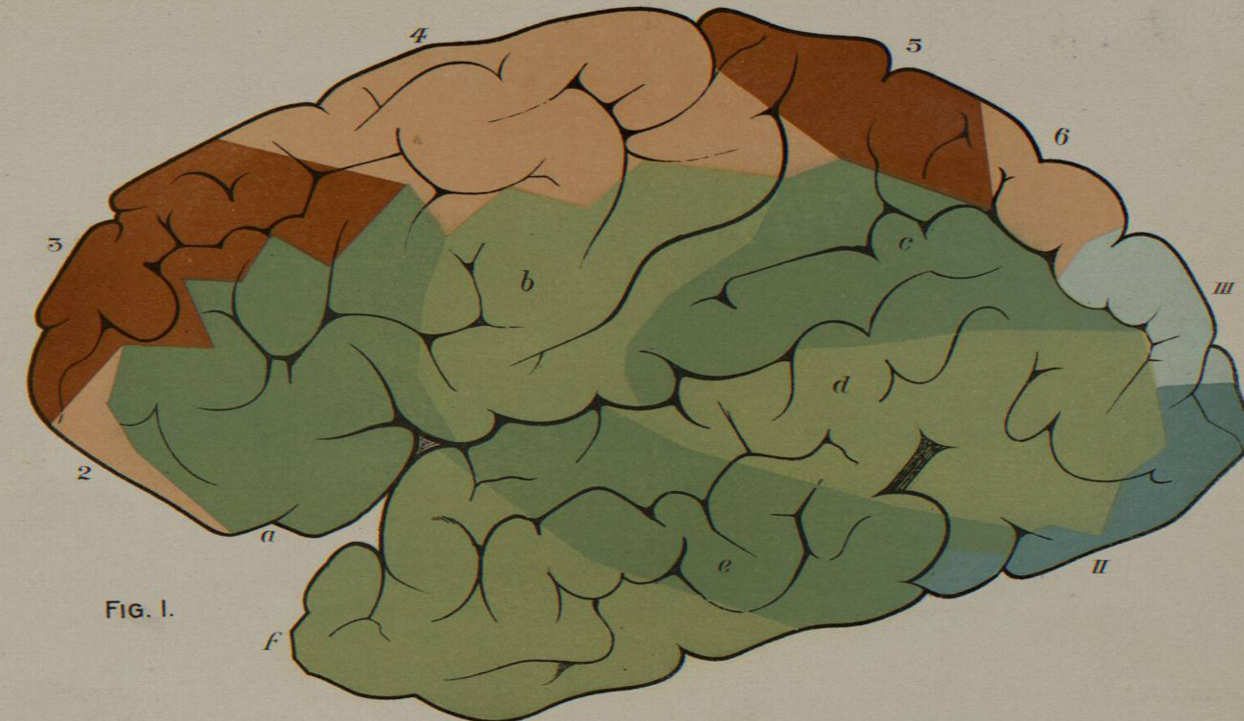

FIG. 1.

FIG. 2.

Arterial Distribution over Convexity (Fig. 1) and Mesial Surface (Fig 2): Precerebral in Brown: Medicerebral in Green: Post-Cerevenous rootlets directly from the organ are the corresponding perforants and some in the cœles. Hence the vessels of the meninges have to be included in any account of the encephalic circulation; and the vascular distribution—especially the arterial—can be best mapped out on the surface. From studies published within the last thirty years our knowledge of this subject has been greatly developed. Our aim is to reclassify and harmonize the often puzzling independent and re-discoveries.

NOMENCLATURE.—In this article the simplified terms of Wilder (*vide* amended list in New York *Medical Journal*, November 25th, 1885) will be employed. These are extended also—with his approval—to the veins, sinuses, and so-called meningeal vessels. As these last lie wholly in one of the membranes, the dura, the general term *meningeal* does not accurately define them; for this the unequivocal *dural* is substituted.

Intrinsic Arteries of the Brain.

Common Latin names.	Proposed names.	English paronyms.	Abbreviations.
Vertebralis	Vertebralis	Vertebral	*vrtb.*
Basilaris (*az.*)	Basilaris	Basilar	*bslr.*
Cerebellaris superior	Precerebellaris	Precerebellar	*prcbl.*
Cerebellaris anterior	Medicerebellaris	Medicerebellar	*mcbl.*
Cerebellaris inferior	Postcerebellaris	Postcerebellar	*pcbl.*
Cerebralis anterior / Corporis callosi	Precerebralis	Precerebral	*prcb.*
Cerebralis media / Fossæ Sylvii	Medicerebralis	Medicerebral	*mcb.*
Profunda cerebri / Cerebralis posterior	Postcerebralis	Postcerebral	*pcb.*
Communicans anterior (*az.*)	Precommunicans.	Precommunicant.	*prcm.*
Communicans posterior.	Postcommunicans	Postcommunicant	*pcm.*
Choroidea anterior	Prechoroidea	Prechoroid	*prchrd.*
Choroidea posterior	Postchoroidea	Postchoroid	*pchrd.*
Perforantes anteriores	Preperforantes	Preperforants	*prpf.*
Perforantes posteriores.	Postperforantes	Postperforants	*ppf.*
Termatica / Cerebralis ant. media (*az.*).	Termatica	Termatic	*trmc.*

Dural Arteries.

Meningea	Duralis	Dural.
Meningea anterior	Preduralis	Predural.
Meningea media	Mediduralis	Medidural.
Meningea parva	Parviduralis	Parvidural.
Meningea posterior	Postduralis	Postdural.
Meningea inferior	Subduralis	Subdural.

Sinuses.

Longitudinalis superior (*az.*).	Longitudinalis	Longitudinal.
Longitudinalis inferior (*az.*).	Falcialis	Falcial.
Torcular Herophili / Confluens sinuum (*az.*).	Torcular	Torcular.
Sphenoparietalis / Alæ parvæ	Sphenoidalis	Sphenoidal.
Petrosus superior	Superpetrosus	Superpetrous.
Petrosus inferior	Subpetrosus	Subpetrous.
Petrosus anterior	Prepetrosus	Prepetrous.
Rectus (*az.*)	Tentorii	Tentorial.
Lacunæ laterales sinuum.	Lacunæ parasinuales.	Parasinual * spaces.

Intrinsic Veins of the Brain.

Cerebri superior	Supercerebralis	Supercerebral.
Cerebri anterior / Callosi anterior externa	Precerebralis	Precerebral.
Cerebri media	Medicerebralis	Medicerebral.
Fossæ Sylvii	Sylvii	Sylvian.
Basilaris Rosenthali / Cerebri inferior s. ascendens	Subcerebralis	Subcerebral.
Occipitalis lateralis / Cerebralis lateralis et inferioris	Postcerebralis	Postcerebral.
Occipitalis interna / Cerebri posterior inferior	Suboccipitalis	Suboccipital.
Callosi posterior externa.	Callosalis	Callosal.
Magna Galeni / Cerebri interna communis (*az.*).	Galeni	Galen's.
Cerebri interna s. intima s. profunda / Right and left vein of Galen	Velaris	Velar.
Corporis striati / Lateralis ventriculi	Tænialis	Tenial.
Cornu anterioris	Precornualis	Precornual.
Septi lucidi / Antr.-ventriculi	Paraseptalis	Paraseptal.
Cornu posterioris	Postcornualis	Postcornual.
Choroidea	Medicornualis	Medicornual.
Medullares superiores	Superalbales	Superalbals.
Rami corporis striati	Striatales	Striatal.
Rami thalami optici	Thalamici	Thalamic.
Ramus thalami optici profundus (Rosenthal) / Pedunculi cerebri	Thalamocruralis	Thalamocrural.
Azygos conarii	Conarialis	Conarial.
Cerebelli sup. media	Supercerebellaris.	Supercerebellar.
Cerebelli sup. lateralis	Paracerebellaris	Paracerebellar.
Cerebelli inferior	Subcerebellaris	Subcerebellar.

* The form parasinual was kindly suggested and approved by Prof. B. I. Wheeler, the comparative philologist.

Dural Veins.

Duræ matris cerebri / Meningea	Duralis	Dural.
Meningea media	Mediduralis	Medidural.
Ophthalmomeningea	Ophthalmoduralis	Ophthalmodural.

ARTERIES.

The encranial arteries present two distinct systems of vessels:

I. The dural, commonly called meningeal.

II. The intrinsic, or those of the brain proper.

These latter do not anastomose with any other arteries. Rarely there are marked exceptions to this rule, and perhaps oftener slight inosculations about the sella turcica.

Heubner (1874), from injections in adults, says: "The territories of the medidural and of the cerebral arteries must be considered as absolutely independent of one another." Langer (1877), speaking of infantile and young subjects, states: (*a*) that one or two dural branches of the precerebral anastomose in the falx with terminal twigs of the dural artery; (*b*) also that pial branches of the precerebral may reach minute dural arteries accompanying the supercerebral veins as they spring over to the dura near the longitudinal sinus.

I. THE DURAL VESSELS ramify in the exterior of the dura. In a general way it is true that the pre-medi- and post-dural arteries are branches respectively of the internal and external carotid and vertebral arteries. These various branches interanastomose freely, so that dural infarction does not occur. They are distributed not simply to the dura, but also to the diploic cranial bones; small twigs may also pass to extracranial parts.

1. *The Branches from the External Carotid* supply the middle belt, and, in fact, nearly the whole of the dura. They are:

(1) The *Medidural*, the largest and most constant of all the dural arteries, arising from the internal maxillary and entering through the spinous foramen. Its branches pass up the divergent sulci meningei (for arteries and accompanying veins) of the lateral cranial wall, connecting at the top with those from the opposite side. Of its two main divisions, the larger anterior is often for a short distance arched over to a canal.

The furrows of the medidural artery on the entocranial wall deepen with years, and in old age the artery sinks quite into them. It has two primary branches, a larger cephalic and a caudal, the former again soon (at the sphenoidal angle of the parietal bone) separating into two secondary rami. The anterior ramus runs up behind the coronal suture, though a little more obliquely, being, according to Marchant, pretty constantly from 0 to 13 mm. (averaging 5 to 6 mm.) away at the foot of the suture, about 1 cm. at its middle, and 15 mm. at its dorsal part. The second ramus starts on the entotemporal surface 4 cm. behind the pterion, on an average. At its middle, on the entoparietal surface, it averages 54 mm. behind the coronal suture. Farther dorsad, the distance is very variable, 30 mm. more or less.

The primitive caudal branch leaves the temporal squama 58 mm. behind the pterion, then goes toward, and becomes parallel with, the lambdoidal suture.

The relations of these vessels to the subjacent cortex, important clinically, Duchaine sums up thus: (1) The cephalic branch runs up opposite the frontal lobe some centimetres before the central fissure, rather nearer the coronal suture. (2) The midramus starts almost opposite the fissure, then runs up some centimetres behind it. (3) The caudal branch is always a centimetre or more distant from the fissure, and is still farther separated above.

Besides many minute branches to the sinus walls, outgoing nerves, and orbit (*vide infra*), it may send to, or receive from, the deep temporal region minute rami perforating the interposed wall; in young subjects (Hyrti) considerable branches may pass through the anterior fontanelle and the sagittal suture to the soft cranial coverings.

(2) The *Parvidural*, an inconstant accessory medidural, arising close to the latter, or even directly from it, and entering by the oval foramen. It goes to the Gasserian ganglion and adjacent dura.

(3) The *Mastoid* branch of the occipital (or external carotid, 15 in 120 times, Wyeth, 1878), entering by the mastoid foramen, within which it always sends a branch to the diploë. It is small, variable, and destined for the wall of the lateral sinus and adjacent dura. Here again a reverse course has been observed, where the postauricular arose from a dural artery by emerging through a foramen in the mastoid (Bankart).

(4) *Supradural* branch or *Ramus Parietalis*, also from the occipital, accompanying the emissary through the parietal foramen. It is usually insignificant, and often absent.

(5) The *Subdural* branches are very small and variable. They include twigs from the ascending pharyngeal, occipital, and stylomastoid arteries, enter by the pre- and post-lacerated, precondyloid, and stylomastoid foramina, and partly supply the dura of the posterior fossa and basilar sinuses.

2. *Branches from the Internal Carotid.*—(1) The cavernous carotid yields several small rami to the sinus wall, the pituitary body, Gasserian ganglion, and dura about the sella turcica. These are variously styled *receptacular* and *rayed arteries*, even predural in case of any prominent single branch. Their field of distribution and that of the parvidural are evidently complementary.

(2) The *Predural* usually refers to the one or more slight branches of the ethmoidal arteries, supplying the adjacent dura of the precranial fossa.

3. *Branch from the Vertebral.*—The *Postdural* artery arises opposite or just below the occipital foramen, passes with the vertebral into the cranial cavity, and supplies the dura of the postcranial fossa, especially the posterior portions, as the cerebellar falx, etc.

The only anastomoses of special interest, between dural and extradural arteries, are with those of the orbit. Such connections always exist. Often a medidural branch enters, through either the sphenoidal foramen or some special opening, and supplies the external wall, even substituting partly or wholly the lachrymal artery, or a branch of the lachrymal may take the reverse course. Very rarely the medidural arises directly from the ophthalmic (Zuckerkandl, four cases, Hulston, one), and then passes by the sphenoidal fissure to its usual distribution. This possible origin should be borne in mind in the rare operation of tying the medidural at the base of the skull.

II. Intrinsic Arteries (or those of the pia and brain substance).—In removing the brain from the skull we sever at its base the four arteries which suffice for its entire blood supply. These are, anteriorly, the two carotids entering through the carotid foramen and canal, posteriorly, the two vertebrals entering beside the foramen magnum. By means of communicating branches at the base of the brain—the vertebrals having first united, and their common basilar trunk having divided into the two postcerebrals—the primary vessels combine to form the circle of Willis. From this practically all and only the *cerebral* arteries emanate. Previously, however, several branches are given off by the vertebrals and basilar; while the carotid yields only the ophthalmic. The latter is said always to originate before any of the cerebral branches, and some millimetres before the bifurcation of the cerebral carotid.

The Vertebrals and Basilar supply in their course the organs of the posterior fossa, viz., cerebellum, pons, oblongata, and their adnexa. In approaching the distal border of the pons the vertebrals unite to form the mesal basilar. This is occasionally divided within by a septum, or separates into two vessels which soon reunite. The basilar lies in the median sulcus of the pons, directly on the basilar process of the occipital bone; opposite the central border of the pons it ends in the two postcerebrals. Only occasional variations are attributed to the vertebrals: (1) absence of one, the existing vessel being joined by a branch from the opposite carotid; (2) both may join the basilar on the same side; (3) or one may be represented by two or three branches before entering the formation of the basilar trunk.

The lateral branches are:

1. *Postcerebellar*, the largest offshoot of the vertebral. It passes around the oblongata, beside the pneumogastric nerve, to supply the extremity of the cerebellar lobe as far as the median line, the subvermis and adjacent surface, and the plexus of the metepicœle.

2. *Recurrent Spinal Twigs*, also from the vertebral, are given as follows by Kadyi: Immediately after the vertebrals traverse the dura there arises from each a 1 mm. thick branch (dorso-myelic), which, after giving up twigs to the restiform body, descends along the dorsal border of the lateral columns of the cord. This is homologous with other branches entering by the dorsal nerve roots. Sometimes this arises from the vertebral in common with the postcerebellar.

Near the union of the vertebral to the basilar there arises—usually one on each side, though unequal—the myelic branch for the ventromyel. These two, however, either soon or oftener after entering the spinal canal, combine to form the azygoid ventro-myelic artery. They are thus continuous and homologous with the other myelic arterioles coming in along the ventral nerve roots.

A full consideration of the minute details of the arterial distribution in the oblongata is given by Adamkiewicz (*vide* Plate XVII.). These vessels come wholly from the upper (intracranial) part of the vertebrals as they cross the ventral surface of the oblongata.

The main facts regarding the three classes of secondary or nutrient arterioles (external or surface vessels) he accepts from Duret: 1. The radicals, direct from the vertebrals, supply the outgoing nerve roots (facial, acoustic, glosso-pharyngeal, vagus, accessorius, and hypoglossus). 2. The nuclears, at right angles from the one or two dorso-myelics in an extent of 3 to 4 cm. These penetrate the median fissure, at the bottom of which they form a kind of sagittal leader, and end beneath the floor of the metepicœle (fourth ventricle). 3. Arteries for the other portions of the oblongata (olivary bodies, pyramids, corpora restiformia), in part at least from the myelics.

Moreover, on the oblongatal surface is a rich network of vessels. The ventromyelics opposite the oblongata give off a multitude of twigs that take a very sinuous course and soon settle into the furrows. For the dorsal surface of the oblongata there is no external supply until below the calamus—upper end of myel. Its source is the dorsomyelics. These latter, at the first cervical roots, turn caudad between the accessory nerve roots (nearer the dorsal), and when at the level of the fourth or fifth cervical roots they end by also anastomosing with vessels of lower origin.

From the middle portion of the vertebrals, between the ventro- and dorso-myelics, arise the largest branches (subcerebellars), but these dodge the oblongata and are wholly for the cerebellum.

Topographically, Adamkiewicz distinguishes three sets of finer or nutrient arterioles (internal or substantial vessels) after the manner of the myelic supply.

(1) Ventro-fissurals, relatively large, dividing in the ventral commissure into two branches, one to each side for the corresponding ventro-mesal cinerea. In the oblongata these supply principally the pyramidal tracts and decussation, lemniscus, interolivary tract, raphé, and the

following nuclei—gray dorsal columna, n. pyramidalis, n. arciformis, oliva, and hypoglossus.

(2) Dorso-fissurals, of course only caudad of the calamus. These divide at the dorsal commissure into two border vessels, and are for the substance of the dorsal columns, nucleus gracilis, accessorius centre, and casually the hypoglossus.

(3) Coronal, radial, or lateral system. These are very numerous, penetrate the alba from all sides (excepting of course the metepicœle), and in part reach the subjacent cinerea to then help form its mass of capillaries. A subclass here—nuclear arteries—consists of six to eight relatively large twigs entering the angulus restiformia olivaris and running parallel toward the middle of the floor of the metepicœle, to supply principally the centres for glosso-pharyngeus, vagus, hypoglossus, and acusticus. The following parts receive these radial or lateral affluents—the ventral columns, lateral nuclei, lateral cornu, caput of substantia gelatinosa, nuclei cuneati gracilis, arciformis et pyramidalis, and the oliva itself.

3. *Medicerebellar*, usually from the basilar trunk. This passes along the middle cerebellar crus to the preventrad surface of the respective cerebellar hemisphere, including the flocculus.

4. *Transverse* branches, three or four in number. These are parallel and accessory to the preceding.

5. *Auditiva Interna.* Starts like the last, but passes to the internal auditory meatus and structures of the inner ear.

6. *Ponticular* branches. These immediately enter the pons perpendicularly, and supply its substance. They represent true terminal arteries (Heubner), quite comparable to the perforants of the cerebrum. From the importance of the tracts supplied they have likewise great interest to the pathologist.

7. *Supercerebellar.* This starts near the end of the basilar, passes outward along the front border of the pons, winds around the crus cerebri near the optic lobes, and is distributed to the supervermis and general dorsal surface of the cerebellum. It also supplies the post-optic arteries.

The basilar branches all emanate at practically a right angle to the mother trunk. Those going to the surface anastomose much more freely than do the cerebral arteries. Accordingly Heubner found the pia districts of single arteries much less definite over the cerebellum than over the cerebrum. Moreover, the branches of the two sides communicate dorsad across the median line; this is explained by the development of the cerebellum from a single median vesicle. The only communication between this system of vessels and the cerebral—except through the basilar trunk—is by small branches of the precerebellars and postcerebrals across the crura cerebri.

Circle of Willis.—The carotid ends at the outer angle of the chiasma in two main branches, the pre- and medi-cerebral arteries. At about 1 cm. in front of the chiasma the two precerebrals are connected by the precommunicant. From either the medicerebral or the carotid passes the postcommunicant to the corresponding postcerebral. Hence the circle (or polygon) of Willis is made up by one precommunicant, two precerebrals, two medicerebrals (or two carotids), two postcommunicants, and two postcerebrals. This is the classical arrangement; from it, however, there are frequent and important deviations. Professor Windle found that it held in only 76, or, overlooking any disproportion in the postcommunicants, in 119 out of 200 cases. Only in the apes do the vertebrals nearly equal the carotids. In man, Ehrmann, from 157 measurements, found that very constantly the basilar trunk was equal to one carotid (*i.e.*, furnished one-third of the brain supply). The communicants are not simply to re-establish a circulation in case of obliteration, but they normally act to equalize pressure in the local vessels. When this circle is complete and of normal structure, an adequate collateral circulation is established after occlusion of any one part. From this circle and the first few centimetres of its branches originate a multitude of arterioles passing to the basal ganglia and adjacent structures.

Dercum offers "A Collection of Anomalies of the Circle of Willis" (*Journal of Nervous and Mental Diseases*, 1889, January), and J. H. Lloyd (*Ibid.*, 1890, p. 225) gives such a case of a type described by Duret (right vertebral absent, both precerebrals from left carotid, etc.). St. John Bullen (*Journal of Mental Science*, 1890, January, p. 33) bases the following statements on the examination of 1,565 brains (from the insane), but holds statistics too uncertain. Arterial variations occur much oftener in general paralytics than in those dying of other forms—this applying equally to all segments of the circle of Willis.

The components of this circle and their branches:

The Precommunicant.—This is a transverse branch beneath the rostrum, from 1 to 2 mm. in size, connecting the two precerebrals, and forming the anterior side of the circle. Windle found it normal in 159, double in 14, incompletely so (forked at one extremity) in 6, triple in 1, absent in 8, and associated with union of the precerebrals in 2. Wilder notes the latter condition in 6 out of 7 cases, and Starr in 2 of 14. Duret says that when double one is of normal size, the other very small. Its place is sometimes supplied by a fasciculus of small twigs. The precommunicant, Bullen finds, may be absent, or merely rudimentary, or double. Its branches—more numerous when the communicant is unusually long—are:

1. The *Termatica*, a mesal vessel at its origin. Wilder found this present in all of seven brains examined. "It usually divides soon into a right and left portion, which supply respectively the cinerea forming the surface of the triangular area ventrad of the genu and rostrum, and then extend around the genu to the dorsal aspect of the callosum." Windle notes it in nine of his cases. It passed along the longitudinal fissure for two-thirds of the length of the callosum, and divided into branches supplying the opposed surfaces of the hemispheres. When the communicant is wanting, this vessel may start from the junction of the precerebrals.

2. Small retrograde rami to the lamina of the chiasm.

3. Arterioles which plunge into the callosal rostrum, and very often one or two considerable branches completely perforating the rostrum and ramifying on the crura of the fornix, the anterior commissure, and the septum.

The Precerebral (*vide* Plate XVI. and Fig. 818, 3).—This at its origin is almost perpendicular to the carotid. Often the artery of one side is larger than, and partly substitutes, that of the other side. Windle found it normal in 181 of 200 cases. In 2 the right was absent, its place being partly supplied in one by twigs from the right medicerebral, in the other by a small branch from the carotid. In 1 the right was double the size of the left; in 1 the two united to a single trunk; and in 8 they united for a short distance, six times replacing and twice accompanying the precommunicant. Either precerebral may, according to Bullen, (1) be replaced by two small trunks; or (2) be absent, its region being supplied by branches of the opposite artery.

The short oblique portion, dorsad of the optic nerve, between carotid and precommunicant, represents part of the circle of Willis. This portion may give off the following branches: 1. Arterioles to the optic nerve of the same side. 2. Lateral arterioles to the neighboring convolution and the callosal rostrum. 3. When, from premature division of the carotid, the precerebral goes over a longer course, it much oftener gives large twigs to the caudate (*preperforantes*). Duret says that these branches take one of two courses. In one they penetrate almost within the expansion of the olfactory nerve, perforate the callosum at its junction with the lower part of the caudate head, and divide into five or six almost subependymal ramifications not extending beyond the first 2 cm. of the caudate. In the other, one or two arterioles, of about 1 mm. diameter, follow a retrograde course of 3–4 cm. to the preperforated space beneath the caudate, to which latter exclusively they are distributed.

From the precommunicants on, the precerebrals run