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NAMED AFTER ABU ALI IBN SINO
DEPARTMENT OF ANATOMY

"APPROVED"
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5510400 – Dentistry (by directions)
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EDUCATIONAL - METHODICAL COMPLEX ON NEUROANATOMY

Bukhara 2021

The scientific program was approved by the Resolution of the Coordination Council No. ___ of August ___, 2020 on the activities of educational and methodological associations in the areas of higher and secondary special and vocational education.

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The working educational program for anatomy is compiled on the basis of working educational curriculum and educational program for the areas of 5510100 - Medical business.

This is discussed and approved at the department
Protocol № _____ of "____" _____2021

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The working educational program for anatomy is compiled on the basis of working educational curriculum and educational program in directions of 5510100 – Medicine

This is discussed and approved by the scientific-methodological Council of BSMI

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Annotation

Neuroanatomy encompasses the anatomy of all structures of the central nervous system, which includes the brain and the spinal cord, and their supporting structures.In this anatomy educational - methodical complex you will be introduced to the central and peripheral nervous systems. You will learn about basic neuroanatomy, sensory pathways, motor pathways and the autonomic nervous system.

The educational - methodical complex on neuroanatomy includes illustrated lecture and quizzes to help you expand and test your knowledge of the nervous system.

By the end of this course, you will have a better understanding of how the entire body influences, and is influenced, by the nervous system.

l. The relevance of the academic discipline and its place in higher professional education

One of the main objectives of the National Program for the Training of Personnel in Medicine is the education of a fully developed, highly spiritual person; in the development of his scientific worldview a huge role is played by the subject of human anatomy. This subject studies the structure, shape, arrangement of organs in connection with the change and influence of external factors; it studies not only the structure of man, but also their phylogenetic origin, the variation of each organ depending on age, as well as anthropogenesis, individual and sex differences, organ structure in connection with their function, as well as the topographic interaction between them.

According to the Bologna process, the educational process is conducted according to the modular system. Depending on this, the anatomy program on the basis of structures studies anatomical experiments and the structure of the human body and its organs in a normal state.

II. Goals and objectives of the academic science

The purpose of studying the subject is to study the development of the human body, systems and their parts, the structure and their names according to the international anatomical nomenclature, as well as phylogenetic development, explain the structure of organs and systems on models and schemes.

Objectives of the subject:

- the construction of the human body, their systems, organs and tissues, the structure of man, depending on age.

- the basis of the structure of a person in connection with their function.

-ontogenetic and phylogenetic development of organs, knowledge of frequent anomalies.

-knowledge that every organ is an integral part of the body.

The construction of each organ is connected with the function that they perform. Anthropological changes in the structure of certain organs as a result of labor activity.

-individual changes in the body, depending on age and external factors.

- the contribution of Russian scientists to the history of the development of anatomy.

-cognition and application of organ topography in the study of anatomy.

- development of basic morphological studies.

Requirements for knowledge, skills and qualifications of students:

As a result of the development of Anatomy, a bachelor must know:

-value of bones, muscles, joints, internal organs, blood vessels, central and peripheral nervous system and sense organs.

-basic patterns of growth, development and formation of the organism.

- Anatomy serves as a basis for the assimilation of clinical subjects.

- the construction of the human body, depending on the composite systems of organs and tissues, as well as the age structure of the organism.

- the structure of organs is closely related to their function.

- every organ in the body system, knowledge of the whole organism.

-individual changes in the body, depending on age and external factors.

- the contribution of Russian scientists to the history of the development of anatomy.

- application of the topography of organs in the study of anatomy.

In order to know topography and sintopia, a bachelor must master the following skills:

- to find and show the spinous procession of the cervical vertebra, to be able to count the ribs, to know the bones of the upper limbs, their processes, the surfaces, the edges, the bones of the hand, the characteristics of each bone, the bones of the lower limb, the bones of the foot, the large and small pelvis, sex differences, , the eyeball, the surface and edges of the bones of the skull.

- be able to show the movements of each joint.

- be able to show the movements of muscles that occur during their contraction.

- be able to show the location of organs in models and schemes and call them according to the international anatomical nomenclature.

- be able to find various blood vessels on the models and call them according to the international anatomical nomenclature.

-to be able to find and show various nerves on models and tables, call them by international anatomical nomenclature.

- to be able to find and show the senses and call them according to the international anatomical nomenclature.

The connection of anatomy with other objects and their continuity:

Anatomy, being the fundamental basis of medical science, is studied at 1, 2, 3, semesters. For the implementation of the curriculum, mathematical and natural-scientific knowledge is required (medical biology and genetics, histology, cytology and embryology, biophysics, normal physiology, bioorganic and bioorganic chemistry).

Modern pedagogical technologies in the study of the subject:

To assimilate the human anatomy, students should use modern information and pedagogical technologies. At assimilation of an object use teaching aids, lecture, distributing, electronic materials. Pedagogical technologies are used in lecture and practical exercises: (visual, problematic, author's lectures, two side analysis, insert, cluster, "Venn diagram", syncvein, assisment) and others.

Place in the health system:

Anatomy plays an important role in forming the basis of medical knowledge of a general practitioner. Human anatomy together with other objects allows us to present a complete and complete picture, provides clinical thinking.

№	Type of classes	Hours	Semester
1	Lectures	20	II
2	Practical	28	II
4	Monitoring (control)	c/c, i/c, f/c – oral, written, test	

Calendar-thematic plan for lecture classes for students 1 course

II SEMESTER

№	Theme	Hours
1	General information about the central nervous system. Philo and ontogenesis of nervous system. Anatomy of the spinal cord. Membranes of the spinal cord. The rhombencephalon. The fourth	2

	ventricle.	
2	The midbrain, the diencephalon. The third ventricle.	2
3	The telencephalon. Furrows, convolutions, centers of the cortex of the brain. The fornix. The corpus callosum. Basal nuclei. The lateral ventricles. Membranes of the brain. Venous sinuses. Circulation of cerebrospinal fluid.	2
4	Motor and sensory pathways of the brain and spinal cord.	2
5	Formation of spinal nerves. Anterior and posterior divisions. Anatomy of the cervical and brachial plexus. Thoracicnerves.	2
6	Anatomy of the lumbosacral plexus	2
7	Functional anatomy I-VI pairs of cranial nerves	2
8	Functional anatomy VII-XII pairs of cranial nerves	2
9	Functional anatomy of the autonomic nervous system.	2
10	Functional anatomy of the sensory organs. Anatomy of the organs of sight, hearing, smell, taste.	2
	TOTAL	**20**

1. Theme. General information about the central nervous system. Philo and ontogenesis of nervous system. Anatomy of the spinal cord. Membranes of the spinal cord. The rhombencephalon. The fourth ventricle.

General information about NS. Morphofunctional unit of the nervous system is a neuron. Neuroglia. White and gray matter. Nuclei, centers that conduct paths. Spinal cord: structure, shape, topography. White and gray matter. Central channel. Segments of the spinal cord. Nodes, roots, branches of the spinal cord. Formation of spinal nerves. Brain. Brainstem, internal structure. Difference and the generality of the brain from the dorsal. Oblong brain: surfaces, internal structure, nuclei, conductive pathways. The rhomboid brain. Voroliev pons: external and internal structure, nuclei and conductive paths. The fourth ventricle. Rhomboid fossa: structure, projection of nucleus of cranial nuclei. Venous plexus of the fourth ventricle.

Literature: 1-8.

2. Theme. The midbrain, the diencephalon. The third ventricle.

The midbrain: parts, structure. The roof of the middle brain. The legs of the brain: the structure, the nuclei that conduct the path. Silviev aqueduct. The diencephalon: thalamus, epithalamus, metathalamus. Hypothalamus, structure, nuclei. The cavity of the diencephalon. The third ventricle: structure, walls, venous plexus.

Literature: 1-8.

3.Theme. The telencephalon. Furrows, convolutions, centers of the cortex of the brain. The fornix. The corpus callosum. Basal nuclei. The lateral ventricles. Membranes of the brain. Venous sinuses. Circulation of cerebrospinal fluid.

The telencephalon. Hemispheres of the brain. Cortex. Furrows and convolutions of the brain. The olfactory brain. White and gray matter of the cerebral hemispheres. Parts, structure and functions of the corpus callosum and arch. Basal nuclei. Inner and outer capsules. Reticular formation: structure and functions. Lateral ventricles: parts, structure, connection with other ventricles. Shells of the brain and spinal cord, the spaces between them. Subarachnoid space. Formation of cerebrospinal fluid, its course and absorption. Venous sinuses.
Literature: 1-8.

4. Theme. Motor and sensory pathways of the brain and spinal cord.

A simple reflex arc. Determination of conductive paths, classification. Long and short association paths. Comissural pathways: corpus callosum, anterior and posterior cerebral adhesions, spike of the arch and leashes. Projection pathways: sensitive, motor. The way of the surface and deep sensitivity. Proprioceptive pathways associated with the cerebellum. Pyramidal and extrapyramidal pathways.
Literature: 1-8.

5. Theme. Formation of spinal nerves. Anterior and posterior divisions. Anatomy of the cervical and brachial plexus. Thoracic nerves.

General anatomy of spinal and cranial nerves. Segmental distribution of peripheral nerves. Composition and structure of nerves. Formation of spinal nerves and their branches: ventral, dorsal, meningeal, connective branches. Formation of plexuses. Relationship of spinal nerves with the autonomic nervous system. Cervical plexus: education, structure, topography. Brachial plexus: education, structure, topography. Long and short branches of the brachial plexus. Supraclavicular and subclavian parts. Intercostal nerves: topography, zones of innervation.
Literature: 1-8.

6. Theme. Anatomy of the lumbosacral plexus

Lumbar plexus: education, structure, topography. Long and short branches of the lumbar plexus. Obstructive, femoral nerves: topography, zones of innervation. Sacral plexus: education, topography, structure. Long and short branches of the sacral plexus. Gluteal nerves: topography, zones of innervation. Sciatic nerve: topography, zones of innervation. Tibial and common peroneal nerves: topography, division, zones of innervation. Innervation of the skin and muscles of the lower limb. Coccygeal plexus: topography and structure. Regularities in the distribution of spinal nerves.
Literature: 1-8.

7. Theme. Functional anatomy I-VI pairs of cranial nerves

The nerves that develop together with the head myotomes (III, IY, YI), the nerves that develop with the gill arches (Y, YII, IX, X, XI), nerves located on the border of the spinal cord (XII). The connection of the cranial nerves with the autonomic nervous system. Anatomy of nerves: nuclei, topography, branches, zones of innervation.
Literature: 1-8.

8. Theme. Functional anatomy VII-XII pairs of cranial nerves

The nerves that develop together with the head myotomes (III, IY, YI), the nerves that develop with the gill arches (Y, YII, IX, X, XI), nerves located on the border of the spinal cord (XII). The connection of the cranial nerves with the autonomic nervous system. Anatomy of nerves: nuclei, topography, branches, zones of innervation.
Literature: 1-8.

9.Theme. Functional anatomy of the autonomic nervous system. Functional anatomy of the senses. Anatomy of the organs of sight, hearing and balance, olfaction, taste.

Generality in the structure and function of the autonomic nerves. Division of the autonomic nervous system into sympathetic and parasympathetic departments. Formation of vegetative nerve fibers, their innervation zones. Preganglionic and postganglionic fibers. The sympathetic division of the autonomic nervous system: nuclei, nodes, interstitial fibers. Parasympathetic section of the autonomic nervous system: nuclei, peripheral part. Parasympathetic innervation of internal organs.
Literature: 1-8.

10.Theme. Functional anatomy of the sensory organs. Anatomy of the organs of sight, hearing, smell, taste.

General features of the sensory organs: receptors, the presence of cortical analyzers. File and ontogeny, topography, structure, functions of the organs of vision. Glossy apple and its membranes: fibrous, vascular, reticular. Front and back chambers of the eyeball. The auxiliary apparatus of the eyeball. The lacrimal apparatus. The division of the auditory organ into the outer, middle and inner divisions is their functional anatomy. The leading path of the pre-cochlear nerve. The organ of smell and taste, their conducting ways.
Literature: 1-8.

Calendar-thematic plan of practical classes

№	Theme	Hours
1	Spinal cord. Membranes of the spinal cord. The base of the brain with the output of 12 pairs of cranial nerves.	2
2	Medulla oblongata. The pons. Cerebellum. IV ventricle of the brain.	2
3	The midbrain. The diencephalon. III ventricle of the brain.	2
4	Cortex of the brain. Fornix, corpus callosum. Basal nuclei of the hemispheres. Lateral ventricles of the brain. Membranes of the brain.	2
5	Conductive pathways of the spinal cord and brain. A simple reflex arc. Sensitive pathways	2
6	Conductive pathways of the brain and spinal cord. Motorway pathways.	2
7	Formation of spinal nerves. Posteriorand anteriordivisions. Thoracic nerves. Cervical plexus.Long and short branches of the brachial plexus.	2
8	Lumbar plexus. The sacral plexus.	2
9	I, II, VIII pairs of cranial nerves	
10	III, IV, VI, XI, XII pairs of cranial nerves	2
11	V, VII pairs of cranial nerves Parasympathetic nodes located along the branches of the trigeminal	2

	nerve.	
12	IX and X pairs of cranial nerves.	2
13	The autonomic nervous system.	2
14	The organ of sight. The organ of hearing, smell and taste	2
	TOTAL	**28**

1. Spinal cord. Membranes of the spinal cord. The base of the brain with the output of 12 pairs of cranial nerves.

Borders, thickenings, furrows of the spinal cord. Gray and white matter. Shells. The shape of the brain, parts, hemispheres, cerebellum, brain stem. Output 12 pairs of cranial nerves from the base of the brain. Method-discussion.

Literature: 1-8.

2. Medulla oblongata. The pons. Cerebellum. IV ventricle of the brain.

Olive, pyramid, grooves of the medulla oblongata. Internal structure. The nucleus of IX, X, XII craniocerebral nerves. The structure of the bridge, the location of the nuclei of V, VI, VIII craniocerebral nerves. Internal and external structure of the cerebellum. Kernels, gray matter. IV ventricle, its bottom, roof, holes. The topography of the rhomboid fossa. Method-Rotation

Literature: 1-8.

3. The midbrain. The diencephalon. III ventricle of the brain.

The roof and legs of the midbrain. Subcortical visual and auditory centers. III ventricle, bottom, roof, holes, topography of the rhomboid fossa. Intermediate brain: thalamus, epithalamus, metathalamus. Method-weak link.

Literature: 1-8.

4. Cortex of the brain. Fornix, corpus callosum. Basal nuclei of the hemispheres. Lateral ventricles of the brain. Membranes of the brain.

The cerebral cortex: furrows, convolutions, centers. Furrows and convolutions of the dorsolateral surface of the brain. Furrows and convolutions of the medial and basal surface of the brain. The centers of the brain. The structure of the vault and corpus callosum. Basal nuclei: caudate, lenticular nucleus, amygdala, and hind legs. Parts and structure of the lateral ventricles. Shells of the brain: hard, arachnoid, soft. Circulation of cerebrospinal fluid in the brain. Method-graphical organizers

Literature: 1-8.

5. Conductive pathways of the spinal cord and brain. A simple reflex arc. Sensitive pathways

Reflex arc. Sensitive pathways: pathways of surface, deep and proprioceptive sensitivity. Method-discussion.

Literature: 1-8.

6. Conductive pathways of the brain and spinal cord. Motorway pathways.

Motorway pathways. Pyramidal, extrapyramidal system. Method-rotation.

Literature: 1-8.

7. Formation of spinal nerves. Posterior and anterior divisions. Thoracic nerves. Cervical plexus. Long and short branches of the brachial plexus.

Formation of spinal nerves, anterior and posterior branches, zones of their innervation. Intercostal nerves, their innervation zones. Cervical plexus: muscular, dermal and mixed branches. Diaphragmatic nerve, sensory and motor nerves. Supraclavicular and subclavian parts of the brachial plexus. Short branches of the brachial plexus, their innervation zones. Long branches of the brachial plexus. Innervation of the chest and upper limbs. Method-weak link.

Literature: 1-8.

8. Lumbar plexus. The sacral plexus. I, II, VIII pairs of cranial nerves

Formation, structure, main branches, topography of the lumbar plexus. Long and short branches of the sacral plexus. Innervation of the pelvic region and lower extremities. Conductive path of the olfactory, visual, auditory analyzer. Nuclei, exit sites, branches of the VIII pair of cranial nerves. Method-graphical organizers

Literature: 1-8.

9. I, II, VIII pairs of cranial nerves

Conductive path of the olfactory, visual, auditory analyzer. Nuclei, exit sites, branches of the VIII pair of cranial nerves. Method-discussion.

Literature: 1-8.

10. III, IV, VI, XI, XII pairs of cranial nerves

Nuclei, places of emergence from the base, branches, zones of innervation III, IV, VI XI, XII pairs of cranial nerves. Method-rotation.

Literature: 1-8.

11. V, VII pairs of cranial nerves Parasympathetic nodes located along the branches of the trigeminal nerve.

Nucleus, exit points, branches of the V,VII pairs. Topography and zones of innervation of the orbital and maxillary nerve. Place of exit and zone of innervation of the mandibular nerve. Method-weak link.

Literature: 1-8.

12. IX and X pairs of cranial nerves.

Nuclei, exit sites, branches, zones of innervation of the X pair of cranial nerves. The method is graphical organizers.

Literature: 1-8.

13. The autonomic nervous system.

The structure of the autonomic nervous system and its differences from the somatic. Nuclei, nodes and patterns of distribution of branches of the sympathetic nervous system. Sympathetic innervation of each organ. Sympathetic innervation of the body and glands. Nucleus, nodes and the course of the branches of the parasympathetic nervous system. Parasympathetic innervation of each organ. Parasympathetic innervation of the glands. Method-discussion.

Literature: 1-8.

14. The organ of sight. The organ of hearing, smell and taste

The structure of the eyeball, the shell. Auxiliary eye device. Conductive path. visual analyzer. External, middle and inner ear. Conductive ways of hearing and balance. Method rotation. Literature: 1-8.

Indications for the preparation of laboratory work

There are no laboratory classes on this subject

List of practical skills:

To study the subject of Anatomy bachelor must be able to:

- find the spinous process of the 7th cervical vertebra;
- counting vertebrae and ribs;
- find the jugular fossa;
- show places of protrusions of tubular bones;
- holotape and sellotape internal organs;
- show the boundaries of the heart;
- find the carotid artery in the carotid triangle;
- sellotape segments of the spinal cord;
- show places of the cranial nerves exits from the skull;
- knowledge of the function and structure of internal organs

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Lecture 1. General information about the central nervous system. Philo and ontogenesis of nervous system. Anatomy of the spinal cord. Membranes of the spinal cord. The rhombencephalon. The fourth ventricle.

The development of the human brain and spinal cord may be divided into several phases, each of which is characterized by particular developmental disorders (Volpe 1987; van der Knaap and Valk 1988; Aicardi 1992; Table 1.3). After implantation, formation and separation of the germ layers occur, followed by dorsal and ventral induction phases, and phases of neurogenesis, migration, organization and myelination. With the transvaginal ultrasound technique a detailed description of the living embryo has become possible. Fetal development of the brain can now be studied in detail from about the beginning of the second half of pregnancy (Garel 2004). In recent years, much progress has been made in elucidating the mechanisms by which the CNS develops, and also in our understanding of its major developmental disorders,

such as neural tube defects, holoprosencephaly, microcephaly and neuronal migration disorders. Molecular genetic data, that explain programming of development aetiologically, can now be incorporated (Sarnat 2000; Barkovich et al. 2001). In this chapter an overview is presented of (1) major stages in the development of the human CNS, (2) the first 3weeks of development, (3) neurulation, (4) pattern formation, (5)

early development of the brain, (6) fetal development of the brain, (7) the development of the blood supply of the brain, and (8) the development of major fibre tracts including the development of myelination. Mechanisms of development are discussed in Chap. 2, and an overview of the causes of developmental malformations and their molecular genetic basis is presented in Chap. 3. In the second, specialized part of this book the development of the CNS and its disorders are discussed in more detail.

1.2 Major Stages in the Development of the Human Brain and Spinal Cord The embryonic period in man, i.e. the first 8 weeks of development, can be divided into 23 stages, the Carnegie stages (O'Rahilly and Müller 1987), originally described as developmental horizons (XI–XXIII) by Streeter (1951), and completed by Heuser and Corner (1957; developmental horizon X) and O'Rahilly (1973; developmental stages 1–9). Important contributions to the description of human embryos were also made by Nishimura et al. (1977) and Jirásek (1983, 2001, 2004). Examples of human embryos

are shown in Figs. 1.1 and 1.2. In the embryonic period, postfertilization or postconceptional age is estimated by assigning an embryo to a developmental stage using a table of norms, going back to the first Normentafeln by Keibel and Elze (1908). The term gestational age is commonly used in clinical practice, beginning with the first day of the last menstrual period. Usually, the number of menstrual or gestational weeks exceeds the number of postfertilization weeks by 2. During week 1 (stages 2–4) the blastocyst is formed, during week 2 (stages 5 and 6) implantation occurs and the primitive streak is formed,followed by the formation of the notochordal

process and the beginning of neurulation (stages 7–10). Somites first appear at stage 9. The neural folds begin to fuse at stage 10, and the rostral and caudal neuropores close at stages 11 and 12, respectively. Gradually, the pharyngeal bars, the optic and oticvesicles and the limb buds appear. The main external and internal features of human embryos are summarized in Table 1.1. The first four embryonic weeks are also described as the period of blastogenesis, and the fifth to eighth weeks as the period of organogenesis (Opitz 1993; Opitz et al. 1997). The fetal period cannot be divided into a series of morphologically defined stages. It is the period of phenogenesis (Opitz 1993; Opitz et al. 1997). In the clinical literature a subdivision of the prenatal period into three trimesters of 13 weeks each is commonly used.At the junction of trimesters 1 and 2, the fetus of about 90 days has a greatest length of 90 mm, whereas at the junction of trimesters 2 and 3, the fetus is about 250 mm in length and weighs approximately 1,000 g (O'Rahilly and Müller 2001; Table 1.2). The newborn brainweighs 300–400 g at full term. Male brains weigh slightly more than those of

females but, in either case, the brain constitutes 10% of the body weight (Crelin 1973). The brain and spinal cord arise from an area of the ectoderm known as the neural plate. The folding of the neural plate, leading to successively the neural groove and the neural tube, is called primary neurulation. The caudal part of the neural tube does not arise by fusion of the neural folds but develops from the so-called caudal eminence. This process is called secondary neurulation (Chap. 4).Before and after the Overview of the Development of the Human Brain and Spinal Cord Hans J. ten Donkelaar and Ton van der Vliet Chapter 1 surface ectoderm of the two sides fuses, the fusing neuroectodermal cells of the neural folds give off the neural crest cells. The neural crest is a transient structure and gives rise to the spinal and cranial ganglia. Moreover, the whole viscerocranium and part of the neurocranium are formed from the neural crest (Le Douarin and Kalcheim 1999;Wilkie and Morriss-Kay 2001; Chap. 5). The embryonic period includes three in time overlapping phases: formation and separation of the germ layers, dorsal and ventral induction phases (Table 1.3). During the first phase, the neural plate is formed. In the dorsal induction phase, the neural tube is formed and closed, and the three primary divisions or neuromeres of the brain (the prosencephalon, mesencephalon and rhombencephalon) appear. In the ventral induction phase (telencephalization), the cerebral hemispheres, the eye vesicles, the olfactory bulbs and tracts, the pituitary gland and part of the face are formed. In the sixth week of development strong proliferation of the ventral walls of the telencephalic vesicles gives rise to the ganglionic or ventricular eminences. These elevations do not only form the basal ganglia but, in addition, give rise to many neurons that migrate tangentially to the cerebral cortex. Neurogenesis starts in the spinal cord and the brain stem. Neurogenesis in the cerebellum and the cerebral cortex occurs largely in the fetal period. In man, the fetal period extends from the ninth week of development to the time of birth.With regard to the prenatal ontogenesis of the cerebral cortex, Marín-Padilla (1990) suggested dividing this long developmental period into two separate ones: (1) the fetal period proper (9–24 gestational weeks), characterized by the formation of the cortical plate; and (2) the perinatal period, extending from the 24th week of gestation to the time of birth. This period is characterized by neuronal maturation.

Fourth Ventricle

The fourth ventricle is a cavity of hindbrain connected to the third ventricle by a narrow cerebral aqueduct. The fourth ventricle is a diamond-shaped cavity located dorsal to the pons and upper medulla oblongata and anterior to the cerebellum. Fourth ventricle connected to the third ventricle above and central canal below. Through medial aperture, foramen of Magendie, it communicates with subarachnoid space. Laterally on either side it communicated with subarachnoid space through foramen of Luschka.

The superior cerebellar peduncles and the anterior and posterior medullary vela form the roof of the fourth ventricle. The apex or fastigium is the extension of the ventricle up into the cerebellum. The floor of the

fourth ventricle is named the rhomboid fossa. The lateral recess is an extension of the ventricle on the dorsal inferior cerebellar peduncle.

Inferiorly, it extends into the central canal of medulla. The fourth ventricle communicates with the subarachnoid space through the lateral foramen of Luschka, located near the flocculus of the cerebellum, and through the median foramen of Magendie, located in the roof of the ventricle. Most of the CSF outflow passes through the medial foramen. The cerebral aqueduct contains no choroid plexus. The tela choroidea of the fourth ventricle, which is supplied by branches of the posterior inferior cerebellar arteries, is located in the posterior medullary velum. The lateral wall of fourth ventricle on the upper side is formed by superior cerebellar peduncle and lower part is formed by inferior cerebellar peduncle and gracile and cuneate tubercle. The roof is tent in shape and projected into cerebellum. Roof is formed superiorly by superior cerebellar peduncle and superior medullary velum and inferiorly by membrane consisting of ependymal and double layer of pia meter which constitute tela choroidea of the fourth ventricle. Floor of the fourth ventricle is rhomboid in shape and thus called as rhomboid fossa. Upper triangular part is formed by pons and lower triangular part by medulla. Intermediate part prolonged laterally to form the lateral recess. The floor of the fourth ventricle is divided into two symmetrical halves. Each half contains facial colliculus, hypoglossal triangle, sulcus limitans, vestibular area, stria medullaris, and vagal triangle. The vital centers are situated in vagal triangle and injury during surgery into the fourth ventricle to these areas can be fatal.

The fourth ventricle is found in the posterior region of the pons and medulla and is rhomboid in shape. Superiorly, it narrows to become continuous with the aqueduct of the midbrain. Inferiorly, it narrows and leads into the central canal of the medulla. This in turn is continuous with the central canal of the spinal cord. The fourth ventricle is widened at the point called the lateral recess.

The anterior boundary, or floor is formed by the pons superiorly and medulla inferiorly. The nuclei of origin of the vestibulocochlear nerves are closely related to this. The median groove divides the floor into left and right halves. Each half is divided by the *sulcus limitans* into the *medial*, or *basal portion* and the *lateral*, or *alar portion*.

The lowermost portion of the floor of the fourth ventricle is called the *calamus scriptorius*, as it appears to resemble the tip of a pen. This region contains the cardiorespiratory, deglutition and vasomotor centers.

The posterior boundary or roof of the fourth ventricle is very thin and concealed by the cerebellum. It consists of white matter referred to as the superior and inferior medullary vela. This is lined by ependymal. There is a deficiency in the lower portion of the roof called the *median aperture* (Foramen of Magendie). At the median aperture, there is direct communication with the subarachnoid space. The ends of the lateral recess have openings called the *lateral apertures* (Foramen of Luschka). It is through the median and lateral apertures that the cerebrospinal fluid enters the subarachnoid space. The blood supply of the choroid plexus is from the cerebellar branches of the basilar and vertebral arteries.

The fourth ventricle is a broad tent-shaped cerebrospinal fluid (CSF) cavity located behind the brain stem and in front of the cerebellum in the center of the posterior fossa (Fig. 31-1). CSF enters through the cerebral aqueduct, which opens into the fourth ventricle at its rostral end. The ventricle widens caudally until its maximum width at the level of the lateral recesses, from which CSF exits through the two foramina of Luschka into the cerebellopontine cisterns on either side. The ventricle narrows again to its caudal terminus at the obliterated central canal of the spinal cord, called the *obex* from the Latin for "barrier." The foramen of Magendie is just posterior to the obex and allows CSF to exit into the cerebellomedullary cistern, which is continuous with the cisterna magna. There are no arteries or veins within the cavity of the fourth ventricle. All of the vessels associated with this region are in the fissures located just outside the fourth ventricular roof.

The glistening white floor of the fourth ventricle is the posterior surface of the brain stem (Fig. 31-2). The border between the pons and medulla occurs approximately at the level of the foramina of Luschka. The superior (pontine) part of the floor begins at the aqueduct and expands to the lower margin of the cerebellar peduncles. The inferior (medullary) part of the floor begins just below the lateral recesses at the attachment of the tela choroidea to the taenia choroidea and extends to the obex, limited laterally be the taeniae, which mark the inferolateral margins of the floor. Between these is the intermediate part, which extends into the lateral recesses on either side. There is a longitudinal midline sulcus in the fourth ventricular floor called the median sulcus. On either side of the median sulcus is the sulcus limitans, which also runs longitudinally parallel to the median sulcus. The sulcus limitans is an important landmark for functional anatomy of nuclei beneath the ventricular floor, as motor nuclei are medial and sensory nuclei lateral to the sulcus limitans. Medial to the sulcus limitans on either side of the median sulcus is the median eminence, a collection of four paired elevations in the fourth ventricular floor that are collectively referred to as the calamus scriptorius since they resemble the head of a fountain pen. Rostral to caudal, the median eminence consists of the facial colliculus, which overlies the facial nucleus; the hypoglossal triangle, which overlies the hypoglossal nucleus; the vagal triangle, which overlies the dorsal nucleus of the vagus; and the area postrema, a tongue-shaped structure that is part of the brain-stem emetic center. Lateral to the sulcus limitans is the vestibular area, so named because is overlies the vestibular nuclei. This area is widest in the neighborhood of the lateral recess, where the striae medullaris cross transversely across the inferior cerebellar peduncles to disappear into the median sulcus. The auditory tubercle in the lateral part of the vestibular area overlies the dorsal cochlear nucleus and cochlear nerve.

The roof of the fourth ventricle is tent-shaped, rising to an apex called the fastigium that divides the superior roof from the inferior roof. The median part of the superior roof, called the superior medullary velum, consists of a thin lamina of white matter between the cerebellar peduncles. Just behind its outer surface is the lingula, the uppermost division of the vermis. The lateral walls of the superior roof are formed by

the superior and inferior cerebellar peduncles, which lie between the fourth ventricle and the middle cerebellar peduncle. The rostral midline of the inferior roof is formed by the nodule, which lies directly in front of the uvula, the lower part of the vermis that hangs down between the tonsils (mimicking the appearance of the pharynx). Lateral to the nodule is the inferior medullary velum, a thin sheet of neural tissue that stretches over the fourth ventricle to connect the nodule to the flocculi on either side just superior to the outer extremity of the lateral recess. The inferior medullary velum is thus part of the primitive flocculonodular lobe of the cerebellum. The caudal inferior roof consists of the tela choroidea, two thin arachnoid-like membranes sandwiching a vascular layer of choroidal vessels to which the choroid plexus is attached. The junction between the tela choroidea and the nodule/inferior medullary velum (telovelar junction) is at the level of the lateral recess. The tela choroidea is attached to the ventricular floor at narrow white ridges called taeniae choroidea, which meet at the obex and extend upward to turn laterally over the inferior cerebellar peduncles into each lateral recess, forming its lower border. As a result, the choroid plexus (extending from the ventricular surface of the tela) forms an upside-down L shape on either side of midline. There is a medial segment of choroid plexus that extends longitudinally from the foramen of Magendie up to the nodule and a lateral segment that extends transversely from the rostral ends of the medial segments out to the foramen of Luschka. The three fourth ventricular outlet foramina (Magendie and Luschka) are located in the tela choroidea itself, and frequently choroid plexus protrudes from these foramina.

External to the fourth ventricle are three deep V-shaped fissures between the cerebellum and brain stem that enclose subarachnoid cisterns and through which course the principle arteries and veins of the posterior fossa. These three fissures are intimately related to the structures of the posterior fossa. Located between the midbrain and cerebellum, the cerebellomesencephalic fissure (also called the precentral cerebellar fissure) is the most rostral of the three and is intimately associated with the superior part of the fourth ventricular roof. This fissure is shaped like a V in the axial plain with the point facing posteriorly. The brain stem and fourth ventricle line the inner surface along with the lingula of the vermis, dorsal superior cerebellar peduncles, and rostral middle cerebellar peduncles. The outer surface of the V consists of the cerebellum, specifically the culmen and wings of the central lobule. The trochlear nerves run through the cerebellomesencephalic fissure, as do the superior cerebellar arteries (SCA). The SCAs leave the brain stem between cranial nerves IV and V to enter the fissure, and then after several sharp hairpin turns give rise to the precerebellar arteries that pass along the superior cerebellar peduncle to reach the superior fourth ventricle and dentate nucleus. Upon leaving the fissure the arteries supply end branches to the tentorial surface of the cerebellum. Venous drainage from the superior fourth ventricle occurs primarily through the vein of Galen. The vein of the cerebellomesencephalic fissure (also called the precentral cerebellar vein) is formed by the union of the

paired veins of the superior cerebellar peduncle and ascends through the quadrigeminal cistern to drain into the vein of Galen either directly or through the superior vermian vein.

The cerebellopontine fissures are intimately related to the lateral recesses of the fourth ventricle. They are produced by the folding of the cerebellum laterally around the sides of the pons and middle cerebellar peduncles. Each cerebellopontine fissure is shaped like a V in the coronal plain with the point facing laterally. The outer surface of the V is made up of the petrosal surfaces of the cerebellum, and the inner surface is made up of the middle cerebellar peduncles. The lateral recess and foramen of Luschka open into the medial part of the inferior limb of the V near the flocculus. Several cranial nerves run through the cerebellopontine fissure, including the trigeminal (through the superior limb) and the facial, glossopharyngeal, and vagus (through the inferior limb). The anterior inferior cerebellar arteries (AICA) also run through these fissures. Each AICA courses posteriorly around the pons then sends branches to nerves of the acoustic meatus and choroid plexus protruding from the foramen of Luschka before passing around the flocculus on the middle cerebellar peduncle to supply the petrosal surface of the cerebellum. Venous blood from the cerebellopontine fissure and lateral recess primarily drains into the superior petrosal sinus. The vein of the cerebellopontine fissure is formed by the convergence of several veins on the apex of the fissure, including the vein of the middle cerebellar peduncle into which the vein of the inferior cerebellar peduncle drains. This vein courses near the superior limb of the fissure to drain into the superior petrosal sinus rostral to the facial and glossopharyngeal nerves.

The cerebellomedullary fissure is directly behind the inferior roof of the fourth ventricle. It is the most caudal of the three fissures and extends between the cerebellum and medulla. Like the cerebellomesencephalic fissure, it is shaped like a V in the axial plain with the point facing posteriorly. The ventral wall consists of the inferior roof of the fourth ventricle (inferior medullary velum and tela choroidea) and the posterior medulla. The dorsal wall consists of the uvula in the midline and the tonsils (paired ovoid structures attached to the cerebellar hemispheres along their superolateral borders) and biventral lobules laterally. The fissure communicates with the cisterna magna around the superior poles of the tonsils through the telovelotonsillar cleft (tonsils to tela/velum) and “supratonsillar cleft” (superior extension of this cleft over superior pole of tonsil). The posterior inferior cerebellar arteries (PICA) course around the medulla to reach the cerebellar tonsil and lower half of the floor of the fourth ventricle. They then loop superiorly at the caudal pole of the tonsil (caudal loop) to ascend in the fissure as far as the upper pole of the tonsil, and then loop again inferiorly over the inferior medullary velum (cranial loop). Branches of the artery radiate outward from the borders of the tonsils to supply the suboccipital surface of the cerebellum. Most of the venous blood from this region drains anteriorly into the superior petrosal sinus through the vein of the cerebellopontine fissure, although some drains posteriorly into the tentorial sinuses converging on the torcular Herophili. The vein of

the cerebellomedullary fissure originates on the lateral edge of the nodule and uvula and courses laterally near the telovelar junction to reach the cerebellopontine angle.

The rhomboid-shaped fourth ventricle extends through the pons and medulla. The foramina of Magendie and Luschka must remain patent for proper flow of the CSF into the cisterns. Bilaterally symmetrical protrusions, depressions, and sulci on the floor of the fourth ventricle define the underlying anatomy of brain stem regions, such as the hypoglossal, vagal, and vestibular areas. Vital brain stem centers for cardiovascular, respiratory, and metabolic functions just below the floor of the fourth ventricle can be damaged by tumors in the region. The lateral margins of the fourth ventricle are embraced by the huge cerebellar peduncles interconnecting the cerebellum with the brain stem and diencephalon. These anatomical relationships are important when interpreting imaging studies in the compact brain stem regions where the diagnosis of tumors and vascular lesions is challenging.

Fourth Ventricle

The **fourth ventricle** is a roughly pyramid-shaped space that forms the cavity of the metencephalon and myelencephalon . The apex of this ventricle extends into the base of the cerebellum, and caudally it tapers to a narrow channel that continues into the cervical spinal cord as the central canal. Laterally the fourth ventricle extends over the surface of the medulla as the lateral recesses, eventually to open into the area of the pons-medulla-cerebellum junction, the cerebellopontine angle, through the **foramina of Luschka** . The irregularly shaped **foramen of Magendie** is located in the caudal sloping roof of the ventricle. Although the roof of the caudal part of the fourth ventricle and the lateral recesses is composed of **tela choroidea,** the rostral boundaries of this space are formed by brain structures. These include the cerebellum (covering about the middle third of the ventricle) and the superior cerebellar peduncles and anterior medullary velum (covering the rostral third of the ventricle). The floor of the fourth ventricle, the rhomboid fossa , is formed by the pons and medulla. The only naturally occurring openings between the ventricles of the brain and the subarachnoid space surrounding the brain are the foramina of Luschka and Magendie in the fourth ventricle.

The fourth ventricle is a midline cavity located between the brainstem and the cerebellum (Matsushima, Rhoton, & Lenkey, 1982; Rhoton Jr, 2000). It is connected to the third ventricle through the aqueduct, to the cisterna magna through the foramen of Magendie, and to the cerebellopontine angle through the foramina of Luschka. The fourth ventricle, when seen from a sagittal cut, resembles the form of a tent. The floor of the tent is formed by the pons and medulla. The roof points posteriorly and is divided in a superior and an inferior roof. The superior and the inferior roof meet at a point called the fastigium. Each part of the tent has a corresponding cerebellar part. The superior part of the roof is related to the tentorial surface of the cerebellum. The inferior part of the roof is related to the suboccipital surface of the cerebellum. The floor of the tent, formed by the pons and the medulla, is related to the petrosal surface of the cerebellum. Most of the

surgical approaches to the fourth ventricle are performed through the inferior part of the roof and also involve exposure of the suboccipital surface of the cerebellum.

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Superior roof of the fourth ventricle: If we remove the pons and the medulla to see the superior and the inferior roofs of the fourth ventricle, we can notice a major difference between them. The superior roof of the fourth ventricle has thick neural structures, the superior cerebellar peduncles. The superior cerebellar peduncles are on the lateral wall of the superior part of the roof and are the continuation of the dentate nuclei. The dentate nuclei are located just above the superior pole of the tonsils. The superior medullary velum is located on the midline, between both superior cerebellar peduncles.

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Inferior roof of the fourth ventricle: In contrast to the superior roof, the inferior roof of the fourth ventricle is formed mainly by two thin membranes, the tela choroidea and the inferior medullary velum. The inferior medullary velum is all that remains of the connection between the nodule and flocculus. It extends laterally from the nodule above the superior pole of the tonsil and forms the peduncle of the flocculus at the level of the lateral recess. The space between the superior cerebellar peduncle and the inferior medullary velum is called the superolateral recess. The tela choroidea, when seen from anteriorly, resembles the letter T. It extends laterally to form the floor of the two lateral recesses and it extends inferiorly from the inferior medullary velum (the telovelar junction) to attach to the inferolateral edges of the floor of the fourth ventricle along the taenia, which are narrow white ridges that meet at the obex.

•Cerebellum: The inferior portion of the suboccipital surface of the cerebellum hides the inferior roof of the fourth ventricle. The tonsil and the biventral lobule cover the tela choroidea and the lateral recess. In the midline, the uvula covers the nodule. The cerebellomedullary fissure is a natural space between the cerebellum and the medulla. It is continuous with the vallecula, the space between both tonsils. The tonsil is the structure that blocks most of the view of the inferior roof of the fourth ventricle. If we remove the tonsils, we have a direct view of the tela choroidea and the inferior medullary velum. The tonsil is attached to the cerebellar hemisphere through the tonsilar peduncle, located at the superolateral aspect of the tonsil.

•Lateral recess: Extends laterally below the cerebellar peduncles to open into the cerebellopontine cistern through the foramina of Luschka. The lateral recess may be divided into a peduncular and a floccular part. The peduncular part is formed by the inferior cerebellar peduncle anteriorly and the peduncle of the flocculus posteriorly. The floccular part is formed by the rhomboid lip anteriorly and by the flocculus posteriorly. The rhomboid lip is a thin sheet of neural tissue located posteriorly to the glossopharyngeal and vagus nerves. The tela choroidea forms the floor of both parts of the lateral recess.

•Floor of the fourth ventricle: Has a rhomboid shape, and formed by the pons and the medulla. The pons forms the superior two-thirds of the floor and the medulla forms the inferior one-third of the floor. The

pontine part of the floor has a triangular shape, with its apex continuous with the aqueduct and the base of the triangle is represented by an imaginary line connecting the lower margin of the cerebellar peduncles. The medullary part of the floor also has a triangular shape, but its apex points inferiorly at the obex. The base of the medullary part is an imaginary line along the site of attachment of the tela choroidea to the tenia just below the lateral recess. The intermediate part of the floor is formed by lateral recesses, between these two imaginary lines. The intermediate part of the floor corresponds to the transition between the pons and the medulla. The floor is divided longitudinally in two halves by the median sulcus. Parallel to the median sulcus is the sulcus limitans, which marks two longitudinal strips between both sulci, the two median eminences. The sulcus limitans does not mark the median, but it has two distinct depressions along its way. The superior depression is the superior fovea, located laterally to the facial colliculus. The inferior depression is the inferior fovea, located laterally to the hypoglossal triangle. The motor nuclei of the cranial nerves are located medially to the sulcus limitans, whereas the sensory nuclei are located laterally. The median eminence contains the facial colliculus and three triangular areas on its inferior end: hypoglossal triangle, vagal triangle, and area postrema. The inferior part of the fourth ventricle is called the calamus scriptorius, because these three triangular areas are grouped together near the median sulcus on the inferior part of the floor, giving a configuration of a feather or pen nib.

Lecture 2. The midbrain, the diencephalon. The third ventricle.

The **midbrain** (also known as the mesencephalon) is the most superior of the three regions of the brainstem. It acts as a conduit between the forebrain above and the pons and cerebellum below.

In this article, we will discuss the anatomy of the midbrain – its external anatomy, internal anatomy, and vasculature.

External Anatomy of the Midbrain

The midbrain is the smallest of the three regions of the brainstem, measuring around 2cm in length. As it ascends, the midbrain travels through the opening in the tentorium cerebelli.It can be divided into two main parts: **Tectum** – located posterior to the cerebral aqueduct

Paired cerebral peduncles – located anteriorly and laterally.Internally, the cerebral peduncles are further separated by the substania nigra into the crus cerebri (anterior) and the tegmentum (posterior).

Tectum The tectum houses four rounded prominences named **colliculi** (collectively the corpora quadrigemina) which sit directly inferior to the pineal gland. The colliculi are separated by the cruciform sulcus; there are two superior and two inferior colliculi.Extending laterally from each colliculi are the quadrigeminal brachium:**Superior quadrigeminal brachium** forms a pathway between the superior colliculus and the retina of the eye.**Inferior quadrigeminal brachium** conveys fibres from the lateral lemniscus and inferior colliculus to the medial geniculate body.Inferior to the colliculi, the **trochlear nerve** **(CN IV)** emerges before sweeping across to the anterior surface.

Cerebral Peduncles The paired cerebral peduncles extend from the cerebral hemispheres to converge as they meet the pons. They are separated anteriorly in the midline by the **interpeduncular fossa**, the floor of which is termed the posterior perforated substance (as many perforating blood vessels can be identified).The oculomotor nerve (CNIII) is seen exiting from between the peduncles while the **optic tract** runs around the superior border of the midbrain.

Internal Anatomy of the Midbrain

Two transverse sections of the midbrain will be discussed: the level of the inferior colliculus, and the level of the superior colliculus.

Level of the Inferior Colliculus

The anteriolateral surface of the midbrain houses the paired crus cerebri. Four fibre tracts run within the crus:

- **Frontopontine fibres** – located most medially.
- **Corticospinal fibres** – motor fibres from the primary motor cortex.
- **Corticobulbar tracts** – motor fibres from the primary motor cortex.
- **Temporopontine fibres** – located posterolaterally.

Posteriorly is the **substantia nigra** – a pigmented nucleus that separates the two regions of the cerebral peduncles. It is further broken down into the pars reticulata (anterior) and pars compacta (posterior).

The **tegmentum** is located posterior to the substantia nigra. It is continuous with that found in the pons by the same name. It is important to note that unlike the crus cerebri, the tegmentum is continuous at the midline.

The cerebral aqueduct (see ventricles) is a midline structure surrounded by central gray matter – the **periaqueductal gray matter**. Within this gray matter lies the mesencephalic nucleus of the trigeminal nerve, as well as the trochlear nucleus with its fibres continuing around the gray matter to exit the midbrain. Anterior to this, the **medial longitudinal fasciculus** can be seen.

The decussation of the **superior cerebellar peduncles** can be seen centrally at this level with some reticular formation (noted throughout the brainstem) lying lateral.

Between the central gray matter and the substantia nigra are four **lemnisci**. Moving anterior to posterior they are the medial, spinal, trigeminal, and lateral leminisci.

At the very posterior pole, we find the **tectum** which, at this level, contains the inferior colliculus.

Level of the Superior Colliculus

Much of the internal structure of the midbrain is unchanged at this level and should be assumed present unless mentioned below.

The central portion which previously was occupied by the decussation of the superior cerebellar peduncles now contains the large paired **red nuclei** with some decussation of the rubrospinal tract occuring anterior to this. The reticular formation now fans around the posterior borders of the red nuclei.

The trochlear nucleus is replaced with the **oculomotor nucleus** while the oculomotor nerve projects anteriorly.

The medial, spinal and **trigeminal lemnisc**i are all present in much the same location however the lateral lemnisci does not reach to this level.

Needless to say, the tectum now contains the **superior colliculi** rather than the inferior colliculi.

VasculatureWe will only briefly look at the vasculature of the midbrain.The supply to the area is derived from the basilar artery and its branches. The major suppliers are: the posterior cerebral artery and its peduncular branch, the superior cerebellar artery, the posterior choroidal artery, and the interpeduncular branches of the basilar artery.

Lecture 3. The telencephalon. Furrows, convolutions, centers of the cortex of the brain. The fornix. The corpus callosum. Basal nuclei. The lateral ventricles. Membranes of the brain. Venous sinuses. Circulation of cerebrospinal fluid.

The cerebrum is the largest part of the brain. It is divided into two hemispheres separated by the longitudinal fissure. The hemispheres are prominently marked with gyri and sulci. The two hemispheres are connected chiefly through a large fiber tract, the corpus callosum.

Each hemisphere has five lobes: frontal, parietal, occipital, and temporal lobes and the insula.

The cerebral cortex is gray matter with two types of neurons: stellate cells and pyramidal cells. All output from the cortex travels by way of axons of the pyramidal cells. Most of the cortex is neocortex, in which there are six layers of nervous tissue. Evolutionarily older parts of the cerebrum have one- to five-layered paleocortex and archicortex.

The basal nuclei are masses of cerebral gray matter lateral to the thalamus, concerned with motor control. They include the caudate nucleus, putamen, and globus pallidus.

The special senses originate in relatively complex sense organs of the head and involve distinct regions of primary sensory cortex and association areas. Vision resides in the occipital lobe and inferior temporal lobe; hearing in the superior temporal lobe; equilibrium in the cerebellum and brainstem, but with centers of consciousness of body movements and position low in the parietal lobe; taste in the parietal lobe and insula; smell in the frontal and temporal lobes; and there is an association area in the frontal lobe for taste and smell combined.

Motor control resides in the motor association area and precentral gyrus of the frontal lobe.

The basal nuclei and cerebellum play important roles in motor coordination and learned motor skills (procedural memory).

Language is coordinated largely by the Wernicke and Broca areas. Recognizing language and formulating what one will say or write occur in the Wernicke area; the Broca area compiles the motor program of speech; and commands to the muscles of speech originate in the precentral gyrus.

The brain exhibits cerebral lateralization: Some functions are coordinated mainly by the left hemisphere and others by the right. The categorical hemisphere (in most people, the left) is responsible for verbal and mathematical skills and logical, linear thinking. The representational hemisphere (usually the right) is a seat of imagination, insight, spatial perception, musical skill, and other "holistic" functions.

The brain is surrounded by dura mater, arachnoid mater, and pia mater. The dura mater is divided into two layers, periosteal and meningeal, which in some places are separated by a blood-filled dural sinus. In some places, the dura folds inward to separate major brain regions. A subdural space separates some areas of dura from the arachnoid, and a subarachnoid space separates arachnoid from pia.

Lecture 4. Motor and sensory pathways of the brain and spinal cord.

passes just dorsal to the olive and above this joins the lateral edge of the lateral lemniscus along which it runs, ventral to the roots of the trigeminal nerve, almost to the level of the superior colliculus, it then crosses over the superior peduncle, turns abruptly backward along its medial border, enters the cerebellum with it and ends in the vermis of the same and the opposite side. Some of its fibers are said to join the dorsal spinocerebellar fasciculus in the medulla oblongata and enter the cerebellum through the inferior peduncle. A number of fibers are said to continue upward in the dorsolateral part of the tegmentum as far as the superior colliculus and a few pass to the thalamus. They probably form part of the sensory or higher reflex path.

The posterior root fibers conducting impulses of pain and temperature probably terminate in the posterior column or the intermediate region of the gray matter soon after they enter the spinal cord. The neurons of the second order are supposed to pass through the anterior commissure to the superficial antero-lateral fasciculus (tract of Gowers) and pass upward in that portion of it known as the lateral spinothalamic fasciculus. This fasciculus lies along the medial side of the ventral spinocerebellar fasciculus. It is stated by some authors that the pain fibers pass upward in the antero-lateral ground bundles. In some of the lower mammals this pathway carries the pain fibers upward by a series of neurons some of which cross to the opposite side, so that in part there is a double path. In man, however, the lateral spinothalamic fasciculus is probably the most important pathway. On reaching the medulla these fibers continue upward through the formatio reticularis in the neighborhood of the median fillet to the thalamus, probably its ventro-lateral region. Whether higher neurons convey the

pain impulses to the cortex through the internal capsule is uncertain. The pathway is probably more complex and Head is of the opinion that our sensations of pain are essentially thalamic. The pain and temperature pathways in the lateral spinothalamic fasciculus are not so closely intermingled but that one can be destroyed without injury to the other.

Ransom suggests that the non-medullated fibers of the posterior roots, which turn into Lissauer's tract and ascend or descend for short distances not exceeding one or two segments and finally end in the substantia gelatinosa, are in part at least pain fibers and that the fasciculus of Lissauer and the substantia gelatinosa represent part of the mechanism for reflexes associated with pain conduction and reception while the fibers to the higher centers pass up in the spinothalamic tract.

The fibers of tactile discrimination, according to Head and Thompson, pass up in the fasciculus cuneatus and fasciculus gracilis of the same side and follow the path of the muscle-sense fibers. The axons of the second order arising in the nucleus cuneatus and gracilis cross with the internal arcuate fibers and ascend to the thalamus with the medial lemniscus, thence by neurons of higher order the impulses are carried to the somatic sensory area of the cortex through the internal capsule. The other touch fibers, shortly after entering the spinal cord, terminate in the dorsal column or intermediate gray matter. Neurons of the second order send their axons through the anterior commissure to pass upward in the antero-lateral funiculus probably in the ventral spinothalamic fasciculus. In the medulla they join or pass upward in the neighborhood of the medial lemniscus to the thalamus and thence by neurons of higher order to the somatic sensory area of the cortex.

The remaining ascending fasciculi form a part of the complex known as the superficial antero-lateral fasciculus (tract of Gowers). The spinotectal fasciculus, as its name indicates, is supposed to have its origin in the gray matter of the cord and terminations in the superior and inferior (?) colliculi of the mid-brain serving for reflexes between the cord and the visceral and auditory centers of the mid-brain.

Lecture 5. Formation of spinal nerves. Anterior and posterior divisions. Anatomy of the cervical and brachial plexus. Thoracic nerves.

Overview of the Spinal Nerves

Spinal nerves, a part of the peripheral nervous system (PNS), are mixed nerves that send motor, sensory, and autonomic signals between the CNS and the body.

LEARNING OBJECTIVES

Describe spinal nerves of the peripheral nervous system

KEY TAKEAWAYS

Key Points

- Afferent sensory axons bring sensory information from the body to the spinal cord and brain; they travel through the dorsal roots of the spinal cord.
- Efferent motor axons bring motor information from the brain to the body; they travel through the ventral roots of the spinal cord.
- All spinal nerves—except the first pair—emerge from the spinal column through an opening between vertebrae, called an intervertebral foramen.
- The spinal nerves are typically labeled by their location in the body: thoracic, lumbar, or sacral.

Key Terms

- **ventral root**: Also called the anterior root, it is the efferent motor root of a spinal nerve.
- **autonomic**: Acting or occurring involuntarily, without conscious control.
- **dorsal root**: Also known as the posterior root, the afferent sensory root of a spinal nerve.
- **intervertebral foramen**: The foramen allows for the passage of the spinal nerve root, dorsal root ganglion, the spinal artery of the segmental artery, the communicating veins between the internal and external plexuses, recurrent meningeal (sinu-vertebral) nerves, and transforaminal ligaments.

Spinal Nerve Anatomy

The term spinal nerve generally refers to a mixed spinal nerve that carries motor, sensory, and autonomic signals between the spinal cord and the body.

Humans have 31 left–right pairs of spinal nerves, each roughly corresponding to a segment of the vertebral column: eight cervical spinal nerve pairs (C1–C8), 12 thoracic pairs (T1–T12), five lumbar pairs (L1–L5), five sacral pairs (S1–S5), and one coccygeal pair. The spinal nerves are part of the peripheral nervous system (PNS).

A spinal nerve: Spinal nerves arise from a combination of nerve fibers from the dorsal and ventral roots of the spinal cord.

Location

Intervertebral foramina: Intervertebral foramina are indicated by arrows.

Each spinal nerve is formed by the combination of nerve fibers from the dorsal and ventral roots of the spinal cord. The dorsal roots carry afferent sensory axons, while the ventral roots carry efferent motor axons.

The spinal nerve emerges from the spinal column through an opening (intervertebral foramen) between adjacent vertebrae.

This is true for all spinal nerves except for the first spinal nerve pair, which emerges between the occipital bone and the atlas (the first vertebra). Thus the cervical nerves are numbered by the vertebra below, except C8, which exists below C7 and above T1.

The thoracic, lumbar, and sacral nerves are then numbered by the vertebra above. In the case of a lumbarized S1 vertebra (i.e., L6) or a sacralized L5 vertebra, the nerves are typically still counted to L5 and the next nerve is S1.

Spinal Nerve Innervation

Outside the vertebral column, the nerve divides into branches. The dorsal ramus contains nerves that serve the dorsal portions of the trunk; it carries visceral motor, somatic motor, and somatic sensory information to and from the skin and muscles of the back (epaxial muscles).

The ventral ramus contains nerves that serve the remaining ventral parts of the trunk and the upper and lower limbs (hypaxial muscles); they carry visceral motor, somatic motor, and sensory information to and from the ventrolateral body surface, structures in the body wall, and the limbs.

The meningeal branches (recurrent meningeal or sinuvertebral nerves) branch from the spinal nerve and re-enter the intervertebral foramen to serve the ligaments, dura, blood vessels, intervertebral discs, facet joints, and periosteum of the vertebrae.

The rami communicantes contain autonomic nerves that serve visceral functions, such as carrying visceral motor and sensory information to and from the visceral organs.

Cervical Nerves

The posterior distribution of the cervical nerves includes the suboccipital nerve (C1), the greater occipital nerve (C2), and the third occipital nerve (C3). The anterior distribution includes the cervical plexus (C1–C4) and brachial plexus (C5–T1).

The muscles innervated by the cervical nerves are the sternohyoid, sternothyroid, and omohyoid muscles.

A loop of nerves called ansa cervicalis is also part of the cervical plexus.

Thoracic Nerves

Thoracic nerve branches exit the spine and go directly to the paravertebral ganglia of the autonomic nervous system, where they are involved in the functions of organs and glands in the head, neck, thorax, and abdomen.

Anterior Divisions

The intercostal nerves come from thoracic nerves T1–T11, and run between the ribs. The subcostal nerve comes from nerve T12, and runs below the twelfth rib.

Posterior Divisions

The medial branches (ramus medialis) of the posterior branches of the upper six thoracic nerves run between the semispinalis dorsi and multifidus, which they supply.

They then pierce the rhomboid and trapezius muscles, and reach the skin by the sides of the spinous processes. This branch is called the medial cutaneous ramus.
The medial branches of the lower six thoracic nerves are distributed chiefly to the multifidus and longissimus dorsi, occasionally they give off filaments to the skin near the middle line. This sensitive branch is called the posterior cutaneous ramus.

Lumbar Nerves

The lumbar nerves are divided into posterior and anterior divisions.

Posterior Divisions

The medial branches of the posterior divisions of the lumbar nerves run close to the articular processes of the vertebrae and end in the multifidus muscle. The lateral branches supply the erector spinae muscles.

Anterior Divisions

The anterior divisions of the lumbar nerves (rami anteriores) consist of long, slender branches that accompany the lumbar arteries around the sides of the vertebral bodies, beneath the psoas major.

The first and second, and sometimes the third and fourth, lumbar nerves are each connected with the lumbar part of the sympathetic trunk by a white ramus communicans.

The nerves pass obliquely outward behind the psoas major, or between its fasciculi, distributing filaments to it and the quadratus lumborum.

The first three and the greater part of the fourth are connected by anastomotic loops and form the lumbar plexus.

The smaller part of the fourth joins with the fifth to form the lumbosacral trunk, which assists in the formation of the sacral plexus. The fourth nerve is named the furcal nerve, from the fact that it is subdivided between the two plexuses.

Sacral Nerves

There are five paired sacral nerves, half of them arising through the sacrum on the left side and the other half on the right side. Each nerve emerges in two divisions: one division through the anterior sacral foramina and the other division through the posterior sacral foramina.

The sacral nerves have both afferent and efferent fibers, thus they are responsible for part of the sensory perception and the movements of the lower extremities of the human body.

The pudendal nerve and parasympathetic fibers arise from S2, S3, and S4. They supply the descending colon and rectum, urinary bladder, and genital organs. These pathways have both afferent and efferent fibers.

Coccygeal Nerve

The coccygeal nerve is the 31st pair of spinal nerves and arises from the conus medullaris. Its anterior root helps form the coccygeal plexus.

Function

Spinal nerve motor functions are summarized in the table below.

Actions of the spinal nerves

Level	Motor Function
C1–C6	Neck flexors
C1–T1	Neck extensors

Actions of the spinal nerves

Level	Motor Function
C3, C4, C5	Supply diaphragm (mostly C4)
C5, C6	Move shoulder, raise arm (deltoid); flex elbow (biceps)
C6	Externally rotate (supinate) the arm
C6, C7	Extend the elbow and wrist (triceps and wrist extensors); pronate wrist
C7, C8	Flex wrist; supply small muscles of the hand
T1–T6	Intercostals and trunk above the waist
T7–L1	Abdominal muscles
L1–L4	Flex thigh
L2, L3, L4	Adduct thigh; extend leg at the knee (quadriceps femoris)
L4, L5, S1	Abduct thigh; flex leg at the knee (hamstrings); dorsiflex foot (tibialis anterior); extend toes
L5, S1, S2	Extend leg at the hip (gluteus maximus); plantar flex foot and flex toes

Branches of Spinal Nerves

The spinal nerves branch into the dorsal ramus, ventral ramus, the meningeal branches, and the rami communicantes.

LEARNING OBJECTIVES

Describe branches of the peripheral nervous system

KEY TAKEAWAYS

Key Points

- The dorsal and ventral rami contain nerves that provide visceral motor, somatic motor, and sensory information, with the dorsal ramus feeding the dorsal trunk (skin and muscles of the

back), and the ventral ramus feeding the ventral trunk and limbs through the ventrolateral surface.

- The meningeal branches supply nerve function to the vertebrae themselves, including the ligaments, dura, blood vessels, intervertebral discs, facet joints, and periosteum.
- The rami communicantes contain autonomic nerves that carry visceral motor and sensory information to and from the visceral organs.

Key Terms

- **nerve plexus**: A branching network of intersecting nerves.
- **dorsal ramus**: The posterior (or dorsal) branches (or divisions) of the spinal nerves are, as a rule, smaller than the anterior divisions. They are also referred to as the dorsal rami. They are directed backwards and—with the exceptions of those of the first cervical, the fourth and fifth sacral, and the coccygeal—divide into medial and lateral branches for the supply of the muscles and skin of the posterior part of the trunk.
- **meningeal branches**: Also known as recurrent meningeal nerves, sinuvertebral nerves, or recurrent nerves of Luschka, these are a number of small nerves that branch from the spinal nerve (or the posterior ramus) near the origin of the anterior and posterior rami. They then re-enter the intervertebral foramen, and innervate the facet joints, the annulus fibrosus of the intervertebral disk, and the ligaments and periosteum of the spinal canal, carrying pain sensation.

Outside the vertebral column, the spinal nerves divide into branches.

- The dorsal ramus: Contains nerves that serve the dorsal portions of the trunk carrying visceral motor, somatic motor, and sensory information to and from the skin and muscles of the back.
- The ventral ramus: Contains nerves that serve the remaining ventral parts of the trunk and the upper and lower limbs carrying visceral motor, somatic motor, and sensory information to and from the ventrolateral body surface, structures in the body wall, and the limbs.
- Some ventral rami merge with adjacent ventral rami to form a nerve plexus, a network of interconnecting nerves. Nerves emerging from a plexus contain fibers from various spinal nerves, which are now carried together to some target location. Major plexuses include the cervical, brachial, lumbar, and sacral plexuses.
- The meningeal branches (recurrent meningeal or sinuvertebral nerves): These branch from the spinal nerve and re-enter the intervertebral foramen to serve the ligaments, dura, blood vessels, intervertebral discs, facet joints, and periosteum of the vertebrae.

- The rami communicantes: Contain autonomic nerves that carry visceral motor and sensory information to and from the visceral organs.

Plexuses

A nerve plexus is a network of intersecting nerves that serve the same part of the body.

LEARNING OBJECTIVES

Describe nerve plexuses in the peripheral nervous system

KEY TAKEAWAYS

Key Points

- Nerve plexuses throughout the body tend to be named after the area in which the plexus occurs and the organs, limbs, and tissues it serves. Examples include the cervical, brachial, lumbar, sacral, celiac, and coccygeal plexuses.
- Auerbach's plexus, which serves the gastrointestinal tract, is named after the first person to describe this plexus, Leopold Auerbach, rather than the area of the body it serves.
- The brachial plexus serves the chest, shoulders, arms and hands and is formed by the ventral rami of C5, C8, and T1 spinal nerves, and the lower and upper halves of the C4 and T2 spinal nerves.

Key Terms

- **nerve plexus**: A network of intersecting nerves.
- **brachial plexus**: A network of nerve fibers, running from the spine, formed by the ventral rami of the lower four cervical and first thoracic nerve roots (C5–C8, T1). It proceeds through the neck, the axilla (armpit region), and into the arm. It also supplies the brachium, the antebrachium, and the hand.
- **coccygeal plexus**: A plexus of nerves near the coccyx bone.
- **Autonomic**: A division of the peripheral nervous system that influences the function of internal organs.

A nerve plexus is a network of intersecting nerves; multiple nerve plexuses exist in the body. Nerve plexuses are composed of afferent and efferent fibers that arise from the merging of the anterior rami of spinal nerves and blood vessels.

There are five spinal nerve plexuses—except in the thoracic region—as well as other forms of autonomic plexuses, many of which are a part of the enteric nervous system.

Spinal Plexuses

Cervical Plexus—Serves the Head, Neck and Shoulders

The cervical plexus is formed by the ventral rami of the upper four cervical nerves and the upper part of fifth cervical ventral ramus. The network of rami is located deep within the neck.

Brachial Plexus—Serves the Chest, Shoulders, Arms and Hands

The brachial plexus is formed by the ventral rami of C5–C8 and the T1 spinal nerves, and lower and upper halves of the C4 and T2 spinal nerves. The plexus extends toward the armpit (axilla).

Lumbar Plexus—Serves the Back, Abdomen, Groin, Thighs, Knees, and Calves

The lumbar plexus is formed by the ventral rami of L1–L5 spinal nerves with a contribution of T12 form the lumbar plexus. This plexus lies within the psoas major muscle.

Sacral Plexus—Serves the Pelvis, Buttocks, Genitals, Thighs, Calves, and Feet

The sacral plexus is formed by the ventral rami of L4-S3, with parts of the L4 and S4 spinal nerves. It is located on the posterior wall of the pelvic cavity.

Coccygeal Plexus—Serves a Small Region over the Coccyx

The coccygeal plexus serves a small region over the coccyx and originates from S4, S5, and Co1 spinal nerves. It is interconnected with the lower part of sacral plexus.

In addition, the celiac plexus serves the internal organs, and Auerbach's plexus serves the gastrointestinal tract.

Autonomic Plexuses

- Celiac plexus (solar plexus)—Serves internal organs.
- Auerbach's plexus—Serves the gastrointestinal tract.
- Meissner's plexus (submucosal plexus)—Serves the gastrointestinal tract.

Lumbar plexus: The lumbar plexus is comprised of the ventral rami of the lumbar spinal nerves (L1–L5) and a contribution from thoracic nerve (T12). The posterior (green) and anterior (yellow) divisions of the lumbar plexus are shown in the diagram.

Intercostal Nerves

The anterior divisions of the thoracic spinal nerves (T1–T11) are called the intercostal nerves.

LEARNING OBJECTIVES

Describe the function of intercostal nerves

KEY TAKEAWAYS

Key Points

- The intercostal nerves are part of the somatic nervous system. This enables them to control the contraction of muscles, as well as provide specific sensory information regarding the skin and parietal pleura.

- Intercostal nerves connect to the appropriate ganglion in the sympathetic trunk through rami communicantes and serve the thoracic pleura and the abdominal peritoneum.
- Unlike most other anterior divisions of spinal nerves, the intercostal nerves do not form a plexus.

Key Terms

- **thoracic spinal nerves**: The spinal nerves emerging from the thoracic vertebrae. Branches also exit the spine and go directly to the sympathetic chain ganglia of the autonomic nervous system where they are involved in the functions of organs and glands in the head, neck, thorax, and abdomen.
- **sympathetic trunk**: Also called the sympathetic chain or gangliated cord, these are a paired bundle of nerve fibers that run from the base of the skull to the coccyx.
- **abdominal peritoneum**: The serous membrane that forms the lining of the abdominal cavity. It covers most of the intra-abdominal organs. It is composed of a layer of mesothelium supported by a thin layer of connective tissue. The peritoneum supports the abdominal organs and serves as a conduit for their blood and lymph vessels and nerves.

The intercostal nerves are part of the somatic nervous system and arise from anterior divisions (rami anteriores, ventral divisions) of the thoracic spinal nerves T1 to T11. The intercostal nerves are distributed chiefly to the thoracic pleura and abdominal peritoneum.

They differ from the anterior divisions of the other spinal nerves in that each pursues an independent course without plexus formation.

First Thoracic Nerve

The anterior division of the first thoracic nerve divides into two branches:

1. The larger branch leaves the thorax in front of the neck of the first rib and enters the brachial plexus.
2. The other smaller branch, the first intercostal nerve, runs along the first intercostal space and ends on the front of the chest as the first anterior cutaneous branch of the thorax.

The Upper Thoracic Nerves (2nd–6th)

These are limited in their distribution to the parietes (wall) of the thorax. The anterior divisions of the second, third, fourth, fifth, and sixth thoracic nerves, and the small branch from the first thoracic, are confined to the walls of the thorax and are named thoracic intercostal nerves.

Near the sternum, they cross in front of the internal mammary artery and transversus thoracis muscle, pierce the intercostales interni, the anterior intercostal membranes, and pectoralis major, and supply the integument of the front of the thorax and over the mamma, forming the anterior cutaneous branches of the thorax.

The branch from the second nerve unites with the anterior supraclavicular nerves of the cervical plexus.

The Lower Thoracic Nerves (7th–12th)

The seventh intercostal nerve terminates at the xyphoid process, at the lower end of the sternum.

The anterior divisions of the seventh, eighth, ninth, tenth, and eleventh thoracic intercostal nerves are continued anteriorly from the intercostal spaces into the abdominal wall; hence they are named thoraco-abdominal nerves or thoracicoabdominal intercostal nerves.

The tenth intercostal nerve terminates at the umbilicus.

The twelfth (subcostal) thoracic nerve is distributed to the abdominal wall and groin.

Unlike the nerves from the autonomic nervous system that innervate the visceral pleura of the thoracic cavity, the intercostal nerves arise from the somatic nervous system. This enables them to control the contraction of muscles, as well as provide specific sensory information regarding the skin and parietal pleura.

This explains why damage to the internal wall of the thoracic cavity can be felt as a sharp pain localized in the injured region. Damage to the visceral pleura is experienced as an unlocalized ache.

Dermatomes

A dermatome is an area of skin that is supplied by a single spinal nerve, and a myotome is a group of muscles that a single spinal nerve root innervates.

LEARNING OBJECTIVES

Describe dermatomes and how they relate to the peripheral nervous system

KEY TAKEAWAYS

Key Points

- There are eight cervical nerves, twelve thoracic nerves, five lumbar nerves and five sacral nerves. Each of these nerves relays sensation, including pain, from a particular region of skin to the brain.
- Along the thorax and abdomen, the dermatomes are like a stack of discs, with each section supplied by a different spinal nerve. The pattern is different along the arms and the legs. The dermatomes run longitudinally along the limbs, so that each half of the limb has a different dermatome.

- Dermatomes have clinical significance, especially in the diagnosis of certain diseases. Symptoms that follow a dermatome, such as pain or a rash, may indicate a pathology that involves the related nerve root. Examples include dysfunction of the spine or a viral infection.

Key Terms

- **shingles**: Also known as herpes zoster, shingles is an acute viral inflammation of the sensory ganglia of spinal and cranial nerves associated with a vesicular eruption and neuralgic pains and caused by reactivation of the poxvirus causing chicken pox.
- **chickenpox**: A common childhood disease caused by the varicella-zoster virus.

A dermatome is an area of skin that is supplied by a single spinal nerve. There are eight cervical nerves, twelve thoracic nerves, five lumbar nerves and five sacral nerves. Each of these nerves relays sensation, including pain, from a particular region of the skin to the brain.

Along the thorax and abdomen, the dermatomes are like a stack of discs, with each section supplied by a different spinal nerve. Along the arms and the legs, the pattern is different. The dermatomes run longitudinally along the limbs, so that each half of the limb has a different dermatome.

Although the general pattern is similar in all people, the precise areas of innervation are as unique to an individual as fingerprints.

Dermatomes have clinical significance, especially in the diagnosis of certain diseases. Symptoms that follow a dermatome, such as pain or a rash, may indicate a pathology that involves the related nerve root. Examples include dysfunction of the spine or a viral infection.

Viruses that remain dormant in nerve ganglia, such as the varicella zoster virus that causes both chickenpox and shingles, often cause either pain, rash, or both in a pattern defined by a dermatome.

Shingles is one of the only diseases that causes a rash in a dermatomal pattern, and as such, this is its defining symptom. The rash of shingles is almost always restricted to a specific dermatome, such as on the chest, leg, or arm caused by the residual varicella zoster virus infection of the nerve that supplies that area of skin. Shingles typically appears years or decades after recovery from chickenpox.

Mytome

A myotome is the group of muscles that a single spinal nerve root innervates. The myotome is the motor equivalent of a dermatome.

The myotome distributions of the upper and lower extremities are listed below:

- C1/C2: Neck flexion / extension
- C3: Neck lateral flexion
- C4: Shoulder elevation
- C5: Shoulder abduction
- C6: Elbow flexion/wrist extension

- C7: Elbow extension/wrist flexion
- C8: Finger flexion
- T1: Finger abduction
- L2: Hip flexion
- L3: Knee extension
- L4: Ankle dorsi-flexion
- L5: Great toe extension
- S1: Ankle plantar flexion/ankle eversion/hip extension
- S2: Knee flexion
- S3–S4: Anal reflex

The testing of myotomes provides the clinician with information about the level in the spine where a lesion may be present. During testing, the clinician looks for muscle weakness of a particular group of muscles. Results may indicate lesions to the spinal cord nerve root, or intervertebral disc herniation that presses on the spinal nerve roots.

Function and Physiology of the Spinal Nerves

Spinal nerves connect the brain and spinal cord to the limbs and organs of the body.

LEARNING OBJECTIVES

Describe the function and physiology of the spinal nerves

KEY TAKEAWAYS

Key Points

- Spinal nerves, considered part of the peripheral nervous system, generally refer to mixed spinal nerves, which carry motor, sensory, and autonomic information between the brain and spinal cord and the rest of the body.
- The cervical spinal nerves innervate the muscles and provide sensation for the head, neck, and diaphragm, as well as the upper limbs and back.
- The lumbar, sacral, and coccygeal nerves combine to form the lumbosacral plexus.
- The spinal cord can be divided into the lateral, posterior, and medial cord, each segment of which gives rise to specific nerves and serves specific areas of the body.
- The somatic nervous system is responsible for voluntary body movements, receiving information from afferent fibers and contracting muscles with efferent fibers.
- The autonomic nervous system involves the visceral organs and regulates involuntary movements or unconscious actions.

- The sympathetic nervous system is responsible for the fight or flight reaction under stressful conditions, while the parasympathetic nervous system conserves energy after high stress situations or during rest and digesting.
- The primary neurotransmitters of the peripheral nervous system (PNS) are acetylcholine and noradrenaline, though other neurotransmitters are also present. Acetylcholine acts on two sets of receptors, muscarinic and nicotinic cholinergic receptors.

Key Terms

- **nicotinic**: Excitatory acetylcholine receptors.
- **mixed spinal nerve**: A nerve that carries motor, sensory, and autonomic signals between the spinal cord and the body.
- **peripheral nervous system**: The nerves and ganglia outside of the brain and spinal cord.
- **muscarinic**: Acetylcholine receptors that can be both excitatory and inhibitory.

Review of Peripheral Nervous System Structure

The peripheral nervous system (PNS) consists of the nerves and ganglia outside of the brain and spinal cord. The main function of the PNS is to connect the central nervous system (CNS) to the limbs and organs.

Unlike the CNS, the PNS is not protected by the bones of the spine and skull, or by the blood –brain barrier, leaving it exposed to toxins and mechanical injuries. The peripheral nervous system is divided into the somatic nervous system and the autonomic nervous system.

The peripheral nervous system includes 12 cranial nerves and 31 pairs of spinal nerves that provide communication from the CNS to the rest of the body by nerve impulses to regulate the functions of the human body. The term spinal nerve generally refers to a mixed spinal nerve, which carries motor, sensory, and autonomic signals between the spinal cord and the body.

Spinal Nerve Correspondences

Each pair of spinal nerves roughly correspond to a segment of the vertebral column: 8 cervical spinal nerve pairs (C1–C8), 12 thoracic pairs (T1–T12), 5 lumbar pairs (L1–L5), 5 sacral pairs (S1–S5), and 1 coccygeal pair.

- The first 4 cervical spinal nerves, C1 through C4, split and recombine to produce a variety of nerves that subserve the neck and back of the head.
- The spinal nerve C1 (suboccipital nerve) provides motor innervation to muscles at the base of the skull.

- C2 and C3 form many of the nerves of the neck, and provides both sensory and motor control. These include the greater occipital nerve that provides sensation to the back of the head, the lesser occipital nerve that provides sensation to the area behind the ears, the greater auricular nerve, and the lesser auricular nerve.
- The phrenic nerve arises from nerve roots C3, C4, and C5. It innervates the diaphragm to enable breathing. If the spinal cord is transected above C3, then spontaneous breathing is not possible.
- The last four cervical spinal nerves, C5 through C8, and the first thoracic spinal nerve, T1, combine to form the brachial plexus, or plexus brachialis, a tangled array of nerves, splitting, combining and recombining to form the nerves that subserve the upper limb region and upper back. Although the brachial plexus may appear tangled, it is highly organized and predictable with little variation among people.

Lecture 6. Anatomy of the lumbosacral plexus

Lumbosacral Plexus

The anterior divisions of the lumbar, sacral, and coccygeal nerves form the lumbosacral plexus, the first lumbar nerve being frequently joined by a branch from the twelfth thoracic. For descriptive purposes, this plexus is usually divided into three parts: lumbar plexus, sacral plexus, and pudendal plexus.

Autonomic Nervous System Function (ANS)

The sympathetic division typically functions in actions that need quick responses. The parasympathetic division functions with actions that do not require immediate reaction.

The sympathetic system is often considered the fight or flight system, while the parasympathetic system is often considered the rest and digest or feed and breed system.

Some typical actions of the sympathetic and parasympathetic systems are listed below.

Sympathetic Nervous System

- Diverts blood flow away from the gastrointestinal (GI) tract and skin via vasoconstriction.
- Enhances blood flow to skeletal muscles and the lungs.
- Dilates bronchioles of the lung by circulating epinephrine to allow for greater alveolar oxygen exchange.
- Increases the heart rate and contractility of cardiac muscle for enhanced blood flow to skeletal muscles.
- Dilates pupils and relaxes the ciliary muscle to the lens for far vision.
- Provides vasodilation for the coronary vessels of the heart.
- Constricts all the intestinal sphincters and the urinary sphincter.
- Inhibits peristalsis.
- Stimulates orgasm.

Parasympathetic Nervous System

- Dilates blood vessels that lead to the GI tract to increase blood flow; this is important following food consumption due to the greater metabolic demands placed on the body by the gut.
- Constricts the bronchiolar diameter when the need for oxygen has diminished.
- Manages heart control via dedicated cardiac branches of the vagus and thoracic spinal accessory nerves.
- Constricts the pupil and contracts the ciliary muscles to facilitate accommodation for closer vision.
- Stimulates salivary gland secretion and accelerates peristalsis to mediate the digestion of food.
- PNS nerves are involved in the erection of genital tissues via the pelvic splanchnic nerves 2–4. They are also responsible for stimulating sexual arousal.

Neurotransmitters

- Acetylcholine is the preganglionic neurotransmitter for both divisions of the ANS, as well as the postganglionic neurotransmitter of parasympathetic neurons.
- Nerves that release acetylcholine are said to be cholinergic. In the parasympathetic system, ganglionic neurons use acetylcholine as a neurotransmitter to stimulate muscarinic receptors.
- At the adrenal medulla, there is no postsynaptic neuron. Instead the presynaptic neuron releases acetylcholine to act on nicotinic receptors.
- Stimulation of the adrenal medulla releases adrenaline (epinephrine) into the bloodstream, which acts on adrenoceptors, producing a widespread increase in sympathetic activity.

Somatic Nervous System Function (SoNS)

The somatic nervous system consists of afferent and efferent nerves and is associated with the voluntary control of skeletal muscle movements. The afferent nerves are responsible for relaying sensations from the body to the central nervous system (CNS), while the efferent nerves are responsible for sending out commands from the CNS to the body to stimulate muscle contraction.

Upper motor neurons release acetylcholine. Acetylcholine is released from the axon terminal knobs of alpha motor neurons and received by postsynaptic receptors (nicotinic acetylcholine receptors) of muscles, thereby relaying the stimulus to contract muscle fibers.

Lecture 7. Functional anatomy I-VI pairs of cranial nerves

The olfactory nerves or nerves of smell are distributed to the mucous membrane of the olfactory region of the nasal cavity: this region comprises the superior nasal concha, and the corresponding part

of the nasal septum. The nerves originate from the central or deep processes of the olfactory cells of the nasal mucous membrane. They form a plexiform net-work in the mucous membrane, and are then collected into about twenty branches, which pierce the cribriform plate of the ethmoid bone in two groups, a lateral and a medial group, and end in the glomeruli of the olfactory bulb. Each branch receives tubular sheaths from the dura mater and pia mater, the former being lost in the periosteum of the nose, the latter in the neurolemma of the nerve.

The olfactory nerves are non-medullated, and consist of axis-cylinders surrounded by nucleated sheaths, in which, however, there are fewer nuclei than are found in the sheaths of ordinary non-medullated nerve fibers.

The olfactory center in the cortex is generally associated with the rhinencephalon.

The olfactary nerves are developed from the cells of the ectoderm which lines the olfactory pits; these cells undergo proliferation and give rise to what are termed the olfactory cells of the nose. The axons of the olfactory cells grow into the overlying olfactory bulb and form the olfactory nerves.

The optic nerve, or nerve of sight, consists mainly of fibers derived from the ganglionic cells of the retina. These axons terminate in arborizations around the cells in the lateral geniculate body, pulvinar, and superior colliculus which constitute the lower or primary visual centers. From the cells of the lateral geniculate body and the pulvinar fibers pass to the cortical visual center, situated in the cuneus and in the neighborhood of the calcarine fissure. A few fibers of the optic nerve, of small caliber, pass from the primary centers to the retina and are supposed to govern chemical changes in the retina and also the movements of some of its elements (pigment cells and cones). There are also a few fine fibers, afferent fibers, extending from the retina to the brain, that are supposed to be concerned in pupillary reflexes.

The optic nerve is peculiar in that its fibers and ganglion cells are probably third in the series of neurons from the receptors to the brain. Consequently the optic nerve corresponds rather to a tract of fibers within the brain than to the other cranial nerves. Its fibers pass backward and medialward through the orbit and optic foramen to the optic commissure where they partially decussate. The mixed fibers from the two nerves are continued in the optic tracts, the primary visual centers of the brain.

The orbital portion of the optic nerve is from 20 mm. to 30 mm. in length and has a slightly sinuous course to allow for movements of the eyeball. It is invested by an outer sheath of dura mater and an inner sheath from the arachnoid which are attached to the sclera around the area where the nerve fibers pierce the choroid and sclera of the bulb. A little behind the bulb of the eye the central artery of the retina with its accompanying vein perforates the optic nerve, and runs within it to the retina. As the nerve enters the optic foramen its dural sheath becomes continuous with that lining the orbit and the

optic foramen. In the optic foramen the ophthalmic artery lies below and to its outer side. The intercranial portion of the optic nerve is about 10 mm. in length.

The Optic Chiasma (chiasma opticum), somewhat quadrilateral in form, rests upon the tuberculum sellæ and on the anterior part of the diaphragma sellæ. It is in relation, above, with the lamina terminalis; behind, with the tuber cinereum; on either side, with the anterior perforated substance. Within the chiasma, the optic nerves undergo a partial decussation. The fibers forming the medial part of each tract and posterior part of the chiasma have no connection with the optic nerves. They simply cross in the chiasma, and connect the medial geniculate bodies of the two sides; they form the commissure of Gudden. The remaining and principal part of the chiasma consists of two sets of fibers, crossed and uncrossed. The crossed fibers which are the more numerous, occupy the central part of the chiasma, and pass from the optic nerve of one side to the optic tract of the other, decussating in the chiasma with similar fibers of the opposite optic nerve. The uncrossed fibers occupy the lateral part of the chiasma, and pass from the nerve of one side into the tract of the same side.

The crossed fibers of the optic nerve tend to occupy the medial side of the nerve and the uncrossed fibers the lateral side. In the optic tract, however, the fibers are much more intermingled.

The Optic Tract, passes backward and outward from the optic chiasma over the tuber cinereum and anterior perforated space to the cerebral peduncle and winds obliquely across its under surface. Its fibers terminate in the lateral geniculate body, the pulvinar and the superior colliculus. It is adherent to the tuber cinereum and the cerebral peduncle as it passes over them. In the region of the lateral geniculate body it splits into two bands. The medial and smaller one is a part of the commissure of Gudden and ends in the medial geniculate body.

From its mode of development, and from its structure, the optic nerve must be regarded as a prolongation of the brain substance, rather than as an ordinary cerebrospinal nerve. As it passes from the brain it receives sheaths from the three cerebral membranes, a perineural sheath from the pia mater, an intermediate sheath from the arachnoid, and an outer sheath from the dura mater, which is also connected with the periosteum as it passes through the optic foramen. These sheaths are separated from each other by cavities which communicate with the subdural and subarachnoid cavities respectively. The innermost or perineural sheath sends a process around the arteria centralis retinæ into the interior of the nerve, and enters intimately into its structure.

Oculomotor Nerve (CN III)

Functions: Somatic motor (general somatic efferent) and visceral motor (general visceral efferent parasympathetic).

Nuclei: There are two oculomotor nuclei, each serving one of the functional components of the nerve. The somatic motor nucleus of the oculomotor nerve is in the midbrain. The visceral motor

(parasympathetic) accessory (Edinger-Westphal) nucleus of the oculomotor nerve lies dorsal to the rostral two thirds of the somatic motor nucleus.

The oculomotor nerve (CN III) provides the following:

Motor to the striated muscle of four of the six extraocular muscles (superior, medial, and inferior recti and inferior oblique) and superior eyelid (L. levator palpebrae superioris); hence the nerve's name.

Proprioceptive to the muscles listed above.

Parasympathetic through the ciliary ganglion to the smooth muscle of the sphincter of the pupil (L.sphincter pupillae), which causes constriction of the pupil and ciliary body, which produces accommodation (allowing the lens to become more rounded) for near vision.

CN III is the chief motor nerve to the ocular and extraocular muscles. It emerges from the midbrain, pierces the dura lateral to the sellar diaphragm roofing over the hypophysis, and then runs through the roof and lateral wall of the cavernous sinus.

CN III leaves the cranial cavity and enters the orbit through the superior orbital fissure. Within this fissure, CN III divides into a superior division (which supplies the superior rectus and levator palpebrae superioris) and an inferior division (which supplies the inferior and medial rectus and inferior oblique). The inferior division also carries presynaptic parasympathetic (visceral efferent) fibers to the ciliary ganglion, where they synapse. Postsynaptic fibers from this ganglion pass to the eyeball in the short ciliary nerves to innervate the ciliary body and sphincter of the pupil.

Trochlear Nerve (CN IV)

Functions: Somatic motor (general somatic efferent) and proprioceptive to one extraocular muscle (superior oblique).

Nucleus: The nucleus of the trochlear nerve is located in the midbrain, immediately caudal to the oculomotor nucleus.

The trochlear nerve (CN IV) is the smallest cranial nerve. It emerges from the posterior surface of the midbrain (the only cranial nerve to do so), passing anteriorly around the brainstem, running the longest intracranial (subarachnoid) course of the cranial nerves. It pierces the dura mater at the margin of the cerebellar tentorium (L. tentorium cerebelli) and passes anteriorly in the lateral wall of the cavernous sinus.

CN IV continues past the sinus to pass through the superior orbital fissure into the orbit, where it supplies the superior oblique the only extraocular muscle that uses a pulley, or trochlea, to redirect its line of action (hence the nerve's name).

Cranial nerves Trigeminal Nerve (CN V)

Functions: General sensory (general somatic afferent) and branchial motor (special visceral efferent) to derivatives of the 1st pharyngeal arch.

Nuclei: There are four trigeminal nuclei one motor and three sensory.

The trigeminal nerve (CN V) is the largest cranial nerve. It emerges from the lateral aspect of the pons by a large sensory root and a small motor root. The roots of CN V are comparable to the posterior and anterior roots of spinal nerves.

CN V is the principal general sensory nerve for the head (face, teeth, mouth, nasal cavity, and dura of the cranial cavity). The large sensory root of CN V is composed mainly of the central processes of the pseudounipolar neurons that make up the trigeminal ganglion. The trigeminal ganglion is flattened and crescent shaped (hence its unofficial name, semilunar ganglion) and is housed within a dural recess (trigeminal cave) lateral to the cavernous sinus. The peripheral processes of the ganglionic neurons form three nerves or divisions:

ophthalmic nerve (CN V1), maxillary nerve (CN V2), and sensory component of the mandibular nerve (CN V3). Maps of the zones of cutaneous innervation by the three divisions resemble the dermatome maps for cutaneous innervation by spinal nerves. Unlike dermatomes, however, there is little overlap in innervation by the divisions; lesions of a single nerve result in clearly demarcated areas of numbness.

The fibers of the motor root of CN V pass inferior to the trigeminal ganglion along the floor of the trigeminal cave, bypassing the ganglion just as the anterior roots of spinal nerves bypass the spinal sensory ganglia. They are distributed exclusively via the mandibular nerve (CN V3), blending with the sensory fibers as the nerve traverses the foramen ovale in the cranium; entering branches pass to the muscles of mastication, mylohyoid, anterior belly of the digastric, tensor veli palatini, and tensor tympani, which are derived from the 1st pharyngeal arch.

Although CN V conveys no presynaptic parasympathetic (visceral efferent) fibers from the CNS, all four parasympathetic ganglia are associated with the divisions of CN V. Postsynaptic parasympathetic fibers from the ganglia join branches of CN V and are carried to their destinations along with the CN V sensory and motor fibers.

Abducent Nerve (CN VI)

Functions: Somatic motor (general somatic efferent and proprioceptive) to one extraocular muscle (lateral rectus).

Nucleus: The abducent (L. abducens) nucleus is in the pons near the median plane.

The abducent nerves (CN VI) emerge from the brainstem between the pons and the medulla and traverse the pontine cistern of the subarachnoid space, straddling the basilar artery. Each abducent

nerve then pierces the dura to run the longest intradural course within the cranial cavity of the cranial nerves that is, its point of entry into the dura covering the clivus is the most

distant from its exit from the cranium via the superior orbital fissure. During its intradural course, it bends sharply over the crest of the petrous part of the temporal bone and then courses through the cavernous sinus, surrounded by the venous blood in the same manner as the internal carotid artery, which it parallels in the sinus.

CN VI traverses the common tendinous ring (L. anulus tendineus communis) as it enters the orbit (see Chapter 7), running on and penetrating the medial surface of the lateral rectus, which abducts the eye (this function being the basis for the name of the nerve).

Lecture 8. Functional anatomy VII-XII pairs of cranial nerves

Facial Nerve (CN VII)

Functions: Sensory (special visceral afferent and general somatic afferent), motor (branchial motor or special visceral efferent), and parasympathetic (general visceral efferent). It also carries proprioceptive fibers from the muscles it innervates.

Nuclei: The motor nucleus of the facial nerve is a branchiomotor nucleus in the ventrolateral part of the pons. The cell bodies of the primary sensory neurons are in the geniculate ganglion. The central processes of those concerned with taste end in the nuclei of the solitary tract in the medulla. The processes of those concerned with general sensations (pain, touch, and thermal) from around the external ear end in the spinal nucleus of the trigeminal nerve.

The facial nerve (CN VII) emerges from the junction of the pons and medulla as two divisions, the motor root and the intermediate nerve. The larger motor root (facial nerve proper) innervates the muscles of facial expression, and the smaller intermediate nerve (L. nervus intermedius) carries taste, parasympathetic, and somatic sensory fibers.

During its course, CN VII traverses the posterior cranial fossa, internal acoustic meatus, facial canal, stylomastoid foramen of the temporal bone, and parotid gland. After traversing the internal acoustic meatus, the nerve proceeds a short distance anteriorly within the temporal bone and then turns abruptly posteriorly to course along the medial wall of the tympanic cavity. The sharp bend is the geniculum of the facial nerve (L. genu, knee), sometimes called the external genu of CN VII, the site of the geniculate ganglion (sensory ganglion of CN VII). While traversing the temporal bone within the facial canal, CN VII gives rise to the: Greater petrosal nerve. Nerve to the stapedius. Chorda tympani nerve.

Then, after running the longest intraosseous course of any cranial nerve, CN VII emerges from the cranium via the stylomastoid foramen; gives off the posterior auricular branch; enters the parotid gland; and forms the parotid plexus, which gives rise to the following five terminal motor branches: temporal, zygomatic, buccal, marginal mandibular, and cervical.

Branchial Motor As the nerve of the 2nd pharyngeal arch, the facial nerve supplies striated muscles derived from its mesoderm, mainly the muscles of facial expression and auricular muscles. It also supplies the posterior bellies of the digastric, stylohyoid, and stapedius muscles.

Presynaptic Parasympathetic CN VII provides presynaptic parasympathetic fibers to the pterygopalatine ganglion for innervation of the lacrimal mucous glands and to the submandibular ganglion for innervation of the sublingual and submandibular salivary glands. The pterygopalatine ganglion is associated with the maxillary nerve (CN V2), which distributes its postsynaptic fibers, whereas the submandibular ganglion is associated with the mandibular nerve (CN V3). Parasympathetic fibers synapse in these ganglia, whereas sympathetic and other fibers pass through them.

General Sensory Some fibers from the geniculate ganglion supply a small area of the skin of the concha of the auricle, close to external acoustic meatus.

Taste (Special Sensory) Fibers carried by the chorda tympani join the lingual nerve to convey taste sensation from the anterior two thirds of the tongue and soft palate.

The acoustic nerve consists of two distinct sets of fibers which differ in their peripheral endings, central connections, functions, and time of medullation. It is soft in texture and devoid of neurilemma.

Cochlear Nerve.—The cochlear nerve or root, the nerve of hearing, arises from bipolar cells in the spiral ganglion of the cochlea, situated near the inner edge of the osseous spiral lamina. The peripheral fibers pass to the organ of Corti. The central ones pass down the modiolus and then through the foramina of the tractus spiralis foraminosus or through the foramen centrale into the lateral or outer end of the internal auditory meatus. The nerve passes along the internal auditory meatus with the vestibular nerve and across the subarachnoid space, just above the flocculus, almost directly medialward toward the inferior peduncle to terminate in the cochlear nucleus.

The cochlear nerve is placed lateral to the vestibular root. Its fibers end in two nuclei: one, the accessory nucleus, lies immediately in front of the inferior peduncle; the other, the tuberculum acusticum, somewhat lateral to it.

The striæ medullares (striæ acusticæ) are the axons of the cells of the tuberculum acusticum. They pass over the inferior peduncle, and across the rhomboid fossa to the median sulcus. Here they dip into the substance of the pons, to end around the cells of the superior olivary nuclei of both sides. There are, however, other fibers, and these are both direct and crossed, which pass into the lateral

lemniscus. The cells of the accessory nucleus give origin to fibers which run transversely in the pons and constitute the trapezium. Of the trapezoid fibers some end around the cells of the superior olivary nucleus or of the trapezoid nucleus of the same or opposite side, while others, crossed or uncrossed, pass directly into the lateral lemniscus.

If the further connections of the cochlear nerve of one side, say the left, be considered, it is found that they lie lateral to the main sensory tract, the lemniscus, and are therefore termed the lateral lemniscus. The fibers comprising the left lateral lemniscus arise in the superior olivary and trapezoid nuclei of the same or opposite side, while others are the uninterrupted fibers already alluded to, and these are either crossed or uncrossed, the former being the axons of the cells of the right accessory nucleus or of the cells of the right tuberculum acusticum, while the latter are derived from the cells of the left nuclei. In the upper part of the lateral lemniscus there is a collection of nerve cells, the nucleus of the lateral lemniscus, around the cells of which some of the fibers arborize and from the cells of which axons originate to continue upward the tract of the lateral lemniscus. The ultimate ending of the left lateral lemniscus is partly in the opposite medial geniculate body, and partly in the inferior colliculi. From the cells of these bodies new fibers arise and ascend in the occipital part of the internal capsule to reach the posterior three-fifths of the left superior temporal gyrus and the transverse temporal gyri.

Vestibular Nerve.—The vestibular nerve or root, the nerve of equilibration, arises from bipolar cells in the vestibular ganglion, ganglion of Scarpa, which is situated in the upper part of the outer end of the internal auditory meatus. The peripheral fibers divide into three branches: the superior branch passes through the foramina in the area vestibularis superior and ends in the utricle and in the ampullæ of the superior and lateral semicircular ducts; the fibers of the inferior branch traverse the foramina in the area vestibularis inferior and end in the saccule; the posterior branch runs through the foramen singulare and supplies the ampulla of the posterior semicircular duct.

Glossopharyngeal Nerve (CN IX)

Functions: Sensory (general somatic afferent, special visceral afferent, general visceral afferent), motor (special visceral efferent), and parasympathetic (general visceral efferent) for derivatives of the 3rd pharyngeal arch.

Nuclei: Four nuclei in the medulla send or receive fibers via CN IX: two motor and two sensory. Three of these nuclei are shared with CN X.

The glossopharyngeal nerve (CN IX) emerges from the lateral aspect of the medulla and passes anterolaterally to leave the cranium through the anterior aspect of the jugular. At this foramen are superior and inferior (sensory) ganglia, which contain the pseudounipolar cell bodies for the afferent

components of the nerve. CN IX follows the stylopharyngeus, the only muscle the nerve supplies, and passes between the superior and the middle constrictor muscles of the pharynx to reach the oropharynx and tongue. It contributes sensory fibers to the pharyngeal plexus of nerves.

CN IX is afferent from the tongue and pharynx (hence its name) and efferent to the stylopharyngeus and parotid gland.

Branchial Motor Motor fibers pass to one muscle, the stylopharyngeus, derived from the 3rd pharyngeal arch.

Parasympathetic (Visceral Motor)

Following a circuitous route initially involving the tympanic nerve, presynaptic parasympathetic fibers are provided to the otic ganglion for innervation of the parotid gland. The otic ganglion is associated with the mandibular nerve (CN V3), branches of which convey the postsynaptic parasympathetic fibers to the parotid gland .

Sensory (General Sensory)

The general sensory branches of CN IX are as follows : The tympanic nerve. The carotid sinus nerve to the carotid sinus, a baro- (presso) receptor sensitive to changes in blood pressure, and the carotid body, a chemoreceptor sensitive to blood gas (oxygen and carbon dioxide levels).

The pharyngeal, tonsillar, and lingual nerves to the mucosa of the oropharynx and isthmus of the fauces (L. throat), including palatine tonsil, soft palate, and posterior third of the tongue. In addition to general sensation (touch, pain, temperature), tactile (actual or threatened) stimuli determined to be unusual or unpleasant here may evoke the gag reflex or even vomiting.

Taste (Special Sensory) Taste fibers are conveyed from the posterior third of the tongue to the sensory ganglia.

Vagus Nerve (CN X)

Functions: Sensory (general somatic afferent, special visceral afferent, general visceral afferent), motor (special visceral efferent), and parasympathetic (general visceral efferent).

Sensory from the inferior pharynx, larynx, and thoracic and abdominal organs.

Sense of taste from the root of the tongue and taste buds on the epiglottis. Branches of the internal laryngeal nerve (a branch of CN X) supply a small area, mostly general but some special sensation; most general and special sensation to the root is supplied by CN IX.

Motor to the soft palate; pharynx; intrinsic laryngeal muscles (phonation); and a nominal extrinsic tongue muscle, the palatoglossus, which is actually a palatine muscle based on its derivation and innervation.

Proprioceptive to the muscles listed above.

Parasympathetic to thoracic and abdominal viscera.

Nuclei: Four nuclei of CN X in the medulla send or receive fibers via CN IX two motor and two sensory. Three of these nuclei are shared with CN IX.

The vagus nerve (CN X) has the longest course and most extensive distribution of all the cranial nerves, most of which is outside of (inferior to) the head. The term vagus is derived from the Latin word vagari meaning **wandering**.

CN X was so called because of its extensive distribution. It arises by a series of rootlets from the lateral aspect of the medulla that merge and leave the cranium through the jugular foramen positioned between CN IX and CN XI.

What was formerly called the cranial root of the accessory nerve is actually a part of CN X. CN X has a **superior ganglion** in the jugular foramen that is mainly concerned with the general sensory component of the nerve. Inferior to the foramen is an inferior ganglion (nodose ganglion) concerned with the visceral sensory components of the nerve. In the region of the superior ganglion are connections to CN IX and the superior cervical (sympathetic) ganglion. CN X continues inferiorly in the carotid sheath to the root of the neck, supplying branches to the palate, pharynx, and .

The course of CN X in the thorax differs on the two sides, a consequence of rotation of the midgut during development. CN X supplies branches to the heart, bronchi, and lungs. The vagi join the esophageal plexus surrounding the esophagus, which is formed by branches of the vagi and sympathetic trunks. This plexus follows the esophagus through the diaphragm into the abdomen, where the anterior and posterior vagal trunks break up into branches that innervate the esophagus, stomach, and intestinal tract as far as the left colic flexure.

CN XI: Spinal Accessory

The accessory nerve provides motor function to some muscles in the neck:

It controls the sternocleidomastoid and trapezius muscles that allow a person to rotate, extend, and flex the neck and shoulders.

The accessory nerve separates into spinal and cranial parts.

The spinal component starts in the spinal cord and travels into the skull through the foramen magnum. From there, it meets the cranial component of the accessory nerve and exits the skull along the internal carotid artery.

The cranial part of the accessory nerve combines with the vagus nerve.

Anatomy. Although CN XI is included in the CNs, the cell bodies of this nerve actually reside in the spinal cord. They probably are continuous with the nucleus ambiguous of the medulla, however. CN XI emerges from the jugular foramen with CNs IX and X, but it does so by first ascending into the skull via the foramen magnum, and then exiting the central nervous system via the jugular foramen. This unusual anatomical configuration makes CN XI at risk for injury in fractures of the cervical vertebrae

or other spinal cord injuries. CN XI innervates the sternocleidomastoid muscle and the trapezius muscle.

Testing. CN XI may be damaged from surgery or trauma involving the neck, such as lymph node biopsy or even whiplash, or other cervical cord lesions (such as syringomyelia). Symptoms of damage to CN XI include shoulder pain, scapular winging, and weakness or atrophy of the trapezius muscle.

Cervical dystonia (torticollis). A cervical lesion to the nerve roots of CN XI can result in cervical dystonia or torticollis. Patients who are receiving antipsychotic medications and develop cervical dystonia should be evaluated for lower motor neuron nerve root compression of CN XI at the cervical level in a differential diagnosis, which also involves the more obvious and common cause of cervical dystonia—central involvement of the motor pathways at the level of the basal ganglia resulting in tardive dystonia.

CN XII: Hypoglossal Nerve

The hypoglossal nerve is a motor nerve that supplies the tongue muscles.

The hypoglossal nerve originates in the medulla.

Disorders of the hypoglossal nerve can cause paralysis of the tongue, most often occurring on one side.

Like CN XI, CN XII is also almost entirely a motor nerve. CN XII supplies the tongue muscles.

Anatomy. The nuclei of CN XII is more dorsal and medial in the medulla than the other CNs in the medulla. Supranuclear innervation is mainly from the contralateral cortex and descends in the corticobulbar tract. The fibers leave the medulla and pass through the hypoglossal canal. CN XII leaves the skull through the hypoglossal foramen, which is different than the previous three CNs. The CN XI is somewhat bilaterally innervated at the upper motor neuron level, but with more input from the contralateral hemisphere. Unilateral upper motor neuron lesions result in mild contralateral weakness of the tongue. Interruption of the nerve at the lower motor neuron on one side causes complete paralysis of that side of the tongue. The tongue will curve slightly to the healthy side when lying inactive and deviate to the affected side upon protrusion because it has lost the strength to resist the push to that side. The denervated side becomes wrinkled and atrophied. CN XII involvement is seen with many of the peripheral lesions that affect the spinal accessory nerve because they are anatomically close at that level.[33]

Metastases. Unilateral 12th nerve palsy (CN XII) is one of the more common cranial mononeuropathies caused from brain metastases.

Pseudobulbar palsy. Bilateral supranuclear lesions of CN XII that are seen in pseudobulbar palsy produce moderate-to-severe inability of the tongue to function.

Amyotrophic lateral sclerosis (ALS). As one might expect, bulbar onset of ALS is more likely to affect the tongue than is limb onset. ALS has features of both upper and lower motor neuron damage.

Some patients will also display upper motor neuron involvement of the hypoglossal nerve, and if this is the sole manifestation it is referred to as pseudobulbar palsy. A smaller group of ALS patients will present initially with lower motor neuron damage, with primary bulbar involvement. Such patients will show evidence of tongue weakness, atrophy, and fasciculations. This is referred to as bulbar palsy.

Lecture 9. Functional anatomy of the autonomic nervous system.

Vagus Nerve (CN X)

Functions: Sensory (general somatic afferent, special visceral afferent, general visceral afferent), motor (special visceral efferent), and parasympathetic (general visceral efferent).

Sensory from the inferior pharynx, larynx, and thoracic and abdominal organs.

Sense of taste from the root of the tongue and taste buds on the epiglottis. Branches of the internal laryngeal nerve (a branch of CN X) supply a small area, mostly general but some special sensation; most general and special sensation to the root is supplied by CN IX.

Motor to the soft palate; pharynx; intrinsic laryngeal muscles (phonation); and a nominal extrinsic tongue muscle, the palatoglossus, which is actually a palatine muscle based on its derivation and innervation.

Proprioceptive to the muscles listed above.

Parasympathetic to thoracic and abdominal viscera.

Nuclei: Four nuclei of CN X in the medulla send or receive fibers via CN IX two motor and two sensory. Three of these nuclei are shared with CN IX.

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Lecture 10. Functional anatomy of the sensory organs. Anatomy of the organs of sight, hearing, smell, taste.

Vagus Nerve (CN X)

Functions: Sensory (general somatic afferent, special visceral afferent, general visceral afferent), motor (special visceral efferent), and parasympathetic (general visceral efferent).

Sensory from the inferior pharynx, larynx, and thoracic and abdominal organs.

Sense of taste from the root of the tongue and taste buds on the epiglottis. Branches of the internal laryngeal nerve (a branch of CN X) supply a small area, mostly general but some special sensation; most general and special sensation to the root is supplied by CN IX.

Motor to the soft palate; pharynx; intrinsic laryngeal muscles (phonation); and a nominal extrinsic tongue muscle, the palatoglossus, which is actually a palatine muscle based on its derivation and innervation.

Proprioceptive to the muscles listed above.

Parasympathetic to thoracic and abdominal viscera.

Nuclei: Four nuclei of CN X in the medulla send or receive fibers via CN IX two motor and two sensory. Three of these nuclei are shared with CN IX.

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Practice 1. Spinal cord. Membranes of the spinal cord. The base of the brain with the output of 12 pairs of cranial nerves.

The Spinal Cord starts at the brain stem and goes to the tail bone. It is about as wide as your little finger and extends the length of your back. Messages are carried from the spinal cord to and from the brain to the rest of the body.

Nerves extend from the spinal cord on each side and go to the parts of the body.

The brain and spinal cord are protected by bony structures: the skull and spinal column.

The spinal cord is further protected by three membranes, collectively called the meninges. The outer membrane surrounding the spinal cord is the dura mater (from Latin, meaning durable mother). The dura, made of a dense fibrous material, forms the dural sac, which surrounds the spinal cord and cauda equina (to be discussed later) and terminates at the level of the second sacral vertebra. The dura is separated from the vertebrae by the epidural fat in the epidural space (epi, meaning upon). The next layer is the delicate arachnoid mater which is thin and has web-like filaments connecting to the underlying pia mater (arachnoid is Greek for spider). Beneath the arachnoid mater is the subarachnoid space, which is filled with cerebrospinal fluid. Abbreviated CSF, cerebrospinal fluid bathes the brain and spinal cord as well as the cauda equina, providing protection, nourishment, and a medium for exchange of nutrients and waste. The innermost membrane surrounding the spinal cord is the vascular pia mater (Latin, meaning tender or devoted mother), which is very closely apposed to the spinal cord. The pia mater has paired specializations called denticulate ligaments, which extend laterally from the surface of the spinal cord and pierce the arachnoid to attach to the inner aspect of the dura mater at 21 pairs of denticulations (dentate means tooth-like - these are tooth-like lateral projections). The denticulate ligaments run longitudinally between the dorsal and ventral roots of the spinal cord and serve to suspend the spinal cord from side to side in the dural sac. The pia continues inferiorly from the end of the spinal cord (at the level of the second lumbar vertebra) as the filum terminale internum. As we said, the dural sac ends at the level of the second sacral vertebra (S2). Caudal to the end of the dural sac is a specialization of meninges called the coccygeal ligament (or filum terminale externum) that attaches the meninges, and consequently the spinal cord, to the coccyx. The coccygeal ligament is composed of specializations of all three layers of meninges.

Meninges are membranes that cover and protect the brain and spinal cord. There are three layers of meninges: Dura mater (closest to the bone), Arachnoid loosely around the brain, Pia mater is closely attached to the brain and spinal cord surface.

Cerebrospinal Fluid (CSF) cushions the brain and spinal cord. It is a clear, water-like fluid, also called spinal fluid, found between the arachnoid and pia mater. It is made within the four ventricles of the brain. The area in the lateral ventricles that makes spinal fluid is called the choroid plexus. About 20cc of spinal fluid is made but not absorbed each hour. There is about 140 cc (about ½ can of soda) of spinal fluid that surrounds the brain and spine. The brain and spinal cord are bathed and cushioned by this spinal fluid, which flows and circulates around the brain and spine.

The cranial nerves are peripheral nerves emerging from the brain. There are 12 pairs of cranial nerves, and most of them arise from the brainstem. Along with their sensory and parasympathetic ganglia the cranial nerves are considered to represent the cranial part of the peripheral nervous system (PNS).

However, the optic nerve is actually an extension of the brain emerging from the prosencephalon, while the olfactory nerve is a collection of axons derived from the telencephalon. Thus, they are not typical cranial nerves as they do not arise from the brainstem, and should be more accurately considered as a part of the central nervous system (CNS). It is also worth noting, that part of the accessory nerve arises from the spinal cord, while the existence of cranial contribution to this nerve is controversial. Thus, there are actually only 9 pairs of typical cranial nerves emerging from the brainstem.

The intercranial parts of the cranial nerves are situated within the cranial cavity. The cranial nerves pass through foramina, fissures, or canals of the skull to exit the cranial vault, and then distribute mainly in regions of head and neck. However, one of the cranial nerves, the vagus (from latin, meaning “wanderer”) continues its course in the trunk innervating various thoracic and abdominal organs.

The cranial nerves can carry information to and from the central nervous system. Afferent fibers provide sensory input, transmitting impulses from the periphery to the CNS, while the efferent fibers give motor output, sending impulses from the CNS to the periphery. The somatic efferents innervate skeletal muscles, while the visceral efferents innervate smooth muscle, cardiac muscle, and glands.

Each cranial nerve is composed of nerve fibers of variable functional modalities. While some cranial nerves are purely sensory in their functions (e.g., the optic nerve), others may be motor (e.g., the hypoglossal nerve), or mixed - consisting of fibers of different modalities (e.g., the facial nerve).

The fibers carried by the cranial nerves can be categorized based on their functionality in the following way.

- General somatic afferents (GSA)
- General somatic efferents (GSE)
- General visceral afferents (GVA)
- General visceral efferents (GVE)
- Special somatic afferents (SSA)
- Special visceral afferents (SVA)
- Special visceral efferents (SVE)

Each cranial nerve has been given a name. In addition, they are numbered sequentially with Roman numerals I to XII in the order in which they arise from the brain, front to back. Thus, often a cranial

nerve is addressed to with the abbreviation CN and its respective number, for example, the facial nerve is also known as the seventh cranial nerve or CN VII.

The following list presents the Roman numerals with the corresponding English names of the twelve cranial nerves:

I - Olfactory
II - Optic
III - Oculomotor
IV - Trochlear
V - Trigeminal
VI - Abducens
VII - Facial
VIII - Vestibulocochlear
IX - Glossopharyngeal
X - Vagus
XI - Accessory
XII - Hypoglossal

Practice 2. Medulla oblongata. The pons. Cerebellum. IV ventricle of the brain.

The medulla oblongata (medulla) is one of the three regions that make up the brainstem. It is the most inferior of the three and is continuous above with the pons and below with the spinal cord. The medulla houses essential ascending and descending nerve tracts as well as brainstem nuclei.

In this article, we shall look at the anatomy of the medulla – its external features, internal anatomy, and blood supply.

External Anatomy of the Medulla

The medulla is conical in shape, decreasing in width as it extends inferiorly. It is approximately 3cm long and 2cm wide at its largest point.

The superior margin of the medulla is located at the junction between the medulla and pons, while the inferior margin is marked by the origin of the first pair of **cervical spinal nerves**. This occurs just as the medulla exits the skull through the **foramen magnum**.

Anterior Surface

There are several structures visible on the anterior surface of the medulla – namely the three fissures/sulci, the pyramids, the olives, and five cranial nerves.

In the midline of the medulla is the **anterior median fissure**, which is continuous along the length of the spinal cord. However, it is interrupted temporarily by the decussation of the pyramids (see below). As we move away from the midline, two sulci are visible – the **ventrolateral sulcus** and the **posterolateral sulcus**.

The **pyramids** are paired swellings found between the anterior median fissure and the ventrolateral sulcus. Information on the pyramids can be found here. The **olives** are another pair of swellings located laterally to the pyramids – between the ventrolateral and posterolateral sulci.

Arising from the junction between the pons and medulla is the abducens nerve (CN VI). Extending out of the ventrolateral sulcus is the hypoglossal nerve (CN XII). In the posteriolateral sulcus, three more cranial nerves join the medulla (CN IX, CN X, and CN XI). Further information on these nerves appears here.

Posterior Surface

Unlike the anterior surface of the medulla, the posterior surface is largely obstructed from view and is relatively devoid of features. In order to appreciate the posterior surface, the cerebellum must be removed.

Similar to the anterior surface, the posterior surface has a midline structure – the posterior median sulcus – which is continuous below as the posterior median sulcus of the spinal cord. Above, the sulcus ends at the point in which the fourth ventricle develops.
As we move lateral from the midline, the fasciculus gracilis and fasciculus cuneatus are seen, separated by the posterior intermediate sulcus.
Internal Anatomy of the Medulla
The internal structures of the medulla must be viewed in cross section to understand the layout. Three levels of the medulla are typically discussed (inferior – superior):

Level of decussation of the pyramids
Level of decussation of the medial lemnisci
Level of the olives
The medulla itself is typically divided into two regions: the open and the closed medulla. This distinction is made based on whether the CSF-containing cavities are surrounded by the medulla (closed medulla) or not (open medulla). The medulla becomes open when the central canal opens into the fourth ventricle (see Fig. 3).

Some features are seen in all three cross sections. Anteriorly we can see the paired lumps representing the pyramids which are separated by the anterior median fissure. Centrally, the central canal can be seen as it rises to form the fourth ventricle in the final cross section.

Level of the Decussation of the Pyramids
This is the major decussation point of the descending motor fibres. Roughly 75% of motor fibres housed within the pyramids cross diagonally and posteriorly, and continue down the spinal column as the lateral corticospinal tracts.
At this level, the central portion of the medulla contains gray matter, while the outer portions consist of white matter. The posterior white matter contains the fasiculus gracilis and the more lateral fasiculus cuneatus. Corresponding portions of gray matter extend to these regions and are the nucleus gracilis and nucleus cuneatus respectively.
Unchanged from the spinal cord, the spinocerebellar tracts (posterior and anterior) are located laterally, with the lateral spinothalamic tract situated between them. The large trigeminal nucleus and tracts can be found posterior to these tracts. This is a continuation of the substantia gelatinosa of the spinal cord.
Level of Decussation of the Medial Lemniscus
This level marks the sensory decussation occurs of the medial lemniscus. (Fig. 5). Purple lines have been used to represent the internal arcuate fibres as they run from the nucleus gracilis and nucleus cuneatus around and anterior to the central gray matter to form the medial lemniscus.
Lateral to the medial lemniscus, the trigeminal nucleus and spinal tract can once again be seen, as can the spinocerebellar tracts and the lateral spinothalamic tract. Similarly, the posterior structures are much the same at this level.
Centrally, the hypoglossal nucleus and medial longitudinal fasciculus are seen. Moving laterally, the nucleus ambiguous can be seen. Between this structure and the pyramids is the inferior olivary nucleus.
Level of the Olives

This level shows significant change in structure both externally and internally when compared with previous levels. The central canal has now expanded into the fourth ventricle and as such makes this region the open medulla.

The large inferior olivary nucleus is responsible for the external expansion of the olives. The related medial and dorsal accessory olivary nuclei can be seen medial and posterior to this structure respectively.

The large inferior cerebellar peduncles come into view and are surrounded by multiple nuclei. The two vestibular nuclei (medial and inferior) are both found towards the midline while the two cochlear nuclei are found somewhat above and below the peduncles. Now a much smaller structure, the trigeminal tract and nucleus is seen adjacent to the peduncle.

The nucleus ambiguous remains as it was previously, while the hypoglossal nucleus has migrated with the central canal posteriorly, joined by the medial longitudinal fasciulus. An additional cranial nucleus comes into view lateral to the hypoglossal – the dorsal vagal nucleus. Moving further lateral, the nucleus of tractus solitarius comes into view.

Centrally, the medial lemniscus hugs the midline posterior to the pyramids, as does the tectospinal tract.

Between the peduncle and the olivary nuclei resides the lateral spinothalamic tract and the more lateral anterior spinocerebellar tract.

The **pons** is the largest part of the brainstem, located above the medulla and below the midbrain. It is a group of nerves that function as a connection between the cerebrum and cerebellum (*pons is Latin for bridge*).

The pons develops from the **embryonic metencephalon** (part of the hindbrain, developed from the rhombencephalon), alongside the cerebellum.

In this article, we will look at the **anatomy of the pons** – its location, structure and function, blood supply and clinical relevance.

Anatomical Position

The pons is a horseshoe-shaped collection of nerve fibres located in the anterior part of the posterior cranial fossa.

Its anatomical relations are as follows:

Posteriorly – the cerebellum, separated by the fourth ventricle.

Inferiorly – the medulla oblongata.

Superiorly – the midbrain lies immediately above the pons.

External Anatomy

Anterior Surface

The anterior or ventral surface of the pons is marked by a bulging formed by the **transverse pontocerebellar fibers**. These fibers wrap around the otherwise vertically oriented brainstem. It measures around 2.5 cm in adults.

The basilar groove demarcates the midline of the ventral surface and is where the basilar artery is located.

The **pontomedullary** junction is an important anatomical landmark defined by the angle between the lower border of the pons and the superior border of the medulla.

Several cranial nerves originate from the ventral surface of the pons:

- **Cranial nerve V**: trigeminal – originates from the lateral aspect of mid pons
- **Cranial nerve VI:** abducens – originates from the pontomedullary junction, close to the midline
- **Cranial nerve VII:** facial – originates from the cerebellopontine angle, the more lateral aspect of the pontomedullary junction.

- **Cranial nerve VIII:** vestibulocochlear – originates laterally to the facial nerve.

Posterior Surface

The pons is intimately related to the cerebellum, and is connected to it by the middle cerebellar peduncles. Removal of the cerebellum will reveal the underlying fourth ventricle.

The floor of the fourth ventricle is composed of the dorsal surface of the pons and the medulla. There are some important anatomical landmarks here:

The medial eminence marks the midline of the floor.
The facial colliculus is a bulging formed by the fibers of the facial nerve looping around the abducens nucleus.
The stria medullaris of the fourth ventricle is a bundle of nerve fibers crossing transversely from the lateral aspect into the midline. They mark the posterior border between the pons and the medulla.
The angle formed at the junction of the pons, medulla, and cerebellum is another anatomical landmark and is named cerebellopontine angle. Here, the cerebellar flocculus, the ventricular choroid plexus and the emerging CNs VII and VIII surround the lateral apertures of the fourth ventricle (the foramen of Luschka).

Internal Anatomy

The pons is comprised of two major components – the ventral pons and the tegmentum.
The ventral pons contains the pontine nuclei, which are responsible for coordinating movement. Fibers from the pontine nuclei cross the midline, and form the middle cerebellar peduncles on their way to the cerebellum.
The tegmentum is the evolutionarily older part of the pons which forms part of the reticular formation – a set of nuclei found throughout the brainstem that are responsible for arousal and attentiveness. Damage to this part of the pons may result in anosognosia for hemiplegia, where patients are unaware of their paralysis.
The rest of the pons is made up of tracts passing through the pons including:

- Descending corticospinal tracts – responsible for voluntary motor control of the body.
- Descending corticobulbar tracts – responsible for voluntary motor control of face, head and neck.
- Ascending medial lemniscus tracts – responsible for fine touch, vibration and proprioception.
- Ascending spinothalamic tracts – responsible for pain and temperature sensation

Cranial Nerve Nuclei

The pons houses important cranial nerve nuclei.
The main sensory nucleus and the trigeminal motor nucleus are located in the midpons – at the level where the fibers originate from the lateral aspect of the pons. The main sensory nucleus receives somatosensory information from the face. There are two other nuclei that receive sensory information from the trigeminal nerve:

- Spinal trigeminal nucleus – extends caudally towards the medulla.
- Mesencephalic nucleus – extends rostrally all the way to the midbrain.

The abducens nucleus controls the abducens nerve, which innervates the ipsilateral lateral rectus muscle. It is located in the caudal pons, on the medial aspect of its dorsal surface.

At the same level of the abducens nucleus, the facial nucleus is located more anteriorly and laterally. It controls the muscles of facial expression. Its fibers take an unusual course and loop around the abducens nucleus before exiting the brainstem through its ventrolateral surface.

The cochlear and vestibular nuclei sit dorsolaterally from the inferior pons to the superior medulla.

Vasculature

The blood supply of the pons is formed by branches of the vertebrobasilar system:

- Most of the pons is supplied by the pontine arteries, branches of the basilar artery
- A smaller part of its blood supply comes from the anterior inferior cerebellar artery and the superior cerebellar artery (AICA and SCA).

The venous drainage of the pons consists of the anterior pontomesencephalic vein, which drains superiorly into the basal vein, that in turn drains into the cerebral veins. Inferiorly, the pons drains into the inferior petrosal sinus, which drains into the internal jugular veins.

•Cerebellum: The inferior portion of the suboccipital surface of the cerebellum hides the inferior roof of the fourth ventricle. The tonsil and the biventral lobule cover the tela choroidea and the lateral recess. In the midline, the uvula covers the nodule. The cerebellomedullary fissure is a natural space between the cerebellum and the medulla. It is continuous with the vallecula, the space between both tonsils. The tonsil is the structure that blocks most of the view of the inferior roof of the fourth ventricle. If we remove the tonsils, we have a direct view of the tela choroidea and the inferior medullary velum. The tonsil is attached to the cerebellar hemisphere through the tonsilar peduncle, located at the superolateral aspect of the tonsil.

•Lateral recess: Extends laterally below the cerebellar peduncles to open into the cerebellopontine cistern through the foramina of Luschka. The lateral recess may be divided into a peduncular and a floccular part. The peduncular part is formed by the inferior cerebellar peduncle anteriorly and the peduncle of the flocculus posteriorly. The floccular part is formed by the rhomboid lip anteriorly and by the flocculus posteriorly. The rhomboid lip is a thin sheet of neural tissue located posteriorly to the glossopharyngeal and vagus nerves. The tela choroidea forms the floor of both parts of the lateral recess.

•Floor of the fourth ventricle: Has a rhomboid shape, and formed by the pons and the medulla. The pons forms the superior two-thirds of the floor and the medulla forms the inferior one-third of the floor. The pontine part of the floor has a triangular shape, with its apex continuous with the aqueduct and the base of the triangle is represented by an imaginary line connecting the lower margin of the cerebellar peduncles. The medullary part of the floor also has a triangular shape, but its apex points inferiorly at the obex. The base of the medullary part is an imaginary line along the site of attachment of the tela choroidea to the tenia just below the lateral recess. The intermediate part of the floor is formed by lateral recesses, between these two imaginary lines. The intermediate part of the floor corresponds to the transition between the pons and the medulla. The floor is divided longitudinally in two halves by the median sulcus. Parallel to the median sulcus is the sulcus limitans, which marks two longitudinal strips between both sulci, the two median eminences. The sulcus limitans does not mark the median, but it has two distinct depressions along its way. The superior

depression is the superior fovea, located laterally to the facial colliculus. The inferior depression is the inferior fovea, located laterally to the hypoglossal triangle. The motor nuclei of the cranial nerves are located medially to the sulcus limitans, whereas the sensory nuclei are located laterally. The median eminence contains the facial colliculus and three triangular areas on its inferior end: hypoglossal triangle, vagal triangle, and area postrema. The inferior part of the fourth ventricle is called the calamus scriptorius, because these three triangular areas are grouped together near the median sulcus on the inferior part of the floor, giving a configuration of a feather or pen nib.

Practice 3. The midbrain. The diencephalon. III ventricle of the brain.

The **midbrain** (also known as the mesencephalon) is the most superior of the three regions of the brainstem. It acts as a conduit between the forebrain above and the pons and cerebellum below.

In this article, we will discuss the anatomy of the midbrain – its external anatomy, internal anatomy, and vasculature.

External Anatomy of the Midbrain

The midbrain is the smallest of the three regions of the brainstem, measuring around 2cm in length. As it ascends, the midbrain travels through the opening in the tentorium cerebelli.It can be divided into two main parts: **Tectum** – located posterior to the cerebral aqueduct

Paired cerebral peduncles – located anteriorly and laterally.Internally, the cerebral peduncles are further separated by the substania nigra into the crus cerebri (anterior) and the tegmentum (posterior).

Tectum The tectum houses four rounded prominences named **colliculi** (collectively the corpora quadrigemina) which sit directly inferior to the pineal gland. The colliculi are separated by the cruciform sulcus; there are two superior and two inferior colliculi.Extending laterally from each colliculi are the quadrigeminal brachium:**Superior quadrigeminal brachium** forms a pathway between the superior colliculus and the retina of the eye.**Inferior quadrigeminal brachium** conveys fibres from the lateral lemniscus and inferior colliculus to the medial geniculate body.Inferior to the colliculi, the **trochlear nerve (CN IV)** emerges before sweeping across to the anterior surface.

Cerebral Peduncles The paired cerebral peduncles extend from the cerebral hemispheres to converge as they meet the pons. They are separated anteriorly in the midline by the **interpeduncular fossa**, the floor of which is termed the posterior perforated substance (as many perforating blood vessels can be

identified).The oculomotor nerve (CNIII) is seen exiting from between the peduncles while the **optic tract** runs around the superior border of the midbrain.2020)

Internal Anatomy of the Midbrain

Two transverse sections of the midbrain will be discussed: the level of the inferior colliculus, and the level of the superior colliculus.

Level of the Inferior Colliculus

The anteriolateral surface of the midbrain houses the paired crus cerebri. Four fibre tracts run within the crus:

- **Frontopontine fibres** – located most medially.
- **Corticospinal fibres** – motor fibres from the primary motor cortex.
- **Corticobulbar tracts** – motor fibres from the primary motor cortex.
- **Temporopontine fibres** – located posterolaterally.

Posteriorly is the **substantia nigra** – a pigmented nucleus that separates the two regions of the cerebral peduncles. It is further broken down into the pars reticulata (anterior) and pars compacta (posterior).

The **tegmentum** is located posterior to the substantia nigra. It is continuous with that found in the pons by the same name. It is important to note that unlike the crus cerebri, the tegmentum is continuous at the midline.

The cerebral aqueduct (see ventricles) is a midline structure surrounded by central gray matter – the **periaqueductal gray matter**. Within this gray matter lies the mesencephalic nucleus of the trigeminal nerve, as well as the trochlear nucleus with its fibres continuing around the gray matter to exit the midbrain. Anterior to this, the **medial longitudinal fasciculus** can be seen.

The decussation of the **superior cerebellar peduncles** can be seen centrally at this level with some reticular formation (noted throughout the brainstem) lying lateral.

Between the central gray matter and the substantia nigra are four **lemnisci**. Moving anterior to posterior they are the medial, spinal, trigeminal, and lateral leminisci.

At the very posterior pole, we find the **tectum** which, at this level, contains the inferior colliculus.

Level of the Superior Colliculus

Much of the internal structure of the midbrain is unchanged at this level and should be assumed present unless mentioned below.

The central portion which previously was occupied by the decussation of the superior cerebellar peduncles now contains the large paired **red nuclei** with some decussation of the rubrospinal tract

occuring anterior to this. The reticular formation now fans around the posterior borders of the red nuclei.

The trochlear nucleus is replaced with the **oculomotor nucleus** while the oculomotor nerve projects anteriorly.

The medial, spinal and **trigeminal lemnisc**i are all present in much the same location however the lateral lemnisci does not reach to this level.

Needless to say, the tectum now contains the **superior colliculi** rather than the inferior colliculi.

VasculatureWe will only briefly look at the vasculature of the midbrain.The supply to the area is derived from the basilar artery and its branches. The major suppliers are: the posterior cerebral artery and its peduncular branch, the superior cerebellar artery, the posterior choroidal artery, and the interpeduncular branches of the basilar artery.

Practice 4. Cortex of the brain. Fornix, corpus callosum. Basal nuclei of the hemispheres. Lateral ventricles of the brain. Membranes of the brain.

The cerebrum is the largest part of the brain. It is divided into two hemispheres separated by the longitudinal fissure. The hemispheres are prominently marked with gyri and sulci. The two hemispheres are connected chiefly through a large fiber tract, the corpus callosum.

Each hemisphere has five lobes: frontal, parietal, occipital, and temporal lobes and the insula.

The cerebral cortex is gray matter with two types of neurons: stellate cells and pyramidal cells. All output from the cortex travels by way of axons of the pyramidal cells. Most of the cortex is neocortex, in which there are six layers of nervous tissue. Evolutionarily older parts of the cerebrum have one- to five-layered paleocortex and archicortex.

The basal nuclei are masses of cerebral gray matter lateral to the thalamus, concerned with motor control. They include the caudate nucleus, putamen, and globus pallidus.

The special senses originate in relatively complex sense organs of the head and involve distinct regions of primary sensory cortex and association areas. Vision resides in the occipital lobe and inferior temporal lobe; hearing in the superior temporal lobe; equilibrium in the cerebellum and brainstem, but with centers of consciousness of body movements and position low in the parietal lobe; taste in the parietal lobe and insula; smell in the frontal and temporal lobes; and there is an association area in the frontal lobe for taste and smell combined.

Motor control resides in the motor association area and precentral gyrus of the frontal lobe.

The basal nuclei and cerebellum play important roles in motor coordination and learned motor skills (procedural memory).

Language is coordinated largely by the Wernicke and Broca areas. Recognizing language and formulating what one will say or write occur in the Wernicke area; the Broca area compiles the motor program of speech; and commands to the muscles of speech originate in the precentral gyrus.

The brain exhibits cerebral lateralization: Some functions are coordinated mainly by the left hemisphere and others by the right. The categorical hemisphere (in most people, the left) is responsible for verbal and mathematical skills and logical, linear thinking. The representational hemisphere (usually the right) is a seat of imagination, insight, spatial perception, musical skill, and other "holistic" functions.

The brain is surrounded by dura mater, arachnoid mater, and pia mater. The dura mater is divided into two layers, periosteal and meningeal, which in some places are separated by a blood-filled dural sinus. In some places, the dura folds inward to separate major brain regions. A subdural space separates some areas of dura from the arachnoid, and a subarachnoid space separates arachnoid from pia.

The Lateral Ventricles (*ventriculus lateralis*).—The two lateral ventricles are irregular cavities situated in the lower and medial parts of the cerebral hemispheres, one on either side of the middle line. They are separated from each other by a median vertical partition, the **septum pellucidum,** but communicate with the third ventricle and indirectly with each other through the **interventricular foramen.** They are lined by a thin, diaphanous membrane, the **ependyma,** covered by ciliated epithelium, and contain cerebrospinal fluid, which, even in health, may be secreted in considerable amount. Each lateral ventricle consists of a **central part** or **body,** and three prolongations from it, termed **cornua**.

The **central part** (*pars centralis ventriculi lateralis; cella*) of the lateral ventricle extends from the interventricular foramen to the splenium of the corpus callosum. It is an irregularly curved cavity, triangular on transverse section, with a roof, a floor, and a medial wall. The roof is formed by the under surface of the corpus callosum; the floor by the following parts, enumerated in their order of position, from before backward: the caudate nucleus of the corpus striatum, the stria terminalis and the terminal vein, the lateral portion of the upper surface of the thalamus, the choroid plexus, and the lateral part of the fornix; the medial wall is the posterior part of the septum pellucidum, which separates it from the opposite ventricle.

The **anterior cornu** (*cornu anterius; anterior horn; precornu*) passes forward and lateralward, with a slight inclination downward, from the interventricular foramen into the frontal lobe, curving around the anterior end of the caudate nucleus. Its floor is formed by the upper surface of the reflected portion of the corpus callosum, the **rostrum.** It is bounded medially by the anterior portion of the septum pellucidum, and laterally by the head of the caudate nucleus. Its apex reaches the posterior surface of the genu of the corpus callosum.

The **posterior cornu** (*cornu posterius; postcornu*) passes into the occipital lobe, its direction being backward and lateralward, and then medialward. Its roof is formed by the fibers of the corpus callosum passing to the temporal and occipital lobes. On its medial wall is a longitudinal eminence, the **calcar avis** (*hippocampus minor*), which is an involution of the ventricular wall produced by the calcarine fissure. Above this the forceps posterior of the corpus callosum, sweeping around to enter the occipital lobe, causes another projection, termed the **bulb of the posterior cornu.** The calcar avis and bulb of the posterior cornu are extremely variable in their degree of development; in some cases they are ill-defined, in others prominent.

The **inferior cornu** (*cornu inferior; descending horn; middle horn; medicornu*), the largest of the three, traverses the temporal lobe of the brain, forming in its course a curve around the posterior end of

the thalamus. It passes at first backward, lateralward, and downward, and then curves forward to within 2.5 cm. of the apex of the temporal lobe, its direction being fairly well indicated on the surface of the brain by that of the superior temporal sulcus. Its roof is formed chiefly by the inferior surface of the tapetum of the corpus callosum, but the tail of the caudate nucleus and the stria terminalis also extend forward in the roof of the inferior cornu to its extremity; the tail of the caudate nucleus joins the putamen. Its floor presents the following parts: the hippocampus, the fimbria hippocampi, the collateral eminence, and the choroid plexus. When the choroid plexus is removed, a cleft-like opening is left along the medial wall of the inferior cornu; this cleft constitutes the lower part of the choroidal fissure.

The **hippocampus** (*hippocampus major*) is a curved eminence, about 5 cm. long, which extends throughout the entire length of the floor of the inferior cornu. Its lower end is enlarged, and presents two or three rounded elevations or digitations which give it a paw-like appearance, and hence it is named the **pes hippocampi.** If a transverse section be made through the hippocampus, it will be seen that this eminence is produced by the folding of the wall of the hemisphere to form the hippocampal fissure. The main mass of the hippocampus consists of gray substance, but on its ventricular surface is a thin white layer, the **alveus,** which is continuous with the fimbria hippocampi.

Practice 5. Conductive pathways of the spinal cord and brain. A simple reflex arc. Sensitive pathways

Sensory Pathways from the Spinal Cord to the Brain.—The posterior root fibers conducting the impulses of conscious muscle sense, tendon sense and joint sense, those impulses which have to do with the coördination and adjustment of muscular movements, ascend in the fasciculus gracilis and fasciculus cuneatus to the nucleus gracilis and nucleus cuneatus in the medulla oblongata.

In the nucleus gracilis and nucleus cuneatus synaptic relations are found with neurons whose cell bodies are located in these nuclei and whose axons pass by way of the internal arcuate fibers, cross in the raphé to the opposite side in the region between the olives and turn abruptly upward to form the medial lemniscus or medial fillet. The medial fillet passes upward in the ventral part of the formatio reticularis through the medulla oblongata, pons and mid-brain to the principal sensory nucleus of the ventro-lateral region of the thalamus. Here the terminals form synapses with neurons of the third order whose axons pass through the internal capsule and corona radiata to the somatic sensory area of the cortex in the post-central gyrus.

Fibers conducting the impulses of unconscious muscle sense pass to the cerebellum partly by way of the fasciculus gracilis and fasciculus cuneatus to the nucleus gracilis and nucleus cuneatus, thence neurons of the second order convey the impulses either via the dorsal external arcuate fibers directly into the inferior peduncle of the cerebellum or via the ventral external arcuate fibers which are continued from the internal arcuate fibers through the ventral part of the raphé and after crossing the midline emerge on the surface of the medulla in the ventral sulcus between the pyramids or in the groove between the pyramid and the olive. They pass over the lateral surface of the medulla and olive to reach the inferior peduncle through which they pass to the cerebellum.

Other fibers conducting impulses of unconscious muscle sense pass upward in the dorsal spinocerebellar fasciculus, which arises from cells in the nucleus dorsalis. The posterior root fibers conducting these impulses pass into the fasciculus cuneatus and the collaterals from them to the nucleus dorsalis are said to come almost exclusively from the middle area of the fasciculus cuneatus. They form by their multiple division baskets about the individual cells of the nucleus dorsalis, each fiber coming in relation with the bodies and dendrites of several cells. The axons of the second order pass into the dorsal spinocerebellar fasciculus of the same side and ascend along the lateral surface of the spinal cord and medulla oblongata until they arrive at the level of the olive, they then curve backward beneath the external arcuate fibers into the inferior peduncle and pass into the cerebellum.

Here they give off collaterals to the dentate nucleus and finally terminate in the cortex of the dorsal and superior portion of the vermis, partly on the same side, but to a great extent by way of a large commissure to the opposite side. The fibers lose their myelin sheaths as they enter the gray substance and terminate by end ramifications among the nerve cells and their processes. Some of the fibers are said to end in the nucleus dentatus and the roof nuclei of the cerebellum (the nucleus globosus, nucleus emboliformis and nucleus fastigius) and others pass through them to terminate in the inferior vermis. A few fibers of the dorsal spinocerebellar fasciculus are said not to enter the inferior peduncle but to pass with the ventral spinocerebellar fasciculus. The cerebellar reflex are is supposed to be completed by the fibers of the superior peduncle which pass from the cerebellum to the red nucleus of the mid-brain where some of their terminals and collaterals form synapses with neurons whose axons descend to the spinal cord in the rubrospinal fasciculus. The terminal and collaterals of this fasciculus end either directly or indirectly about the motor cells in the anterior column.

The ventral spinocerebellar fasciculus, since most of its fibers pass to the cerebellum, is also supposed to be concerned in the conduction of unconscious muscle sense. The location of its cells of origin is uncertain. They are probably in or near the dorsal nucleus of the same and the opposite side; various other locations are given, the dorsal column, the intermediate zone of the gray matter and the central portion of the anterior column. The neurons of the first order whose central fibers enter the fasciculus cuneatus from the dorsal roots send collaterals and terminals to form synapses with these cells. The fibers which come from the opposite gray columns cross some in the white and some in the gray commissure and pass with fibers from the same side through the lateral funiculus to the marginal region ventral to the dorsal spinocerebellar fasciculus. The fasciculus begins about the level of the third lumbar nerve and continues upward on the lateral surface of the spinal cord and medulla oblongata until it passes under cover of the external arcuate fibers. It passes just dorsal to the olive and above this joins the lateral edge of the lateral lemniscus along which it runs, ventral to the roots of the trigeminal nerve, almost to the level of the superior colliculus, it then crosses over the superior peduncle, turns abruptly backward along its medial border, enters the cerebellum with it and ends in the vermis of the same and the opposite side. Some of its fibers are said to join the dorsal spinocerebellar fasciculus in the medulla oblongata and enter the cerebellum through the inferior peduncle. A number of fibers are said to continue upward in the dorsolateral part of the tegmentum as far as the superior colliculus and a few pass to the thalamus. They probably form part of the sensory or higher reflex path.

The posterior root fibers conducting impulses of pain and temperature probably terminate in the posterior column or the intermediate region of the gray matter soon after they enter the spinal cord. The neurons of the second order are supposed to pass through the anterior commissure to the superficial antero-lateral fasciculus (tract of Gowers) and pass upward in that portion of it known as the lateral spinothalamic fasciculus. This fasciculus lies along the medial side of the ventral spinocerebellar fasciculus. It is stated by some authors that the pain fibers pass upward in the antero-lateral ground bundles. In some of the lower mammals this pathway carries the pain fibers upward by a series of neurons some of which cross to the opposite side, so that in part there is a double path. In man, however, the lateral spinothalamic fasciculus is probably the most important pathway. On reaching the medulla these fibers continue upward through the formatio reticularis in the neighborhood of the median fillet to the thalamus, probably its ventro-lateral region. Whether higher neurons convey the pain impulses to the cortex through the internal capsule is uncertain. The pathway is probably more complex and Head is of the opinion that our sensations of pain are essentially thalamic. The pain and temperature pathways in the lateral spinothalamic fasciculus are not so closely intermingled but that one can be destroyed without injury to the other.

Ransom suggests that the non-medullated fibers of the posterior roots, which turn into Lissauer's tract and ascend or descend for short distances not exceeding one or two segments and finally end in the substantia gelatinosa, are in part at least pain fibers and that the fasciculus of Lissauer and the substantia gelatinosa represent part of the mechanism for reflexes associated with pain conduction and reception while the fibers to the higher centers pass up in the spinothalamic tract.

The fibers of tactile discrimination, according to Head and Thompson, pass up in the fasciculus cuneatus and fasciculus gracilis of the same side and follow the path of the muscle-sense fibers. The axons of the second order arising in the nucleus cuneatus and gracilis cross with the internal arcuate fibers and ascend to the thalamus with the medial lemniscus, thence by neurons of higher order the impulses are carried to the somatic sensory area of the cortex through the internal capsule. The other touch fibers, shortly after entering the spinal cord, terminate in the dorsal column or intermediate gray matter. Neurons of the second order send their axons through the anterior commissure to pass upward in the antero-lateral funiculus probably in the ventral spinothalamic fasciculus. In the medulla they join or pass upward in the neighborhood of the medial lemniscus to the thalamus and thence by neurons of higher order to the somatic sensory area of the cortex.

The remaining ascending fasciculi form a part of the complex known as the superficial antero-lateral fasciculus (tract of Gowers). The spinotectal fasciculus, as its name indicates, is supposed to have its origin in the gray matter of the cord and terminations in the superior and inferior (?) colliculi of the mid-brain serving for reflexes between the cord and the visceral and auditory centers of the mid-brain.

Practice 6. Conductive pathways of the brain and spinal cord. Motorway pathways.

The Motor Tract, conveying voluntary impulses, arises from the pyramid cells situated in the motor area of the cortex, the anterior central and the posterior portions of the frontal gyri and the paracentral lobule. The fibers are at first somewhat widely diffused, but as they descend through the corona radiata they gradually approach each other, and pass between the lentiform nucleus and thalamus, in the genu and anterior two-thirds of the occipital part of the internal capsule; those in the genu are named the geniculate fibers, while the remainder constitute the cerebrospinal fibers; proceeding downward they enter the middle three-fifths of the base of the cerebral peduncle. The geniculate fibers cross the middle line, and end by arborizing around the cells of the motor nuclei of the cranial nerves. The cerebrospinal fibers are continued downward into the pyramids of the medulla oblongata, and the transit of the fibers from the medulla oblongata is effected by two paths. The fibers nearest to the anterior median fissure cross the middle line, forming the decussation of the pyramids, and descend in the opposite side of the medulla spinalis, as the lateral cerebrospinal fasciculus (crossed pyramidal tract). Throughout the length of the medulla spinalis fibers from this column pass into the gray substance, to terminate either directly or indirectly around the motor cells of the anterior column. The more laterally placed portion of the tract does not decussate in the medulla oblongata, but descends as the anterior cerebrospinal fasciculus (direct pyramidal tract); these fibers, however, end in the anterior gray column of the opposite side of the medulla spinalis by passing across in the anterior white commissure. There is considerable variation in the extent to which decussation takes place in the medulla oblongata; about two-thirds or three-fourths of the fibers usually decussate in the medulla oblongata and the remainder in the medulla spinalis.

The axons of the motor cells in the anterior column pass out as the fibers of the anterior roots of the spinal nerves, along which the impulses are conducted to the muscles of the trunk and limbs.

From this it will be seen that all the fibers of the motor tract pass to the nuclei of the motor nerves on the opposite side of the brain or medulla spinalis, a fact which explains why a lesion involving the motor area of one side causes paralysis of the muscles of the opposite side of the body. Further, it will be seen that there is a break in the continuity of the motor chain; in the case of the cranial nerves this break occurs in the nuclei of these nerves; and in the case of the spinal nerves, in the anterior gray column of the medulla spinalis. For clinical purposes it is convenient to emphasize this break and divide the motor tract into two portions: (1) a series of upper motor neurons which comprises the motor cells in the cortex and their descending fibers down to the nuclei of the motor nerves; (2) a series of lower motor neurons which includes the cells of the nuclei of the motor cerebral nerves or the cells of the anterior columns of the medulla spinalis and their axiscylinder processes to the periphery.

The rubrospinal fasciculus arises from the large cells of the red nucleus. The fibers cross the raphé of the mid-brain in the decussation of Forel and descend in the formatio reticularis of the pons and

medulla dorsal to the medial lemniscus and as they pass into the spinal cord come to lie in a position ventral to the crossed pyramidal tracts in the lateral funiculus. The rubrospinal fibers end either directly or indirectly by terminals and collaterals about the motor cells in the anterior column on the side opposite from their origin in the red nucleus. A few are said to pass down on the same side. Since the red nucleus is intimately related to the cerebellum by terminals and collaterals of the superior peduncle which arises in the dentate nucleus of the cerebellum, the rubrospinal fasciculus is supposed to be concerned with cerebellar reflexes, complex motor coördinations necessary in locomotion and equilibrium. The afferent paths concerned in these reflexes have already been partly considered, namely, the dorsal and ventral spinocerebellar fasciculi, and probably some of the fibers of the posterior funiculi which reach the cerebellum by the inferior peduncle.

The tectospinal fasciculus arises from the superior colliculus of the roof (tectum) of the mid-brain. The axons come from large cells in the stratum opticum and stratum lemnisci and sweep ventrally around the central gray matter of the aqueduct, cross the raphé in the fountain decussation of Meynert and turn downward in the tegmentum in the ventral longitudinal bundle. Some of the fibers do not cross in the raphé but pass down on the same side; it is uncertain whether they come from the superior colliculus of the same side or arch over the aqueduct from the colliculus of the opposite side. The tectospinal fasciculus which comprises the major part of the ventral longitudinal bundle passes down through the tegmentum and reticular formation of the pons and medulla oblongata ventral to the medial longitudinal bundle. In the medulla the two bundles are more or less intermingled and the tectospinal portion is continued into the antero-lateral funiculus of the spinal cord ventral to the rubrospinal fasciculus with which some of its fibers are intermingled. Some of the fibers of the tectospinal fasciculus pass through the red nucleus giving off collaterals to it, others are given off to the motor nuclei of the cranial nerves and in the spinal cord they terminate either directly or indirectly by terminals and collaterals among the nuclei of the anterior column. Since the superior colliculus is an important optic reflex center, this tract is probably concerned in optic reflexes; and possibly also with auditory reflexes since some of the fibers of the central auditory path, the lateral lemniscus, terminate in the superior colliculus.

The vestibulospinal fasciculus (part of the anterior marginal fasciculus or Loewenthal's tract) situated chiefly in the marginal part of the anterior funiculus is mainly derived from the cells of the terminal nuclei of the vestibular nerve, probably Deiters's and Bechterew's, and some of its fibers are supposed to come from the nucleus fastigius (roof nucleus of the cerebellum). The latter nucleus is intimately connected with Dieters's and Bechterew's nuclei. The vestibulospinal fasciculus is concerned with equilibratory reflexes. Its terminals and collaterals end about the motor cells in the anterior column. It extends to the sacral region of the cord. Its fibers are intermingled with the ascending spinothalamic fasciculus, with the anterior proper fasciculus and laterally with the tectospinal fasciculus. Its fibers are supposed to be both crossed and uncrossed. In the brain-stem it is associated with the dorsal longitudinal bundle.

The pontospinal fasciculus (Bechterew) arises from the cells in the reticular formation of the pons from the same and the opposite side and is associated in the brain-stem with the ventral longitudinal bundle. In the cord it is intermingled with the fibers of the vestibulospinal fasciculus in the anterior funiculus. Not much is known about this tract.

There are probably other descending fasciculi such as the thalamospinal but not much is known about them.

Practice 7. Formation of spinal nerves. Posteriorand anterior divisions. Thoracic nerves. Cervical plexus.Long and short branches of the brachial plexus.

The spinal nerves spring from the medulla spinalis, and are transmitted through the intervertebral foramina. They number thirty-one pairs, which are grouped as follows: Cervical, 8; Thoracic, 12; Lumbar, 5; Sacral, 5; Coccygeal, 1.

The first cervical nerve emerges from the vertebral canal between the occipital bone and the atlas, and is therefore called the suboccipital nerve; the eighth issues between the seventh cervical and first thoracic vertebræ.

Nerve Roots.—Each nerve is attached to the medulla spinalis by two roots, an anterior or ventral, and a posterior or dorsal, the latter being characterized by the presence of a ganglion, the spinal ganglion.

The Anterior Root (radix anterior; ventral root) emerges from the anterior surface of the medulla spinalis as a number of rootlets or filaments (fila radicularia), which coalesce to form two bundles near the intervertebral foramen.

The Posterior Root (radix posterior; dorsal root) is larger than the anterior owing to the greater size and number of its rootlets; these are attached along the posterolateral furrow of the medulla spinalis and unite to form two bundles which join the spinal ganglion. The posterior root of the first cervical nerve is exceptional in that it is smaller than the anterior; it is occasionally wanting.

The Spinal Ganglia (ganglion spinale) are collections of nerve cells on the posterior roots of the spinal nerves. Each ganglion is oval in shape, reddish in color, and its size bears a proportion to that of the nerve root on which it is situated; it is bifid medially where it is joined by the two bundles of the posterior nerve root. The ganglia are usually placed in the intervertebral foramina, immediately outside the points where the nerve roots perforate the dura mater, but there are exceptions to this rule; thus the ganglia of the first and second cervical nerves lie on the vertebral arches of the atlas and axis respectively, those of the sacral nerves are inside the vertebral canal, while that on the posterior root of the coccygeal nerve is placed within the sheath of dura mater.

Structure.—The ganglia consist chiefly of unipolar nerve cells, and from these the fibers of the posterior root take origin—the single process of each cell dividing after a short course into a central fiber which enters the medulla spinalis and a peripheral fiber which runs into the spinal nerve. Two other forms of cells are, however, present, viz.: (a) the cells of Dogiel, whose axons ramify close to the cell (type II, of Golgi), and are distributed entirely within the ganglion; and (b) multipolar cells similar to those found in the sympathetic ganglia.

The ganglia of the first cervical nerve may be absent, while small aberrant ganglia consisting of groups of nerve cells are sometimes found on the posterior roots between the spinal ganglia and the medulla spinalis. Each nerve root receives a covering from the pia mater, and is loosely invested by the arachnoid, the latter being prolonged as far as the points where the roots pierce the dura mater. The two roots pierce the dura mater separately, each receiving a sheath from this membrane; where the roots join to form the spinal nerve this sheath is continuous with the epineurium of the nerve.

Size and Direction.—The roots of the upper four cervical nerves are small, those of the lower four are large. The posterior roots of the cervical nerves bear a proportion to the anterior of three to one, which is greater than in the other regions; their individual filaments are also larger than those of the anterior roots. The posterior root of the first cervical is an exception to this rule, being smaller than the anterior root; in eight per cent. of cases it is wanting. The roots of the first and second cervical nerves are short, and run nearly horizontally to their points of exit from the vertebral canal. From the second to the eighth cervical they are directed obliquely downward, the obliquity and length of the roots successively increasing; the distance, however, between the level of attachment of any of these roots to the medulla spinalis and the points of exit of the corresponding nerves never exceeds the depth of one vertebra.

The roots of the thoracic nerves, with the exception of the first, are of small size, and the posterior only slightly exceed the anterior in thickness. They increase successively in length, from above downward, and in the lower part of the thoracic region descend in contact with the medulla spinalis for a distance equal to the height of at least two vertebræ before they emerge from the vertebral canal.

The roots of the lower lumbar and upper sacral nerves are the largest, and their individual filaments the most numerous of all the spinal nerves, while the roots of the coccygeal nerve are the smallest.

The roots of the lumbar, sacral, and coccygeal nerves run vertically downward to their respective exits, and as the medulla spinalis ends near the lower border of the first lumbar vertebra it follows that the

length of the successive roots must rapidly increase. As already mentioned, the term cauda equina is applied to this collection of nerve roots.

From the description given it will be seen that the largest nerve roots, and consequently the largest spinal nerves, are attached to the cervical and lumbar swellings of the medulla spinalis; these nerves are distributed to the upper and lower limbs.

Connections with Sympathetic.—Immediately beyond the spinal ganglion, the anterior and posterior nerve roots unite to form the spinal nerve which emerges through the intervertebral foramen. Each spinal nerve receives a branch (gray ramus communicans) from the adjacent ganglion of the sympathetic trunk, while the thoracic, and the first and second lumbar nerves each contribute a branch (white ramus communicans) to the adjoining sympathetic ganglion. The second, third, and fourth sacral nerves also supply white rami; these, however, are not connected with the ganglia of the sympathetic trunk, but run directly into the pelvic plexuses of the sympathetic.

Structure.—Each typical spinal nerve contains fibers belonging to two systems, viz., the somatic, and the sympathetic or splanchnic, as well as fibers connecting these systems with each other.

1. The somatic fibers are efferent and afferent. The efferent fibers originate in the cells of the anterior column of the medulla spinalis, and run outward through the anterior nerve roots to the spinal nerve. They convey impulses to the voluntary muscles, and are continuous from their origin to their peripheral distribution. The afferent fibers convey impressions inward from the skin, etc., and originate in the unipolar nerve cells of the spinal ganglia. The single processes of these cells divide into peripheral and central fibers, and the latter enter the medulla spinalis through the posterior nerve roots.

2. The sympathetic fibers are also efferent and afferent. The efferent fibers, preganglionic fibers, originate in the lateral column of the medulla spinalis, and are conveyed through the anterior nerve root and the white ramus communicans to the corresponding ganglion of the sympathetic trunk; here they may end by forming synapses around its cells, or may run through the ganglion to end in another of the ganglia of the sympathetic trunk, or in a more distally placed ganglion in one of the sympathetic plexuses. In all cases they end by forming synapses around other nerve cells. From the cells of the ganglia of the sympathetic trunk other fibers, postganglionic fibers, take origin; some of these run through the gray rami communicantes to join the spinal nerves, along which they are carried to the bloodvessels of the trunk and limbs, while others pass to the viscera, either directly or after interruption in one of the distal ganglia. The afferent fibers are derived partly from the unipolar cells and partly from the multipolar cells of the spinal ganglia. Their peripheral processes are carred through the white rami communicantes, and after passing through one or more sympathetic ganglia (but always without interruption in them) finally end in the tissues of the viscera. The central processes of the unipolar cells enter the medulla spinalis through the posterior nerve root and form synapses around either somatic or sympathetic efferent neurons, thus completing reflex arcs. The dendrites of the multipolar nerve cells form synapses around the cells of type II (cells of Dogiel) in the spinal ganglia, and by this path the original impulse is transferred from the sympathetic to the somatic system, through which it is conveyed to the sensorium.

Divisions.—After emerging from the intervertebral foramen, each spinal nerve gives off a small meningeal branch which reënters the vertebral canal through the intervertebral foramen and supplies the vertebræ and their ligaments, and the bloodvessels of the medulla spinalis and its membranes. The spinal nerve then splits into a posterior or dorsal, and an anterior or ventral division, each receiving fibres from both nerve roots.

The posterior divisions are as a rule smaller than the anterior. They are directed backward, and, with the exceptions of those of the first cervical, the fourth and fifth sacral, and the coccygeal, divide into medial and lateral branches for the supply of the muscles and skin of the posterior part of the trunk.

The Cervical Nerves (Nn. Cervicales)—The posterior division of the first cervical or suboccipital nerve is larger than the anterior division, and emerges above the posterior arch of the atlas and beneath the vertebral artery. It enters the suboccipital triangle and supplies the muscles which bound this triangle, viz., the Rectus capitis posterior major, and the Obliqui superior and inferior; it gives branches also to

the Rectus capitis posterior minor and the Semispinalis capitis. A filament from the branch to the Obliquus inferior joins the posterior division of the second cervical nerve.

The nerve occasionally gives off a cutaneous branch which accompanies the occipital artery to the scalp, and communicates with the greater and lesser occipital nerves.

The posterior division of the second cervical nerve is much larger than the anterior division, and is the greatest of all the cervical posterior divisions. It emerges between the posterior arch of the atlas and the lamina of the axis, below the Obliquus inferior. It supplies a twig to this muscle, receives a communicating filament from the posterior division of the first cervical, and then divides into a large medial and a small lateral branch.

The medial branch (ramus medialis; internal branch), called from its size and distribution the greater occipital nerve (n. occipitalis major; great occipital nerve), ascends obliquely between the Obliquus inferior and the Semispinalis capitis, and pierces the latter muscle and the Trapezius near their attachments to the occipital bone. It is then joined by a filament from the medial branch of the posterior division of the third cervical, and, ascending on the back of the head with the occipital artery, divides into branches which communicate with the lesser occipital nerve and supply the skin of the scalp as far forward as the vertex of the skull. It gives off muscular branches to the Semispinalis capitis, and occasionally a twig to the back of the auricula. The lateral branch (ramus lateralis; external branch) supplies filaments to the Splenius, Longus capitis, and Semispinalis capitis, and is often joined by the corresponding branch of the third cervical.

The posterior division of the third cervical is intermediate in size between those of the second and fourth. Its medial branch runs between the Semispinalis capitis and cervicis, and, piercing the Splenius and Trapezius, ends in the skin. While under the Trapezius it gives off a branch called the third occipital nerve, which pierces the Trapezius and ends in the skin of the lower part of the back of the head. It lies medial to the greater occipital and communicates with it. The lateral branch often joins that of the second cervical.

The posterior division of the suboccipital, and the medial branches of the posterior division of the second and third cervical nerves are sometimes joined by communicating loops to form the posterior cervical plexus (Cruveilhier).

The posterior divisions of the lower five cervical nerves divide into medial and lateral branches. The medial branches of the fourth and fifth run between the Semispinales cervicis and capitis, and, having reached the spinous processes, pierce the Splenius and Trapezius to end in the skin. Sometimes the branch of the fifth fails to reach the skin. Those of the lower three nerves are small, and end in the Semispinales cervicis and capitis, Multifidus, and Interspinales. The lateral branches of the lower five nerves supply the Iliocostalis cervicis, Longissimus cervicis, and Longissimus capitis.

The Thoracic Nerves (Nn. Thoracales)—The medial branches (ramus medialis; internal branch) of the posterior divisions of the upper six thoracic nerves run between the Semispinalis dorsi and Multifidus, which they supply; they then pierce the Rhomboidei and Trapezius, and reach the skin by the sides of the spinous processes. The medial branches of the lower six are distributed chiefly to the Multifidus and Longissimus dorsi, occasionally they give off filaments to the skin near the middle line.

The lateral branches (ramus lateralis; external branch) increase in size from above downward. They run through or beneath the Longissimus dorsi to the interval between it and the Iliocostales, and supply these muscles; the lower five or six also give off cutaneous branches which pierce the Serratus posterior inferior and Latissimus dorsi in a line with the angles of the ribs. The lateral branches of a variable number of the upper thoracic nerves also give filaments to the skin. The lateral branch of the twelfth thoracic, after sending a filament medialward along the iliac crest, passes downward to the skin of the buttock.

The medial cutaneous branches of the posterior divisions of the thoracic nerves descend for some distance close to the spinous processes before reaching the skin, while the lateral branches travel downward for a considerable distance—it may be as much as the breadth of four ribs—before they

become superficial; the branch from the twelfth thoracic, for instance, reaches the skin only a little way above the iliac crest.

The Lumbar Nerves (Nn. Lumbales)—The medial branches of the posterior divisions of the lumbar nerves run close to the articular processes of the vertebræ and end in the Multifidus.

The lateral branches supply the Sacrospinalis. The upper three give off cutaneous nerves which pierce the aponeurosis of the Latissimus dorsi at the lateral border of the Sacrospinalis and descend across the posterior part of the iliac crest to the skin of the buttock, some of their twigs running as far as the level of the greater trochanter.

The Sacral Nerves (Nn. Sacrales)—The posterior divisions of the sacral nerves (rami posteriores) are small, and diminish in size from above downward; they emerge, except the last, through the posterior sacral foramina. The upper three are covered at their points of exit by the Multifidus, and divide into medial and lateral branches.

The medial branches are small, and end in the Multifidus.

The lateral branches join with one another and with the lateral branches of the posterior divisions of the last lumbar and fourth sacral to form loops on the dorsal surface of the sacrum. From these loops branches run to the dorsal surface of the sacrotuberous ligament and form a second series of loops under the Glutæus maximus. From this second series cutaneous branches, two or three in number, pierce the Glutæus maximus along a line drawn from the posterior superior iliac spine to the tip of the coccyx; they supply the skin over the posterior part of the buttock.

The posterior divisions of the lower two sacral nerves are small and lie below the Multifidus. They do not divide into medial and lateral branches, but unite with each other and with the posterior division of the coccygeal nerve to form loops on the back of the sacrum; filaments from these loops supply the skin over the coccyx.

The Coccygeal Nerve (N. Coccygeus)—The posterior division of the coccygeal nerve (ramus posterior) does not divide into a medial and a lateral branch, but receives, as already stated, a communicating branch from the last sacral; it is distributed to the skin over the back of the coccyx.

The anterior divisions of the spinal nerves supply the antero-lateral parts of the trunk, and the limbs; they are for the most part larger than the posterior divisions. In the thoracic region they run independently of one another, but in the cervical, lumbar, and sacral regions they unite near their origins to form plexuses.

The Cervical Nerves (Nn. Cervicales)

The anterior divisions of the cervical nerves (rami anteriores), with the exception of the first, pass outward between the Intertransversarii anterior and posterior, lying on the grooved upper surfaces of the transverse processes of the vertebræ. The anterior division of the first or suboccipital nerve issues from the vertebral canal above the posterior arch of the atlas and runs forward around the lateral aspect of its superior articular process, medial to the vertebral artery. In most cases it descends medial to and in front of the Rectus capitis lateralis, but occasionally it pierces the muscle.

The anterior divisions of the upper four cervical nerves unite to form the cervical plexus, and each receives a gray ramus communicans from the superior cervical ganglion of the sympathetic trunk. Those of the lower four cervical, together with the greater part of the first thoracic, form the brachial plexus. They each receive a gray ramus communicans, those for the fifth and sixth being derived from the middle, and those for the seventh and eighth from the lowest, cervical ganglion of the sympathetic trunk.

The Cervical Plexus (plexus cervicalis).

—The cervical plexus is formed by the anterior divisions of the upper four cervical nerves; each nerve, except the first, divides into an upper and a lower branch, and the branches unite to form three loops. The plexus is situated oppostie the upper four cervical vertebræ, in front of the Levator scapulæ and Scalenus medius, and covered by the Sternocleidomastoideus.

Its branches are divided into two groups, superficial and deep, and are here given in tabular form; the figures following the names indicate the nerves from which the different branches take origin:

Superficial Branches of the Cervical Plexus.—The Smaller Occipital Nerve (n. occipitalïs minor; small occipital nerve) arises from the second cervical nerve, sometimes also from the third; it curves around and ascends along the posterior border of the Sternocleidomastoideus. Near the cranium it perforates the deep fascia, and is continued upward along the side of the head behind the auricula, supplying the skin and communicating with the greater occipital, the great auricular, and the posterior auricular branch of the facial. The smaller occipital varies in size, and is sometimes duplicated.

It gives off an auricular branch, which supplies the skin of the upper and back part of the auricula, communicating with the mastoid branch of the great auricular. This branch is occasionally derived from the greater occipital nerve.

The Great Auricular Nerve (n. auricularis magnus) is the largest of the ascending branches. It arises from the second and third cervical nerves, winds around the posterior border of the Sternocleidomastoideus, and, after perforating the deep fascia, ascends upon that muscle beneath the Platysma to the parotid gland, where it divides into an anterior and a posterior branch.

The anterior branch (ramus anterior; facial branch) is distributed to the skin of the face over the parotid gland, and communicates in the substance of the gland with the facial nerve.

The posterior branch (ramus posterior; mastoid branch) supplies the skin over the mastoid process and on the back of the auricula, except at its upper part; a filament pierces the auricula to reach its lateral surface, where it is distributed to the lobule and lower part of the concha. The posterior branch communicates with the smaller occipital, the auricular branch of the vagus, and the posterior auricular branch of the facial.

The Cutaneous Cervical (n. cutaneus colli; superficial or transverse cervical nerve) arises from the second and third cervical nerves, turns around the posterior border of the Sternocleidomastoideus about its middle, and, passing obliquely forward beneath the external jugular vein to the anterior border of the muscle, it perforates the deep cervical fascia, and divides beneath the Platysma into ascending and descending branches, which are distributed to the antero-lateral parts of the neck.

The ascending branches (rami superiores) pass upward to the submaxillary region, and form a plexus with the cervical branch of the facial nerve beneath the Platysma; others pierce that muscle, and are distributed to the skin of the upper and front part of the neck.

The descending branches (rami inferiores) pierce the Platysma, and are distributed to the skin of the side and front of the neck, as low as the sternum.

The Supraclavicular Nerves (nn. supraclaviculares; descending branches) arise from the third and fourth cervical nerves; they emerge beneath the posterior border of the Sternocleidomastoideus, and descend in the posterior triangle of the neck beneath the Platysma and deep cervical fascia. Near the clavicle they perforate the fascia and Platysma to become cutaneous, and are arranged, according to their position, into three groups—anterior, middle and posterior.

The anterior supraclavicular nerves (nn. supraclaviculares anteriores; suprasternal nerves) cross obliquely over the external jugular vein and the clavicular and sternal heads of the Sternocleidomastoideus, and supply the skin as far as the middle line. They furnish one or two filaments to the sternoclavicular joint.

The middle supraclavicular nerves (nn. supraclaviculares medii; supraclavicular nerves) cross the clavicle, and supply the skin over the Pectoralis major and Deltoideus, communicating with the cutaneous branches of the upper intercostal nerves.

The posterior supraclavicular nerves (nn. supraclaviculares posteriores; supra-acromial nerves) pass obliquely across the outer surface of the Trapezius and the acromion, and supply the skin of the upper and posterior parts of the shoulder.

Deep Branches of the Cervical Plexus. INTERNAL SERIES.—The Communicating Branches consist of several filaments, which pass from the loop between the first and second cervical nerves to the vagus, hypoglossal, and sympathetic. The branch to the hypoglossal ultimately leaves that nerve as a series of branches, viz., the descending ramus, the nerve to the Thyreohyoideus and the nerve, to the Geniohyoideus. A communicating branch also passes from the fourth to the fifth cervical, while each of

the first four cervical nerves receives a gray ramus communicans from the superior cervical ganglion of the sympathetic.

Muscular Branches supply the Longus capitis, Rectus capitis anterior, and Rectus capitis lateralis.

The Communicantes Cervicales (communicantes hypoglossi) consist usually of two filaments, one derived from the second, and the other from the third cervical. These filaments join to form the descendens cervicalis, which passes downward on the lateral side of the internal jugular vein, crosses in front of the vein a little below the middle of the neck, and forms a loop (ansa hypoglossi) with the descending ramus of the hypoglossal in front of the sheath of the carotid vessels. Occasionally, the loop is formed within the sheath.

The Phrenic Nerve (n. phrenicus; internal respiratory nerve of Bell) contains motor and sensory fibers in the proportion of about two to one. It arises chiefly from the fourth cervical nerve, but receives a branch from the third and another from the fifth; (the fibers from the fifth occasionally come through the nerve to the Subclavius.) It descends to the root of the neck, running obliquely across the front of the Scalenus anterior, and beneath the Sternocleidomastoideus, the inferior belly of the Omohyoideus, and the transverse cervical and transverse scapular vessels. It next passes in front of the first part of the subclavian artery, between it and the subclavian vein, and, as it enters the thorax, crosses the internal mammary artery near its origin. Within the thorax, it descends nearly vertically in front of the root of the lung, and then between the pericardium and the mediastinal pleura, to the diaphragm, where it divides into branches, which pierce that muscle, and are distributed to its under surface. In the thorax it is accompanied by the pericardiacophrenic branch of the internal mammary artery. The two phrenic nerves differ in their length, and also in their relations at the upper part of the thorax.

The right nerve is situated more deeply, and is shorter and more vertical in direction than the left; it lies lateral to the right innominate vein and superior vena cava.

The left nerve is rather longer than the right, from the inclination of the heart to the left side, and from the diaphragm being lower on this than on the right side. At the root of the neck it is crossed by the thoracic duct; in the superior mediastinal cavity it lies between the left common carotid and left subclavian arteries, and crosses superficial to the vagus on the left side of the arch of the aorta.

Each nerve supplies filaments to the pericardium and pleura, and at the root of the neck is joined by a filament from the sympathetic, and, occasionally, by one from the ansa hypoglossi. Branches have been described as passing to the peritoneum.

From the right nerve, one or two filaments pass to join in a small phrenic ganglion with phrenic branches of the celiac plexus; and branches from this ganglion are distributed to the falciform and coronary ligaments of the liver, the suprarenal gland, inferior vena cava, and right atrium. From the left nerve, filaments pass to join the phrenic branches of the celiac plexus, but without any ganglionic enlargement; and a twig is distributed to the left suprarenal gland.

Deep Branches of the Cervical Plexus. EXTERNAL SERIES.—Communicating Branches.—The external series of deep branches of the cervical plexus communicates with the accessory nerve, in the substance of the Sternocleidomastoideus, in the posterior triangle, and beneath the Trapezius.

Muscular Branches are distributed to the Sternocleidomastoideus, Trapezius, Levator scapulæ, and Scalenus medius.

The branch for the Sternocleidomastoideus is derived from the second cervical; the Trapezius and Levator scapulæ receive branches from the third and fourth. The Scalenus medius receives twigs either from the third or fourth, or occasionally from both.

The Branchial Plexus (plexus brachialis).—The brachial plexus is formed by the union of the anterior divisions of the lower four cervical nerves and the greater part of the anterior division of the first thoracic nerve; the fourth cervical usually gives a branch to the fifth cervical, and the first thoracic frequently receives one from the second thoracic. The plexus extends from the lower part of the side of the neck to the axilla. The nerves which form it are nearly equal in size, but their mode of communication is subject to some variation. The following is, however, the most constant arrangement. The fifth and sixth cervical unite soon after their exit from the intervertebral foramina to form a trunk.

The eighth cervical and first thoracic also unite to form one trunk, while the seventh cervical runs out alone. Three trunks—upper, middle, and lower—are thus formed, and, as they pass beneath the clavicle, each splits into an anterior and a posterior division. The anterior divisions of the upper and middle trunks unite to form a cord, which is situated on the lateral side of the second part of the axillary artery, and is called the lateral cord or fasciculus of the plexus. The anterior division of the lower trunk passes down on the medial side of the axillary artery, and forms the medial cord or fasciculus of the brachial plexus. The posterior divisions of all three trunks unite to form the posterior cord or fasciculus of the plexus, which is situated behind the second portion of the axillary artery.

Relations.—In the neck, the brachial plexus lies in the posterior triangle, being covered by the skin, Platysma, and deep fascia; it is crossed by the supraclavicular nerves, the inferior belly of the Omohyoideus, the external jugular vein, and the transverse cervical artery. It emerges between the Scaleni anterior and medius; its upper part lies above the third part of the subclavian artery, while the trunk formed by the union of the eighth cervical and first thoracic is placed behind the artery; the plexus next passes behind the clavicle, the Subclavius, and the transverse scapular vessels, and lies upon the first digitation of the Serratus anterior, and the Subscapularis. In the axilla it is placed lateral to the first portion of the axillary artery; it surrounds the second part of the artery, one cord lying medial to it, one lateral to it, and one behind it; at the lower part of the axilla it gives off its terminal branches to the upper limb. Branches of Communication.—Close to their exit from the intervertebral foramina the fifth and sixth cervical nerves each receive a gray ramus communicans from the middle cervical ganglion of the sympathetic trunk, and the seventh and eighth cervical similar twigs from the inferior ganglion. The first thoracic nerve receives a gray ramus from, and contributes a white ramus to, the first thoracic ganglion. On the Scalenus anterior the phrenic nerve is joined by a branch from the fifth cervical.

Branches of Distribution.—The branches of distribution of the brachial plexus may be arranged into two groups, viz., those given off above and those below the clavicle.

Supraclavicular Branches.

Dorsal Scapular…….. 5 C.
Suprascapular…… 5, 6 C.
Nerve to Subclavius…… 5, 6 C.
Long thoracic……. 5, 6, 7 C.
To Longus colli and Scaleni… 5, 6, 7, 8 C.

The Dorsal Scapular Nerve (n. dorsalis scapulæ; nerve to the Rhomboidei; posterior scapular nerve) arises from the fifth cervical, pierces the Scalenus medius, passes beneath the Levator scapulæ, to which it occasionally gives a twig, and ends in the Rhomboidei.

The Suprascapular (n. suprascapularis) arises from the trunk formed by the union of the fifth and sixth cervical nerves. It runs lateralward beneath the Trapezius and the Omohyoideus, and enters the supraspinatous fossa through the suprascapular notch, below, the superior transverse scapular ligament; it then passes beneath the Supraspinatus, and curves around the lateral border of the spine of the scapula to the infraspinatous fossa. In the supraspinatous fossa it gives off two branches to the Supraspinatus muscle, and an articular filament to the shoulder-joint; and in the infraspinatous fossa it gives off two branches to the Infraspinatous muscle, besides some filaments to the shoulder-joint and scapula.

The Nerve to the Subclavius (n. subclavius) is a small filament, which arises from the point of junction of the fifth and sixth cervical nerves; it descends to the muscle in front of the third part of the subclavian artery and the lower trunk of the plexus, and is usually connected by a filament with the phrenic nerve.

The Long Thoracic Nerve (n. thoracalis longus; external respiratory nerve of Bell; posterior thoracic nerve) supplies the Serratus anterior. It usually arises by three roots from the fifth, sixth, and seventh cervical nerves; but the root from the seventh nerve may be absent. The roots from the fifth and sixth nerves pierce the Scalenus medius, while that from the seventh passes in front of the muscle. The nerve

descends behind the brachial plexus and the axillary vessels, resting on the outer surface of the Serratus anterior. It extends along the side of the thorax to the lower border of that muscle, supplying filaments to each of its digitations.

The branches for the Longus colli and Scaleni arise from the lower four cervical nerves at their exit from the intervertebral foramina.

Infraclavicular Branches.—The infraclavicular branches are derived from the three cords of the brachial plexus, but the fasciculi of the nerves may be traced through the plexus to the spinal nerves from which they originate.

The Anterior Thoracic Nerves (nn. thoracales anteriores) supply the Pectorales major and minor.

The lateral anterior thoracic (fasciculus lateralis) the larger of the two, arises from the lateral cord of the brachial plexus, and through it from the fifth, sixth, and seventh cervical nerves. It passes across the axillary artery and vein, pierces the coracoclavicular fascia, and is distributed to the deep surface of the Pectoralis major. It sends a filament to join the medial anterior thoracic and form with it a loop in front of the first part of the axillary artery.

The medial anterior thoracic (fasciculus medialis) arises from the medial cord of the plexus and through it from the eighth cervical and first thoracic. It passes behind the first part of the axillary artery, curves forward between the axillary artery and vein, and unites in front of the artery with a filament from the lateral nerve. It then enters the deep surface of the Pectoralis minor, where it divides into a number of branches, which supply the muscle. Two or three branches pierce the muscle and end in the Pectoralis major.

The Subscapular Nerves (nn. subscapulares), two in number, spring from the posterior cord of the plexus and through it from the fifth and sixth cervical nerves.

The upper subscapular (short subscapular), the smaller enters the upper part of the Subscapularis, and is frequently represented by two branches.

The lower subscapular supplies the lower part of the Subscapularis, and ends in the Teres major; the latter muscle is sometimes supplied by a separate branch.

The Thoracodorsal Nerve (n. thoracodorsalis; middle or long subscapular nerve), a branch of the posterior cord of the plexus, derives its fibers from the fifth, sixth, and seventh cervical nerves; it follows the course of the subscapular artery, along the posterior wall of the axilla to the Latissimus dorsi, in which it may be traced as far as the lower border of the muscle.

The Axillary Nerve (n. axillaris; circumflex nerve) arises from the posterior cord of the brachial plexus, and its fibers are derived from the fifth and sixth cervical nerves. It lies at first behind the axillary artery, and in front of the Subscapularis, and passes downward to the lower border of that muscle. It then winds backward, in company with the posterior humeral circumflex artery, through a quadrilateral space bounded above by the Subscapularis, below by the Teres major, medially by the long head of the Triceps brachii, and laterally by the surgical neck of the humerus, and divides into an anterior and a posterior branch.

The anterior branch (upper branch) winds around the surgical neck of the humerus, beneath the Deltoideus, with the posterior humeral circumflex vessels, as far as the anterior border of that muscle, supplying it, and giving off a few small cutaneous branches, which pierce the muscle and ramify in the skin covering its lower part.

The posterior branch (lower branch) supplies the Teres minor and the posterior part of the Deltoideus; upon the branch to the Teres minor an oval enlargement (pseudoganglion) usually exists. The posterior branch then pierces the deep fascia and is continued as the lateral brachial cutaneous nerve, which sweeps around the posterior border of the Deltoideus and supplies the skin over the lower two-thirds of the posterior part of this muscle, as well as that covering the long head of the Triceps brachii.

The trunk of the axillary nerve gives off an articular filament which enters the shoulder-joint below the Subscapularis.

The Musculocutaneous Nerve (n. musculocutaneus) arises from the lateral cord of the brachial plexus, opposite the lower border of the Pectoralis minor, its fibers being derived from the fifth, sixth, and

seventh cervical nerves. It pierces the Coracobrachialis muscle and passes obliquely between the Biceps brachii and the Brachialis, to the lateral side of the arm; a little above the elbow it pierces the deep fascia lateral to the tendon of the Biceps brachii and is continued into the forearm as the lateral antibrachial cutaneous nerve. In its course through the arm it supplies the Coracobrachialis, Biceps brachii, and the greater part of the Brachialis. The branch to the Coracobrachialis is given off from the nerve close to its origin, and in some instances as a separate filament from the lateral cord of the plexus; it is derived from the seventh, cervical nerve. The branches to the Biceps brachii and Brachialis are given off after the musculocutaneous has pierced the Coracobrachialis; that supplying the Brachialis gives a filament to the elbow-joint. The nerve also sends a small branch to the bone, which enters the nutrient foramen with the accompanying artery.

The lateral antibrachial cutaneous nerve (n. cutaneus antibrachii cutaneous lateralis; branch of musculocutaneous nerve) passes behind the cephalic vein, and divides, opposite the elbow-joint, into a volar and a dorsal branch.

The volar branch (ramus volaris; anterior branch) descends along the radial border of the forearm to the wrist, and supplies the skin over the lateral half of its volar surface. At the wrist-joint it is placed in front of the radial artery, and some filaments, piercing the deep fascia, accompany that vessel to the dorsal surface of the carpus. The nerve then passes downward to the ball of the thumb, where it ends in cutaneous filaments. It communicates with the superficial branch of the radial nerve, and with the palmar cutaneous branch of the median nerve.

The dorsal branch (ramus dorsalis; posterior branch) descends, along the dorsal surface of the radial side of the forearm to the wrist. It supplies the skin of the lower two-thirds of the dorso-lateral surface of the forearm, communicating with the superficial branch of the radial nerve and the dorsal antibrachial cutaneous branch of the radial.

The musculocutaneous nerve presents frequent irregularities. It may adhere for some distance to the median and then pass outward, beneath the Biceps brachii, instead of through the Coracobrachialis. Some of the fibers of the median may run for some distance in the musculocutaneous and then leave it to join their proper trunk; less frequently the reverse is the case, and the median sends a branch to join the musculocutaneous. The nerve may pass under the Coracobrachialis or through the Biceps brachii. Occasionally it gives a filament to the Pronator teres, and it supplies the dorsal surface of the thumb when the superficial branch of the radial nerve is absent.

The Medial Antibrachial Cutaneous Nerve (n. cutaneus antibrachii medialis; internal cutaneous nerve) arises from the medial cord of the brachial plexus. It derives its fibers from the eighth cervical and first thoracic nerves, and at its commencement is placed medial to the axillary artery. It gives off, near the axilla, a filament, which pierces the fascia and supplies the integument covering the Biceps brachii, nearly as far as the elbow. The nerve then runs down the ulnar side of the arm medial to the brachial artery, pierces the deep fascia with the basilic vein, about the middle of the arm, and divides into a volar and an ulnar branch.

The volar branch (ramus volaris; anterior branch), the larger, passes usually in front of, but occasionally behind, the vena mediana cubiti (median basilic vein). It then descends on the front of the ulnar side of the forearm, distributing filaments to the skin as far as the wrist, and communicating with the palmar cutaneous branch of the ulnar nerve (Fig. 811).

The ulnar branch (ramus ulnaris; posterior branch) passes obliquely downward on the medial side of the basilic vein, in front of the medial epicondyle of the humerus, to the back of the forearm, and descends on its ulnar side as far as the wrist, distributing filaments to the skin. It communicates with the medial brachial cutaneous, the dorsal antibrachial cutaneous branch of the radial, and the dorsal branch of the ulnar.

The Medial Brachial Cutaneous Nerve (n. cutaneus brachii medialis; lesser internal cutaneous nerve; nerve of Wrisberg) is distributed to the skin on the ulnar side of the arm. It is the smallest branch of the brachial plexus, and arising from the medial cord receives its fibers from the eighth cervical and first thoracic nerves. It passes through the axilla, at first lying behind, and then medial to the axillary vein,

and communicates with the intercostobrachial nerve. It descends along the medial side of the brachial artery to the middle of the arm, where it pierces the deep fascia, and is distributed to the skin of the back of the lower third of the arm, extending as far as the elbow, where some filaments are lost in the skin in front of the medial epicondyle, and others over the olecranon. It communicates with the ulnar branch of the medial antibrachial cutaneous nerve.

In some cases the medial brachial cutaneous and intercostobrachial are connected by two or three filaments, which form a plexus in the axilla. In other cases the intercostobrachial is of large size, and takes the place of the medial brachial cutaneous, receiving merely a filament of communication from the brachial plexus, which represents the latter nerve; in a few cases, this filament is wanting.

The Median Nerve (n. medianus) extends along the middle of the arm and forearm to the hand. It arises by two roots, one from the lateral and one from the medial cord of the brachial plexus; these embrace the lower part of the axillary artery, uniting either in front of or lateral to that vessel. Its fibers are derived from the sixth, seventh, and eighth cervical and first thoracic nerves. As it descends through the arm, it lies at first lateral to the brachial artery; about the level of the insertion of the Coracobrachialis it crosses the artery, usually in front of, but occasionally behind it, and lies on its medial side at the bend of the elbow, where it is situated behind the lacertusfibrosus (bicipital fascia), and is separated from the elbow-joint by the Brachialis. In the forearm it passes between the two heads of the Pronator teres and crosses the ulnar artery, but is separated from this vessel by the deep head of the Pronator teres. It descends beneath the Flexor digitorum sublimis, lying on the Flexor digitorum profundus, to within 5 cm. of the transverse carpal ligament; here it becomes more superficial, and is situated between the tendons of the Flexor digitorum sublimis and Flexor carpi radialis. In this situation it lies behind, and rather to the radial side of, the tendon of the Palmaris longus, and is covered by the skin and fascia. It then passes behind the transverse carpal ligament into the palm of the hand. In its course through the forearm it is accompanied by the median artery, a branch of the volar interroseous artery.

Branches.—With the exception of the nerve to the Pronator teres, which sometimes arises above the elbow-joint, the median nerve gives off no branches in the arm. As it passes in front of the elbow, it supplies one or two twigs to the joint.

In the forearm its branches are: muscular, volar interosseous, and palmar.

The muscular branches (rami musculares) are derived from the nerve near the elbow and supply all the superficial muscles on the front of the forearm, except the Flexor carpi ulnaris.

The volar interosseous nerve (n. interosseus [antibrachii] volaris; anterior interosseous nerve) supplies the deep muscles on the front of the forearm, except the ulnar half of the Flexor digitorum profundus. It accompanies the volar interosseous artery along the front of the interosseous membrane, in the interval between the Flexor pollicis longus and Flexor digitorum profundus, supplying the whole of the former and the radial half of the latter, and ending below in the Pronator quadratus and wrist-joint.

The palmar branch (ramus cutaneus palmaris n. mediani) of the median nerve arises at the lower part of the forearm. It pierces the volar carpal ligament, and divides into a lateral and a medial branch; the lateral branch supplies the skin over the ball of the thumb, and communicates with the volar branch of the lateral antibrachial cutaneous nerve; the medial branch supplies the skin of the palm and communicates with the palmar cutaneous branch of the ulnar.

In the palm of the hand the median nerve is covered by the skin and the palmar aponeurosis, and rests on the tendons of the Flexor muscles. Immediately after emerging from under the transverse carpal ligament the nerve becomes enlarged and flattened and splits into a smaller, lateral, and a larger, medial portion. The lateral portion supplies a short, stout branch to certain of the muscles of the ball of the thumb, viz., the Abductor brevis, the Opponens, and the superficial head of the Flexor brevis, and then divides into three proper volar digital nerves; two of these supply the sides of the thumb, while the third gives a twig to the first Lumbricalis and is distributed to the radial side of the index finger. The medial portion of the nerve divides into two common volar digital nerves. The first of these gives a twig to the second Lumbricalis and runs toward the cleft between the index and middle fingers, where it divides into two proper digital nerves for the adjoining sides of these digits; the second runs toward the cleft

between the middle and ring fingers, and splits into two proper digital nerves for the adjoining sides of these digits; it communicates with a branch from the ulnar nerve and sometimes sends a twig to the third Lumbricalis.

Each proper digital nerve, opposite the base of the first phalanx, gives off a dorsal branch which joins the dorsal digital nerve from the superficial branch of the radial nerve, and supplies the integument on the dorsal aspect of the last phalanx. At the end of the digit, the proper digital nerve divides into two branches, one of which supplies the pulp of the finger, the other ramifies around and beneath the nail. The proper digital nerves, as they run along the fingers, are placed superficial to the corresponding arteries.

The Ulnar Nerve (n. ulnaris) is placed along the medial side of the limb, and is distributed to the muscles and skin of the forearm and hand. It arises from the medial cord of the brachial plexus, and derives its fibers from the eighth cervical and first thoracic nerves. It is smaller than the median, and lies at first behind it, but diverges from it in its course down the arm. At its origin it lies medial to the axillary artery, and bears the same relation to the brachial artery as far as the middle of the arm. Here it pierces the medial intermuscular septum, runs obliquely across the medial head of the Triceps brachii, and descends to the groove between the medial epicondyle and the olecranon, accompanied by the superior ulnar collateral artery. At the elbow, it rests upon the back of the medial epicondyle, and enters the forearm between the two heads of the Flexor carpi ulnaris. In the forearm, it descends along the ulnar side lying upon the Flexor digitorum profundus; its upper half is covered by the Flexor carpi ulnaris, its lower half lies on the lateral side of the muscle, covered by the integument and fascia. In the upper third of the forearm, it is separated from the ulnar artery by a considerable interval, but in the rest of its extent lies close to the medial side of the artery. About 5 cm. above the wrist it ends by dividing into a dorsal and a volar branch.

The branches of the ulnar nerve are: articular to the elbow-joint, muscular, palmar cutaneous, dorsal, and volar.

The articular branches to the elbow-joint are several small filaments which arise from the nerve as it lies in the groove between the medial epicondyle and olecranon.

The muscular branches (rami musculares) two in number, arise near the elbow: one supplies the Flexor carpi ulnaris; the other, the ulnar half of the Flexor digitorum profundus.

The palmar cutaneous branch (ramus cutaneus palmaris) arises about the middle of the forearm, and descends on the ulnar artery, giving off some filaments to the vessel. It perforates the volar carpal ligament and ends in the skin of the palm, communicating with the palmar branch of the median nerve.

The dorsal branch (ramus dorsalis manus) arises about 5 cm. above the wrist; it passes backward beneath the Flexor carpi ulnaris, perforates the deep fascia, and, running along the ulnar side of the back of the wrist and hand, divides into two dorsal digital branches; one supplies the ulnar side of the little finger; the other, the adjacent sides of the little and ring fingers. It also sends a twig to join that given by the superficial branch of the radial nerve for the adjoining sides of the middle and ring fingers, and assists in supplying them. A branch is distributed to the metacarpal region of the hand, communicating with a twig of the superficial branch of the radial nerve.

On the little finger the dorsal digital branches extend only as far as the base of the terminal phalanx, and on the ring finger as far as the base of the second phalanx; the more distal parts of these digits are supplied by dorsal branches derived from the proper volar digital branches of the ulnar nerve.

The volar branch (ramus volaris manus) crosses the transverse carpal ligament on the lateral side of the pisiform bone, medial to and a little behind the ulnar artery. It ends by dividing into a superficial and a deep branch.

The superficial branch (ramus superficialis [n. ulnaris] supplies the Palmaris brevis, and the skin on the ulnar side of the hand, and divides into a proper volar digital branch for the ulnar side of the little finger, and a common volar digital branch which gives a communicating twig to the median nerve and divides into two proper digital nerves for the adjoining sides of the little and ring fingers (Fig. 811). The proper digital branches are distributed to the fingers in the same manner as those of the median.

The deep branch (ramus profundus) accompanied by the deep branch of the ulnar artery, passes between the Abductor digiti quinti and Flexor digiti quinti brevis; it then perforates the Opponens digiti quinti and follows the course of the deep volar arch beneath the Flexor tendons. At its origin it supplies the three short muscles of the little finger. As it crosses the deep part of the hand, it supplies all the Interossei and the third and fourth Lumbricales; it ends by supplying the Adductores pollicis and the medial head of the Flexor pollicis brevis. It also sends articular filaments to the wrist-joint.

It has been pointed out that the ulnar part of the Flexor digitorum profundus is supplied by the ulnar nerve; the third and fourth Lumbricales, which are connected with the tendons of this part of the muscle, are supplied by the same nerve. In like manner the lateral part of the Flexor digitorum profundus and the first and second Lumbricales are supplied by the median nerve; the third Lumbricalis frequently receives an additional twig from the median nerve.

The Radial Nerve (n. radialis; musculospiral nerve), the largest branch of the brachial plexus, is the continuation of the posterior cord of the plexus. Its fibres are derived from the fifth, sixth,seventh, and eighth cervical and first thoracic nerves. It descends behind the first part of the axillary artery and the upper part of the brachial artery, and in front of the tendons of the Latissimus dorsi and Teres major. It then winds around from the medial to the lateral side of the humerus in a groove with the a. profunda brachii, between the medial and lateral heads of the Triceps brachii. It pierces the lateral intermuscular septum, and passes between the Brachialis and Brachioradialis to the front of the lateral epicondyle, where it divides into a superficial and a deep branch.

The branches of the musculospiral nerve are:

Muscular. Superficial.

Cutaneous. Deep.

The muscular branches (rami musculares) supply the Triceps brachii, Anconæus, Brachioradialis, Extensor carpi radialis longus, and Brachialis, and are grouped as medial, posterior, and lateral.

The medial muscular branches supply the medial and long heads of the Triceps brachii. That to the medial head is a long, slender filament, which lies close to the ulnar nerve as far as the lower third of the arm, and is therefore frequently spoken of as the ulnar collateral nerve.

The posterior muscular branch, of large size, arises from the nerve in the groove between the Triceps brachii and the humerus. It divides into filaments, which supply the medial and lateral heads of the Triceps brachii and the Anconæus muscles. The branch for the latter muscle is a long, slender filament, which descends in the substance of the medial head of the Triceps brachii.

The lateral muscular branches supply the Brachioradialis, Extensor carpi radialis longus, and the lateral part of the Brachialis.

The cutaneous branches are two in number, the posterior brachial cutaneous and the dorsal antibrachial cutaneous.

The posterior brachial cutaneous nerve (n. cutaneus brachii posterior; internal cutaneous branch of musculospiral) arises in the axilla, with the medial muscular branch. It is of small size, and passes through the axilla to the medial side of the area supplying the skin on its dorsal surface nearly as far as the olecranon. In its course it crosses behind, and communicates with, the intercostobrachial.

The dorsal antibrachial cutaneous nerve (n. cutaneus antibrachii dorsalis; external cutaneous branch of musculospiral) perforates the lateral head of the Triceps brachii at its attachment to the humerus. The upper and smaller branch of the nerve passes to the front of the elbow, lying close to the cephalic vein, and supplies the skin of the lower half of the arm. The lower branch pierces the deep fascia below the insertion of the Deltoideus, and descends along the lateral side of the arm and elbow, and then along the back of the forearm to the wrist, supplying the skin in its course, and joining, near its termination, with the dorsal branch of the lateral antibrachial cutaneous nerve.

The Superficial Branch of the Radial Nerve (ramus superficialis radial nerve) passes along the front of the radial side of the forearm to the commencement of its lower third. It lies at first slightly lateral to the radial artery, concealed beneath the Brachioradialis. In the middle third of the forearm, it lies behind the same muscle, close to the lateral side of the artery. It quits the artery about 7 cm. above the

wrist, passes beneath the tendon of the Brachioradialis, and, piercing the deep fascia, divides into two branches.

The lateral branch, the smaller, supplies the skin of the radial side and ball of the thumb, joining with the volar branch of the lateral antibrachial cutaneous nerve.

The medial branch communicates, above the wrist, with the dorsal branch of the lateral antibrachial cutaneous, and, on the back of the hand, with the dorsal branch of the ulnar nerve. It then divides into four digital nerves, which are distributed as follows: the first supplies the ulnar side of the thumb; the second, the radial side of the index finger; the third, the adjoining sides of the index and middle fingers; the fourth communicates with a filament from the dorsal branch of the ulnar nerve, and supplies the adjacent sides of the middle and ring fingers.

The Deep Branch of the Radial Nerve (n. interosseus dorsalis; dorsal or posterior interosseous nerve) winds to the back of the forearm around the lateral side of the radius between the two planes of fibers of the Supinator, and is prolonged downward between the superficial anddeep layers of muscles, to the middle of the forearm. Considerably diminished in size, it descends, as the dorsal interosseous nerve, on the interosseous membrane, in front of the Extensor pollicis longus, to the back of the carpus, where it presents a gangliform enlargement from which filaments are distributed to the ligaments and articulations of the carpus. It supplies all the muscles on the radial side and dorsal surface of the forearm, excepting the Anconæus, Brachioradialis, and Extenosr carpi radialis longus.

The anterior divisions of the thoracic nerves (rami anteriores; ventral divisions) are twelve in number on either side. Eleven of them are situated between the ribs, and are therefore termed intercostal; the twelfth lies below the last rib. Each nerve is connected with the adjoining ganglion of the sympathetic trunk by a gray and a white ramus communicans. The intercostal nerves are distributed chiefly to the parietes of the thorax and abdomen, and differ from the anterior divisions of the other spinal nerves, in that each pursues an independent course, i. e., there is no plexus formation. The first two nerves supply fibers to the upper limb in addition to their thoracic branches; the next four are limited in their distribution to the parietes of the thorax; the lower five supply the parietes of the thorax and abdomen. The twelfth thoracic is distributed to the abdominal wall and the skin of the buttock.

The First Thoracic Nerve.—The anterior division of the first thoracic nerve divides into two branches: one, the larger, leaves the thorax in front of the neck of the first rib, and enters the brachial plexus; the other and smaller branch, the first intercostal nerve, runs along the first intercostal space, and ends on the front of the chest as the first anterior cutaneous branch of the thorax. Occasionally this anterior cutaneous branch is wanting. The first intercostal nerve as a rule gives off no lateral cutaneous branch; but sometimes it sends a small branch to communicate with the intercostobrachial. From the second thoracic nerve it frequently receives a connecting twig, which ascends over the neck of the second rib.

The Upper Thoracic Nerves (nn. intercostales).—The anterior divisions of the second, third, fourth, fifth, and sixth thoracic nerves, and the small branch from the first thoracic, are confined to the parietes of the thorax, and are named thoracic intercostal nerves. They pass forward in the intercostal spaces below the intercostal vessels. At the back of the chest they lie between the pleura and the posterior intercostal membranes, but soon pierce the latter and run between the two planes of Intercostal muscles as far as the middle of the rib. They then enter the substance of the Intercostales interni, and, running amidst their fibers as far as the costal cartilages, they gain the inner surfaces of the muscles and lie between them and the pleura. Near the sternum, they cross in front of the internal mammary artery and Transversus thoracis muscle, pierce the Intercostales interni, the anterior intercostal membranes, and Pectoralis major, and supply the integument of the front of the thorax and over the mamma, forming the anterior cutaneous branches of the thorax; the branch from the second nerve unites with the anterior supraclavicular nerves of the cervical plexus.

Branches.—Numerous slender muscular filaments supply the Intercostales, the Subcostales, the Levatores costarum, the Serratus posterior superior, and the Transversus thoracis. At the front of the thorax some of these branches cross the costal cartilages from one intercostal space to another.

Lateral cutaneous branches (rami cutanei laterales) are derived from the intercostal nerves, about midway between the vertebræ and sternum; they pierce the Intercostales externi and Serratus anterior, and divide into anterior and posterior branches. The anterior branches run forward to the side and the forepart of the chest, supplying the skin and the mamma; those of the fifth and sixth nerves supply the upper digitations of the Obliquus externus abdominis. The posterior branches run backward, and supply the skin over the scapula and Latissimus dorsi.

The lateral cutaneous branch of the second intercostal nerve does not divide, like the others, into an anterior and a posterior branch; it is named the intercostobrachial nerve. It pierces the Intercostalis externus and the Serratus anterior, crosses the axilla to the medial side of the arm, and joins with a filament from the medial brachial cutaneous nerve. It then pierces the fascia, and supplies the skin of the upper half of the medial and posterior part of the arm, communicating with
the posterior brachial cutaneous branch of the radial nerve. The size of the intercostobrachial nerve is in inverse proportion to that of the medial brachial cutaneous nerve. A second intercostobrachial nerve is frequently given off from the lateral cutaneous branch of the third intercostal; it supplies filaments to the axilla and medial side of the arm.

The Lower Thoracic Nerves.—The anterior divisions of the seventh, eighth, ninth, tenth, and eleventh thoracic nerves are continued anteriorly from the intercostal spaces into the abdominal wall; hence they are named thoracicoabdominal intercostal nerves. They have the same arrangement as the upper ones as far as the anterior ends of the intercostal spaces, where they pass behind the costal cartilages, and between the Obliquus internus and Transversus abdominis, to the sheath of the Rectus abdominis, which they perforate. They supply the Rectus abdominis and end as the anterior cutaneous branches of the abdomen; they supply the skin of the front of the abdomen. The lower intercostal nerves supply the Intercostales and abdominal muscles; the last three send branches to the Serratus posterior inferior. About the middle of their course they give off lateral cutaneous branches. These pierce the Intercostales externi and the Obliquus externus abdominis, in the same line as the lateral cutaneous branches of the upper thoracic nerves, and divide into anterior and posterior branches, which are distributed to the skin of the abdomen and back; the anterior branches supply the digitations of the Obliquus externus abdominis, and extend downward and forward nearly as far as the margin of the Rectus abdominis; the posterior branches pass backward to supply the skin over the Latissimus dorsi.

The anterior division of the twelfth thoracic nerve is larger than the others; it runs along the lower border of the twelfth rib, often gives a communicating branch to the first lumbar nerve, and passes under the lateral lumbocostal arch. It then runs in front of the Quadratus lumborum, perforates the Transversus, and passes forward between it and the Obliquus internus to be distributed in the same manner as the lower intercostal nerves. It communicates with the iliohypogastric nerve of the lumbar plexus, and gives a branch to the Pyramidalis. The lateral cutaneous branch of the last thoracic nerve is large, and does not divide into an anterior and a posterior branch. It perforates the Obliqui internus and externus, descends over the iliac crest in front of the lateral cutaneous branch of the iliohypogastric, and is distributed to the skin of the front part of the gluteal region, some of its filaments extending as low as the greater trochanter.

Practice 8. Lumbar plexus. The sacral plexus.

The lumbar plexus is a network of nerve fibres that supplies the skin and musculature of the lower limb. It is located in the lumbar region, within the substance of the **psoas major** muscle and anterior to the transverse processes of the **lumbar vertebrae**.

The plexus is formed by the **anterior rami** (divisions) of the lumbar spinal nerves L1, L2, L3 and L4. It also receives contributions from thoracic spinal nerve 12. In this article, we shall look at the anatomy of the lumbar plexus – its formation and major branches.

Spinal Nerves

The spinal nerves L1 – L4 form the basis of the lumbar plexus. At each vertebral level, paired spinal nerves leave the spinal cord via the intervertebral foramina of the vertebral column. Each nerve then divides into anterior and posterior nerve fibres.
The lumbar plexus begins as the anterior fibres of the spinal nerves L1, L2, L3, and L4.

The Branches

The anterior rami of the L1-L4 spinal roots divide into several cords. These cords then combine together to form the six major peripheral nerves of the lumbar plexus. These nerves then descend down the posterior abdominal wall to reach the lower limb, where they innervate their target structures.
We shall now consider the branches of the lumbar plexus. (Note: In this article we shall include only brief notes on the function of these nerves – for more detailed information click on the title to visit their respective pages)
Iliohypogastric Nerve
The iliohypogastric nerve is the first major branch of the lumbar plexus. It runs to the iliac crest, across the quadratus lumborum muscle of the posterior abdominal wall. It then perforates the transversus abdominis, and divides into its terminal branches.
Roots: L1 (with contributions from T12).

Motor Functions: Innervates the internal oblique and transversus abdominis.

Sensory Functions: Innervates the posterolateral gluteal skin in the pubic region. *(Tip: an easy way to remember that the Ilio**H**ypogastric comes before the Ilio**I**nguinal is that **H** comes before **I** in the alphabet!)*

Ilioinguinal Nerve

The ilioinguinal nerve follows the same anatomical course as the larger iliohypogastric nerve. After innervating the muscles of the anterior abdominal wall, it passes through the superficial inguinal ring to innervate the skin of the genitalia and middle thigh.

Roots: L1.

Motor Functions: Innervates the internal oblique and transversus abdominis.

Sensory Functions: Innervates the skin on the superior antero-medial thigh. In males, it also supplies the skin over the root of the penis and anterior scrotum. In females, it supplies the skin over mons pubis and labia majora.

Genitofemoral Nerve

After leaving the psoas major muscle, the genitofemoral nerve quickly divides into a genital branch, and a femoral branch.

Roots: L1, L2.

Motor Functions: The genital branch innervates the cremasteric muscle.

Sensory Functions: The genital branch innervates the skin of the anterior scrotum (in males) or the skin over mons pubis and labia majora (in females). The femoral branch innervates the skin on the upper anterior thigh.

Lateral Cutaneous Nerve of the Thigh

This nerve has a purely sensory function. It enters the thigh at the lateral aspect of the inguinal ligament, where it provides cutaneous innervation to the skin there.

Roots: L2, L3

Motor Functions: None.

Sensory Functions: Innervates the anterior and lateral thigh down to the level of the knee.

Obturator Nerve

Roots: L2, L3, L4.

Motor Functions: Innervates the muscles: obturator externus, pectineus, adductor longus, adductor brevis, adductor magnus, gracilis.

Sensory Functions: Innervates the skin over the medial thigh.

Femoral Nerve

Roots: L2, L3, L4.

Motor Functions: Innervates the muscles: Illiacus, pectineus, sartorius, all the muscles of quadriceps femoris.

Sensory Functions: Innervates the skin on the anterior thigh and the medial leg.

The sacral plexus is a network of nerve fibres that supplies the skin and muscles of the pelvis and lower limb. It is located on the surface of the posterior pelvic wall, anterior to the piriformis muscle.

The plexus is formed by the anterior rami (divisions) of the sacral spinal nerves S1, S2, S3 and S4. It also receives contributions from the lumbar spinal nerves L4 and L5.

In this article, we shall look at the anatomy of the sacral plexus – its formation and major branches.

Spinal Nerves

The spinal nerves S1 – S4 form the basis of the sacral plexus.

At each vertebral level, paired spinal nerves leave the spinal cord via the intervertebral foramina of the vertebral column.
Each nerve then divides into anterior and posterior nerve fibres. The sacral plexus begins as the anterior fibres of the spinal nerves S1, S2, S3, and S4. They are joined by the 4th and 5th lumbar roots, which combine to form the lumbosacral trunk. This descends into the pelvis to meet the sacral roots as they emerge from the spinal cord.

The Branches

The anterior rami of the S1-S4 spinal roots (and the lumbosacral trunk) divide into several cords. These cords then combine together to form the five major peripheral nerves of the sacral plexus.

These nerves then descend down the posterior pelvic wall. They have two main destinations:

- Leave the pelvis via the **greater sciatic foramen** – these nerves enter the gluteal region of the lower limb, innervating the structures there.
- **Remain in the pelvis** – these nerves innervate the pelvic muscles, organs and perineum.

Superior Gluteal Nerve

The superior gluteal nerve leaves the pelvis via the greater sciatic foramen, entering the gluteal region superiorly to the piriformis muscle. It is accompanied by the superior gluteal artery and vein for much of its course.

Roots: L4, L5, S1.

Motor Functions: Innervates the gluteus minimus, gluteus medius and tensor fascia lata.

Sensory Functions: None.

Inferior Gluteal Nerve

The inferior gluteal nerve leaves the pelvis via the greater sciatic foramen, entering the gluteal region inferiorly to the piriformis muscle.

It is accompanied by the inferior gluteal artery and vein for much of its course.

Roots: L5, S1, S2.

Motor Functions: Innervates gluteus maximus.

Sensory Functions: None.

Sciatic Nerve

- **Roots**: L4, L5, S1, S2, S3
- **Motor Functions**:
  - Tibial portion – Innervates the muscles in the posterior compartment of the thigh (apart from the short head of the biceps femoris), and the hamstring component of adductor magnus. Innervates all the muscles in the posterior compartment of the leg and sole of the foot.
  - Common fibular portion – Short head of biceps femoris, all muscles in the anterior and lateral compartments of the leg and extensor digitorum brevis.
- **Sensory Functions**:
  - Tibial portion: supplies the skin of the posterolateral leg, lateral foot and the sole of the foot.
  - Common fibular portion: supplies the skin of the lateral leg and the dorsum of the foot.

Posterior Femoral Cutaneous

The posterior cutaneous nerve of thigh leaves the pelvis via the greater sciatic foramen, entering the gluteal region inferiorly to the piriformis muscle. It descends deep to the gluteus maximus and runs down the back of the thigh to the knee.

Roots: S1, S2, S3

Motor Functions: None

Sensory Functions: Innervates the skin on the posterior surface of the thigh and leg. Also innervates the skin of the perineum.

Pudendal Nerve

This nerve leaves the pelvis via the greater sciatic foramen, then re-enters via the lesser sciatic foramen. It moves anterosuperiorly along the lateral wall of the ischiorectal fossa, and terminates by dividing into several branches.

Roots: S2, S3, S4

Motor Functions: Innervates the skeletal muscles in the perineum, the external urethral sphincter, the external anal sphincter, levator ani.

Sensory Functions: Innervates the penis and the clitoris and most of the skin of the perineum.

Other Branches

In addition to the five major nerves of the sacral plexus, there are a number of smaller branches. These tend to be nerves that directly supplying muscles (with the exception of the perforating cutaneous nerve, which supplies the skin over the inferior gluteal region and the pelvic splanchnic nerves, which innervate the abdominal viscera):

- Nerve to piriformis
- Nerve to obturator internus
- Nerve to quadratus femoris

Practice 9. I, II, VIII pairs of cranial nerves

The olfactory nerves or nerves of smell are distributed to the mucous membrane of the olfactory region of the nasal cavity: this region comprises the superior nasal concha, and the corresponding part of the nasal septum. The nerves originate from the central or deep processes of the olfactory cells of the nasal mucous membrane. They form a plexiform net-work in the mucous membrane, and are then collected into about twenty branches, which pierce the cribriform plate of the ethmoid bone in two groups, a lateral and a medial group, and end in the glomeruli of the olfactory bulb. Each branch receives tubular sheaths from the dura mater and pia mater, the former being lost in the periosteum of the nose, the latter in the neurolemma of the nerve.

The olfactory nerves are non-medullated, and consist of axis-cylinders surrounded by nucleated sheaths, in which, however, there are fewer nuclei than are found in the sheaths of ordinary non-medullated nerve fibers.

The olfactory center in the cortex is generally associated with the rhinencephalon.

The olfactary nerves are developed from the cells of the ectoderm which lines the olfactory pits; these cells undergo proliferation and give rise to what are termed the olfactory cells of the nose. The axons of the olfactory cells grow into the overlying olfactory bulb and form the olfactory nerves.

The optic nerve, or nerve of sight, consists mainly of fibers derived from the ganglionic cells of the retina. These axons terminate in arborizations around the cells in the lateral geniculate body, pulvinar, and superior colliculus which constitute the lower or primary visual centers. From the cells of the lateral geniculate body and the pulvinar fibers pass to the cortical visual center, situated in the cuneus and in the neighborhood of the calcarine fissure. A few fibers of the optic nerve, of small caliber, pass from the primary centers to the retina and are supposed to govern chemical changes in the retina and also the movements of some of its elements (pigment cells and cones). There are also a few fine fibers, afferent fibers, extending from the retina to the brain, that are supposed to be concerned in pupillary reflexes.

The optic nerve is peculiar in that its fibers and ganglion cells are probably third in the series of neurons from the receptors to the brain. Consequently the optic nerve corresponds rather to a tract of fibers within the brain than to the other cranial nerves. Its fibers pass backward and medialward through the orbit and optic foramen to the optic commissure where they partially decussate. The mixed fibers from the two nerves are continued in the optic tracts, the primary visual centers of the brain.

The orbital portion of the optic nerve is from 20 mm. to 30 mm. in length and has a slightly sinuous course to allow for movements of the eyeball. It is invested by an outer sheath of dura mater and an inner sheath from the arachnoid which are attached to the sclera around the area where the nerve fibers pierce the choroid and sclera of the bulb. A little behind the bulb of the eye the central artery of the retina with its accompanying vein perforates the optic nerve, and runs within it to the retina. As the nerve enters the optic foramen its dural sheath becomes continuous with that lining the orbit and the optic foramen. In the optic foramen the ophthalmic artery lies below and to its outer side. The intercranial portion of the optic nerve is about 10 mm. in length.

The Optic Chiasma (chiasma opticum), somewhat quadrilateral in form, rests upon the tuberculum sellæ and on the anterior part of the diaphragma sellæ. It is in relation, above, with the lamina terminalis; behind, with the tuber cinereum; on either side, with the anterior perforated substance. Within the chiasma, the optic nerves undergo a partial decussation. The fibers forming the medial part of each tract and posterior part of the chiasma have no connection with the optic nerves. They simply cross in the chiasma, and connect the medial geniculate bodies of the two sides; they form the commissure of Gudden. The remaining and principal part of the chiasma consists of two sets of fibers, crossed and uncrossed. The crossed fibers which are the more numerous, occupy the central part of the chiasma, and pass from the optic nerve of one side to the optic tract of the other, decussating in the chiasma with similar fibers of the opposite optic nerve. The uncrossed fibers occupy the lateral part of the chiasma, and pass from the nerve of one side into the tract of the same side.

The crossed fibers of the optic nerve tend to occupy the medial side of the nerve and the uncrossed fibers the lateral side. In the optic tract, however, the fibers are much more intermingled.

The Optic Tract, passes backward and outward from the optic chiasma over the tuber cinereum and anterior perforated space to the cerebral peduncle and winds obliquely across its under surface. Its fibers terminate in the lateral geniculate body, the pulvinar and the superior colliculus. It is adherent to the tuber cinereum and the cerebral peduncle as it passes over them. In the region of the lateral geniculate body it splits into two bands. The medial and smaller one is a part of the commissure of Gudden and ends in the medial geniculate body.

From its mode of development, and from its structure, the optic nerve must be regarded as a prolongation of the brain substance, rather than as an ordinary cerebrospinal nerve. As it passes from the brain it receives sheaths from the three cerebral membranes, a perineural sheath from the pia mater, an intermediate sheath from the arachnoid, and an outer sheath from the dura mater, which is also connected with the periosteum as it passes through the optic foramen. These sheaths are separated from each other by cavities which communicate with the subdural and subarachnoid cavities respectively. The innermost or perineural sheath sends a process around the arteria centralis retinæ into the interior of the nerve, and enters intimately into its structure.

The acoustic nerve consists of two distinct sets of fibers which differ in their peripheral endings, central connections, functions, and time of medullation. It is soft in texture and devoid of neurilemma.

Cochlear Nerve.—The cochlear nerve or root, the nerve of hearing, arises from bipolar cells in the spiral ganglion of the cochlea, situated near the inner edge of the osseous spiral lamina. The peripheral fibers pass to the organ of Corti. The central ones pass down the modiolus and then through the foramina of the tractus spiralis foraminosus or through the foramen centrale into the lateral or outer end of the internal auditory meatus. The nerve passes along the internal auditory meatus with the vestibular nerve and across the subarachnoid space, just above the flocculus, almost directly medialward toward the inferior peduncle to terminate in the cochlear nucleus.

The cochlear nerve is placed lateral to the vestibular root. Its fibers end in two nuclei: one, the accessory nucleus, lies immediately in front of the inferior peduncle; the other, the tuberculum acusticum, somewhat lateral to it.

The striæ medullares (striæ acusticæ) are the axons of the cells of the tuberculum acusticum. They pass over the inferior peduncle, and across the rhomboid fossa to the median sulcus. Here they dip into the substance of the pons, to end around the cells of the superior olivary nuclei of both sides. There are, however, other fibers, and these are both direct and crossed, which pass into the lateral lemniscus. The cells of the accessory nucleus give origin to fibers which run transversely in the pons and constitute the trapezium. Of the trapezoid fibers some end around the cells of the superior olivary nucleus or of the trapezoid nucleus of the same or opposite side, while others, crossed or uncrossed, pass directly into the lateral lemniscus.

If the further connections of the cochlear nerve of one side, say the left, be considered, it is found that they lie lateral to the main sensory tract, the lemniscus, and are therefore termed the lateral lemniscus. The fibers comprising the left lateral lemniscus arise in the superior olivary and trapezoid

nuclei of the same or opposite side, while others are the uninterrupted fibers already alluded to, and these are either crossed or uncrossed, the former being the axons of the cells of the right accessory nucleus or of the cells of the right tuberculum acusticum, while the latter are derived from the cells of the left nuclei. In the upper part of the lateral lemniscus there is a collection of nerve cells, the nucleus of the lateral lemniscus, around the cells of which some of the fibers arborize and from the cells of which axons originate to continue upward the tract of the lateral lemniscus. The ultimate ending of the left lateral lemniscus is partly in the opposite medial geniculate body, and partly in the inferior colliculi. From the cells of these bodies new fibers arise and ascend in the occipital part of the internal capsule to reach the posterior three-fifths of the left superior temporal gyrus and the transverse temporal gyri.

Vestibular Nerve.—The vestibular nerve or root, the nerve of equilibration, arises from bipolar cells in the vestibular ganglion, ganglion of Scarpa, which is situated in the upper part of the outer end of the internal auditory meatus. The peripheral fibers divide into three branches: the superior branch passes through the foramina in the area vestibularis superior and ends in the utricle and in the ampullæ of the superior and lateral semicircular ducts; the fibers of the inferior branch traverse the foramina in the area vestibularis inferior and end in the saccule; the posterior branch runs through the foramen singulare and supplies the ampulla of the posterior semicircular duct.

Practice 10. III, IV, VI, XI, XII pairs of cranial nerves

The olfactory nerves or nerves of smell are distributed to the mucous membrane of the olfactory region of the nasal cavity: this region comprises the superior nasal concha, and the corresponding part of the nasal septum. The nerves originate from the central or deep processes of the olfactory cells of the nasal mucous membrane. They form a plexiform net-work in the mucous membrane, and are then collected into about twenty branches, which pierce the cribriform plate of the ethmoid bone in two groups, a lateral and a medial group, and end in the glomeruli of the olfactory bulb. Each branch receives tubular sheaths from the dura mater and pia mater, the former being lost in the periosteum of the nose, the latter in the neurolemma of the nerve.

The olfactory nerves are non-medullated, and consist of axis-cylinders surrounded by nucleated sheaths, in which, however, there are fewer nuclei than are found in the sheaths of ordinary non-medullated nerve fibers.

The olfactory center in the cortex is generally associated with the rhinencephalon.

The olfactary nerves are developed from the cells of the ectoderm which lines the olfactory pits; these cells undergo proliferation and give rise to what are termed the olfactory cells of the nose. The axons of the olfactory cells grow into the overlying olfactory bulb and form the olfactory nerves.

The optic nerve, or nerve of sight, consists mainly of fibers derived from the ganglionic cells of the retina. These axons terminate in arborizations around the cells in the lateral geniculate body, pulvinar, and superior colliculus which constitute the lower or primary visual centers. From the cells of the lateral geniculate body and the pulvinar fibers pass to the cortical visual center, situated in the cuneus and in the neighborhood of the calcarine fissure. A few fibers of the optic nerve, of small caliber, pass from the primary centers to the retina and are supposed to govern chemical changes in the retina and also the movements of some of its elements (pigment cells and cones). There are also a few fine fibers, afferent fibers, extending from the retina to the brain, that are supposed to be concerned in pupillary reflexes.

The optic nerve is peculiar in that its fibers and ganglion cells are probably third in the series of neurons from the receptors to the brain. Consequently the optic nerve corresponds rather to a tract of fibers within the brain than to the other cranial nerves. Its fibers pass backward and medialward through the orbit and optic foramen to the optic commissure where they partially decussate. The mixed fibers from the two nerves are continued in the optic tracts, the primary visual centers of the brain.

The orbital portion of the optic nerve is from 20 mm. to 30 mm. in length and has a slightly sinuous course to allow for movements of the eyeball. It is invested by an outer sheath of dura mater

and an inner sheath from the arachnoid which are attached to the sclera around the area where the nerve fibers pierce the choroid and sclera of the bulb. A little behind the bulb of the eye the central artery of the retina with its accompanying vein perforates the optic nerve, and runs within it to the retina. As the nerve enters the optic foramen its dural sheath becomes continuous with that lining the orbit and the optic foramen. In the optic foramen the ophthalmic artery lies below and to its outer side. The intercranial portion of the optic nerve is about 10 mm. in length.

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The cochlear nerve is placed lateral to the vestibular root. Its fibers end in two nuclei: one, the accessory nucleus, lies immediately in front of the inferior peduncle; the other, the tuberculum acusticum, somewhat lateral to it.

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and constitute the trapezium. Of the trapezoid fibers some end around the cells of the superior olivary nucleus or of the trapezoid nucleus of the same or opposite side, while others, crossed or uncrossed, pass directly into the lateral lemniscus.

If the further connections of the cochlear nerve of one side, say the left, be considered, it is found that they lie lateral to the main sensory tract, the lemniscus, and are therefore termed the lateral lemniscus. The fibers comprising the left lateral lemniscus arise in the superior olivary and trapezoid nuclei of the same or opposite side, while others are the uninterrupted fibers already alluded to, and these are either crossed or uncrossed, the former being the axons of the cells of the right accessory nucleus or of the cells of the right tuberculum acusticum, while the latter are derived from the cells of the left nuclei. In the upper part of the lateral lemniscus there is a collection of nerve cells, the nucleus of the lateral lemniscus, around the cells of which some of the fibers arborize and from the cells of which axons originate to continue upward the tract of the lateral lemniscus. The ultimate ending of the left lateral lemniscus is partly in the opposite medial geniculate body, and partly in the inferior colliculi. From the cells of these bodies new fibers arise and ascend in the occipital part of the internal capsule to reach the posterior three-fifths of the left superior temporal gyrus and the transverse temporal gyri.

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Practice 11. V, VII pairs of cranial nerves Parasympathetic nodes located along the branches of the trigeminal nerve.

The olfactory nerves or nerves of smell are distributed to the mucous membrane of the olfactory region of the nasal cavity: this region comprises the superior nasal concha, and the corresponding part of the nasal septum. The nerves originate from the central or deep processes of the olfactory cells of the nasal mucous membrane. They form a plexiform net-work in the mucous membrane, and are then collected into about twenty branches, which pierce the cribriform plate of the ethmoid bone in two groups, a lateral and a medial group, and end in the glomeruli of the olfactory bulb. Each branch receives tubular sheaths from the dura mater and pia mater, the former being lost in the periosteum of the nose, the latter in the neurolemma of the nerve.

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The optic nerve is peculiar in that its fibers and ganglion cells are probably third in the series of neurons from the receptors to the brain. Consequently the optic nerve corresponds rather to a tract of fibers within the brain than to the other cranial nerves. Its fibers pass backward and medialward through the orbit and optic foramen to the optic commissure where they partially decussate. The mixed fibers from the two nerves are continued in the optic tracts, the primary visual centers of the brain.

The orbital portion of the optic nerve is from 20 mm. to 30 mm. in length and has a slightly sinuous course to allow for movements of the eyeball. It is invested by an outer sheath of dura mater and an inner sheath from the arachnoid which are attached to the sclera around the area where the nerve fibers pierce the choroid and sclera of the bulb. A little behind the bulb of the eye the central artery of the retina with its accompanying vein perforates the optic nerve, and runs within it to the retina. As the nerve enters the optic foramen its dural sheath becomes continuous with that lining the orbit and the optic foramen. In the optic foramen the ophthalmic artery lies below and to its outer side. The intercranial portion of the optic nerve is about 10 mm. in length.

The Optic Chiasma (chiasma opticum), somewhat quadrilateral in form, rests upon the tuberculum sellæ and on the anterior part of the diaphragma sellæ. It is in relation, above, with the lamina terminalis; behind, with the tuber cinereum; on either side, with the anterior perforated substance. Within the chiasma, the optic nerves undergo a partial decussation. The fibers forming the medial part of each tract and posterior part of the chiasma have no connection with the optic nerves. They simply cross in the chiasma, and connect the medial geniculate bodies of the two sides; they form the commissure of Gudden. The remaining and principal part of the chiasma consists of two sets of fibers, crossed and uncrossed. The crossed fibers which are the more numerous, occupy the central part of the chiasma, and pass from the optic nerve of one side to the optic tract of the other, decussating in the chiasma with similar fibers of the opposite optic nerve. The uncrossed fibers occupy the lateral part of the chiasma, and pass from the nerve of one side into the tract of the same side.

The crossed fibers of the optic nerve tend to occupy the medial side of the nerve and the uncrossed fibers the lateral side. In the optic tract, however, the fibers are much more intermingled.

The Optic Tract, passes backward and outward from the optic chiasma over the tuber cinereum and anterior perforated space to the cerebral peduncle and winds obliquely across its under surface. Its fibers terminate in the lateral geniculate body, the pulvinar and the superior colliculus. It is adherent to the tuber cinereum and the cerebral peduncle as it passes over them. In the region of the lateral geniculate body it splits into two bands. The medial and smaller one is a part of the commissure of Gudden and ends in the medial geniculate body.

From its mode of development, and from its structure, the optic nerve must be regarded as a prolongation of the brain substance, rather than as an ordinary cerebrospinal nerve. As it passes from the brain it receives sheaths from the three cerebral membranes, a perineural sheath from the pia mater, an intermediate sheath from the arachnoid, and an outer sheath from the dura mater, which is also connected with the periosteum as it passes through the optic foramen. These sheaths are separated from each other by cavities which communicate with the subdural and subarachnoid cavities respectively. The innermost or perineural sheath sends a process around the arteria centralis retinæ into the interior of the nerve, and enters intimately into its structure.

The acoustic nerve consists of two distinct sets of fibers which differ in their peripheral endings, central connections, functions, and time of medullation. It is soft in texture and devoid of neurilemma.

Cochlear Nerve.—The cochlear nerve or root, the nerve of hearing, arises from bipolar cells in the spiral ganglion of the cochlea, situated near the inner edge of the osseous spiral lamina. The peripheral fibers pass to the organ of Corti. The central ones pass down the modiolus and then through the foramina of the tractus spiralis foraminosus or through the foramen centrale into the lateral or outer end of the internal auditory meatus. The nerve passes along the internal auditory meatus with the vestibular nerve and across the subarachnoid space, just above the flocculus, almost directly medialward toward the inferior peduncle to terminate in the cochlear nucleus.

The cochlear nerve is placed lateral to the vestibular root. Its fibers end in two nuclei: one, the accessory nucleus, lies immediately in front of the inferior peduncle; the other, the tuberculum acusticum, somewhat lateral to it.

The striæ medullares (striæ acusticæ) are the axons of the cells of the tuberculum acusticum. They pass over the inferior peduncle, and across the rhomboid fossa to the median sulcus. Here they dip into the substance of the pons, to end around the cells of the superior olivary nuclei of both sides. There are, however, other fibers, and these are both direct and crossed, which pass into the lateral lemniscus. The cells of the accessory nucleus give origin to fibers which run transversely in the pons and constitute the trapezium. Of the trapezoid fibers some end around the cells of the superior olivary nucleus or of the trapezoid nucleus of the same or opposite side, while others, crossed or uncrossed, pass directly into the lateral lemniscus.

If the further connections of the cochlear nerve of one side, say the left, be considered, it is found that they lie lateral to the main sensory tract, the lemniscus, and are therefore termed the lateral lemniscus. The fibers comprising the left lateral lemniscus arise in the superior olivary and trapezoid nuclei of the same or opposite side, while others are the uninterrupted fibers already alluded to, and these are either crossed or uncrossed, the former being the axons of the cells of the right accessory nucleus or of the cells of the right tuberculum acusticum, while the latter are derived from the cells of the left nuclei. In the upper part of the lateral lemniscus there is a collection of nerve cells, the nucleus of the lateral lemniscus, around the cells of which some of the fibers arborize and from the cells of which axons originate to continue upward the tract of the lateral lemniscus. The ultimate ending of the left lateral lemniscus is partly in the opposite medial geniculate body, and partly in the inferior colliculi. From the cells of these bodies new fibers arise and ascend in the occipital part of the internal capsule to reach the posterior three-fifths of the left superior temporal gyrus and the transverse temporal gyri.

Vestibular Nerve.—The vestibular nerve or root, the nerve of equilibration, arises from bipolar cells in the vestibular ganglion, ganglion of Scarpa, which is situated in the upper part of the outer end of the internal auditory meatus. The peripheral fibers divide into three branches: the superior branch passes through the foramina in the area vestibularis superior and ends in the utricle and in the ampullæ of the superior and lateral semicircular ducts; the fibers of the inferior branch traverse the foramina in the area vestibularis inferior and end in the saccule; the posterior branch runs through the foramen singulare and supplies the ampulla of the posterior semicircular duct.

Practice 12. IX and X pairs of cranial nerves.

The olfactory nerves or nerves of smell are distributed to the mucous membrane of the olfactory region of the nasal cavity: this region comprises the superior nasal concha, and the corresponding part of the nasal septum. The nerves originate from the central or deep processes of the olfactory cells of the nasal mucous membrane. They form a plexiform net-work in the mucous membrane, and are then collected into about twenty branches, which pierce the cribriform plate of the ethmoid bone in two groups, a lateral and a medial group, and end in the glomeruli of the olfactory bulb. Each branch receives tubular sheaths from the dura mater and pia mater, the former being lost in the periosteum of the nose, the latter in the neurolemma of the nerve.

The olfactory nerves are non-medullated, and consist of axis-cylinders surrounded by nucleated sheaths, in which, however, there are fewer nuclei than are found in the sheaths of ordinary non-medullated nerve fibers.

The olfactory center in the cortex is generally associated with the rhinencephalon.

The olfactary nerves are developed from the cells of the ectoderm which lines the olfactory pits; these cells undergo proliferation and give rise to what are termed the olfactory cells of the nose. The axons of the olfactory cells grow into the overlying olfactory bulb and form the olfactory nerves.

The optic nerve, or nerve of sight, consists mainly of fibers derived from the ganglionic cells of the retina. These axons terminate in arborizations around the cells in the lateral geniculate body,

pulvinar, and superior colliculus which constitute the lower or primary visual centers. From the cells of the lateral geniculate body and the pulvinar fibers pass to the cortical visual center, situated in the cuneus and in the neighborhood of the calcarine fissure. A few fibers of the optic nerve, of small caliber, pass from the primary centers to the retina and are supposed to govern chemical changes in the retina and also the movements of some of its elements (pigment cells and cones). There are also a few fine fibers, afferent fibers, extending from the retina to the brain, that are supposed to be concerned in pupillary reflexes.

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Practice 13. The autonomic nervous system.

Introduction

The autonomic nervous system is a component of the peripheral nervous system that regulates involuntary physiologic processes including heart rate, blood pressure, respiration, digestion, and sexual arousal. It contains three anatomically distinct divisions: sympathetic, parasympathetic and enteric.

The sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) contain both afferent and efferent fibers that provide sensory input and motor output, respectively, to the central nervous system (CNS). Generally, the SNS and PNS motor pathways consist of a two-neuron series: a

preganglionic neuron with a cell body in the CNS and a postganglionic neuron with a cell body in the periphery that innervates target tissues. The enteric nervous system (ENS) is an extensive, web-like structure that is capable of function independently of the remainder of the nervous system. It contains over 100 million neurons of over 15 morphologies, greater than the sum of all other peripheral ganglia, and is chiefly responsible for the regulation of digestive processes.

Activation of the SNS leads to a state of overall elevated activity and attention: the "fight or flight" response. In this process, blood pressure and heart rate increase, glycogenolysis ensues, gastrointestinal peristalsis ceases, etc. The SNS innervates nearly every living tissue in the body. The PNS promotes the "rest and digest" processes; heart rate and blood pressure lower, gastrointestinal peristalsis/digestion restarts, etc. The PNS innervates only the head, viscera and external genitalia, notably vacant in much of the musculoskeletal system and skin, making it significantly smaller than the SNS. The ENS is composed of reflex pathways that control the digestive functions of muscle contraction/relaxation, secretion/absorption, and blood flow.

Presynaptic neurons of both the SNS and PNS utilize acetylcholine (ACh) as their neurotransmitter. Postsynaptic sympathetic neurons generally produce norepinephrine (NE) as their effector transmitter to act upon target tissues, while postsynaptic parasympathetic neurons use ACh throughout. Enteric neurons have been known to use several major neurotransmitters such as ACh, nitrous oxide and serotonin, to name a few.

Structure and Function

Sympathetic Nervous System

Sympathetic neurons have cell bodies located in the intermediolateral columns, or lateral horns, of the spinal cord. The presynaptic fibers exit the spinal cord through anterior roots and enter the anterior rami of T1-L2 spinal nerves and onto the sympathetic trunks via white rami communicantes. From here, the fibers may ascend or descend the sympathetic trunk to a superior or inferior paravertebral ganglion, respectively, pass to adjacent anterior spinal nerve rami via gray rami communicantes, or cross through the trunk without synapsing and continue through an abdominopelvic splanchnic nerve to reach prevertebral ganglia. Because of the central location of the sympathetic ganglia, presynaptic fibers tend to be shorter than their postsynaptic counterparts. Paravertebral ganglia exist as nodules throughout the sympathetic trunk, adjacent to the spinal column, where pre- and postganglionic neurons synapse. While the numbers may vary by individual, generally, there are three cervical, 12 thoracic, four lumbar, and five sacral ganglia. Of these, only the cervical have names of superior, middle, and inferior cervical ganglia. The inferior cervical ganglion may fuse with the first thoracic ganglion to form the stellate ganglion.

All nerves distal to the paravertebral ganglia are splanchnic nerves. These convey afferent and efferent fibers between the CNS and the viscera. Cardiopulmonary splanchnic nerves carry the postsynaptic fibers destined for the thoracic cavity.

Nerves that will innervate the abdominal and pelvic viscera pass through the paravertebral without synapsing, becoming abdominopelvic splanchnic nerves. These nerves include the greater, lesser, least, and lumbar splanchnic nerves. The presynaptic nerves finally synapse in prevertebral ganglia that are closer to their target organ. Prevertebral ganglia are part of the nervous plexuses that surround the branches of the aorta. These include the celiac, aorticorenal, and superior and inferior mesenteric ganglia. The celiac ganglion receives input from the greater splanchnic nerve, the aorticorenal from the lesser and least splanchnic nerves, and the superior and inferior mesenteric from the least and lumbar splanchnic nerves. The celiac ganglion innervates organs derived from the foregut: distal esophagus, stomach, proximal duodenum, pancreas, liver, biliary system, spleen, and adrenal glands. The superior mesenteric ganglion innervates the derivatives of the midgut: distal duodenum, jejunum, ileum, cecum,

appendix, ascending colon, and proximal transverse colon. Lastly, the inferior mesenteric ganglion provides sympathetic innervation to the structures developed from the hindgut: distal transverse, descending, and sigmoid colon; rectum and upper anal canal; as well as the bladder, external genitalia, and gonads. For more information, see the relevant StatPearls article, at this reference.

The two-neuron general rule for SNS and PNS circuits has several notable exceptions. Sympathetic and parasympathetic postganglionic neurons that synapse onto the ENS are functionally part of a three-or-more neuron chain. The presynaptic sympathetic fibers that are destined for the adrenal medulla pass through the celiac ganglia and synapse directly onto chromaffin cells. These unique cells function as postganglionic fibers that secrete epinephrine directly into the venous system.

Postganglionic sympathetic neurons release NE that acts on adrenergic receptors in the target tissue. The subtype of the receptor, alpha-1, alpha-2, beta-1, beta-2, or beta-3, and the tissues in which they express influences the affinity of NE for the receptor.https://www.ncbi.nlm.nih.gov/books/NBK539845/ For more information, see the StatPearls articles related to adrenergic receptors, at the following references.

As stated, the SNS enables the body to handle stressors via the "fight-or-flight" response. This reaction primarily regulates blood vessels. Vessels are tonically innervated, and in most cases, an increase in sympathetic signals leads to vasoconstriction and the opposite of vasodilation. The exceptions include coronary vessels and those that supply the skeletal muscles and external genitalia, for which the opposite reaction occurs. This contradictory effect is mediated by the balance of alpha and beta receptor activity. In a physiologic state, beta-receptor stimulation increases coronary vessel dilation, but there is blunting of this effect by alpha-receptor-mediated vasoconstriction. In a pathologic state, such as in coronary artery disease, alpha-receptor activity is enhanced, and there is the muting of beta-activity. Thus, the coronary arteries may constrict via sympathetic stimulation. Sympathetic activation increases heart rate and contractile force, which, however, increases metabolic demand and is thus detrimental to cardiac function in compromised individuals.

The SNS is constantly active, even in non-stressful situations. In addition to the aforementioned tonic stimulation of blood vessels, the SNS is active during the normal respiratory cycle. Sympathetic activation complements the PNS by acting during inspiration to dilate the airways allowing for an appropriate inflow of air.

Additionally, the SNS regulates immunity through the innervation of immune organs such as the spleen, thymus, and lymph nodes. This influence may up- or down-regulate inflammation. Cells of the adaptive immune system primarily express beta-2 receptors, while those of the innate immune system express those as well as alpha-1 and alpha-2 adrenergic receptors. Macrophages activate by alpha-2 stimulation and are suppressed by beta-2 adrenergic receptor activation.

The majority of postganglionic sympathetic neurons are noradrenergic, and also release one or more peptides such as neuropeptide Y or somatostatin. NE/neuropeptide Y neurons innervate blood vessels of the heart, thus regulating blood flow, while NE/somatostatin neurons of the celiac and superior mesenteric ganglia supply the submucosal ganglia of the intestine and are involved in the control of gastrointestinal motility. The thinking is that these peptides serve to modulate the response of the postsynaptic neuron to the primary neurotransmitter. Peptides also have associations with cholinergic sympathetic postganglionic neurons. These neurons are most commonly found innervating sweat glands and precapillary resistance vessels in skeletal muscle and produce vasoactive intestinal polypeptide along with ACh. Calcitonin gene-related peptide, a potent vasodilator, has also been discovered in paravertebral sympathetic neurons.

Parasympathetic Nervous System

Parasympathetic fibers exit the CNS via cranial nerves (CN) III, VII, IX, and X, as well as through the S2-4 nerve roots. There are four pairs of parasympathetic ganglia, and they are all located in the head. CN III, via the ciliary ganglion, innervates the iris and ciliary muscles of the eye. CN VII innervates the lacrimal, nasal, palatine, and pharyngeal glands via the pterygopalatine ganglion, as well as the sublingual and submandibular glands via the submandibular ganglion. CN IX innervates the parotid glands via the otic ganglion. Every other presynaptic parasympathetic fiber synapses in a ganglion near or on the wall of the target tissue; this leads to the presynaptic fibers being significantly longer than the postsynaptic. The location of these ganglia gives the PNS its name: "para-" means adjacent to, hence, "parasympathetic."

The vagus nerve, CN X, makes up about 75% of the PNS and provides parasympathetic input to most of the thoracic and abdominal viscera, with the sacral parasympathetic fibers innervating the descending and sigmoid colon and rectum. The vagus nerve has four cell bodies in the medulla oblongata. These include the following:

- Dorsal nucleus: provides parasympathetic output to the viscera
- Nucleus ambiguus: produces motor fibers and preganglionic neurons that innervate the heart
- Nucleus solitarius: receives afferents of taste sensation and that from viscera, and lastly
- Spinal trigeminal nucleus: receives information of touch, pain, and temperature of the outer ear, the mucosa of the larynx, and part of the dura

Additionally, the vagus nerve conducts sensory information from baroreceptors of the carotid sinus and the aortic arch to the medulla.

As mentioned in the introduction, the vagus nerve is responsible for the "rest and digest" processes. The vagus nerve promotes cardiac relaxation in several aspects of function. It decreases contractility in the atria and less-so in the ventricles. Primarily, it reduces conduction speed through the atrioventricular node. It is by this mechanism that carotid sinus massage acts to limit reentry in Wolff-Parkinson-White syndrome. The other key function of the PNS centers around digestion. Parasympathetic fibers to the head promote salivation, while those that synapse onto the ENS lead to increased peristaltic and secretory activity. The vagus nerve also has a significant effect on the respiratory cycle. In a nonpathological state, parasympathetic nerves fire during expiration, contracting and stiffening airways to prevent collapse. This function has implicated the PNS in the onset of postoperative acute respiratory distress syndrome.

Due to the expansive nature of the vagus nerve, it has been described as an ideal "early warning system" for foreign invaders as well as for monitoring the body's recovery. Up to 80% of vagal fibers are sensory and innervate nearly all major organs. Parasympathetic ganglia have been found to express receptors for interleukin-1, a key cytokine in the inflammatory immune response. This, in turn, activates the hypothalamic-pituitary-adrenal axis and SNS, leading to the release of glucocorticoids and NE, respectively. Studies have correlated inhibited vagal action through vagotomy and cholinergic inhibitors with significantly reduced, if not eliminated, allergic, asthmatic, and inflammatory responses.

Postganglionic parasympathetic neurons release ACh that acts on muscarinic and nicotinic receptors, each with various subunits: M1, M2, and M3, and N1 and N2, with "M" and "N" standing for muscarine and nicotine, respectively. The postganglionic ACh receptors and those on the adrenal medulla are N-type, while the parasympathetic effectors and sweat glands are M-type. As in sympathetic neurons, several peptides, such as vasoactive intestinal peptide (VIP), Neuropeptide Y (NPY), and calcitonin gene-related peptide (CGRP) are expressed in, and released from, parasympathetic neurons. For more information, see the StatPearls article on cholinergic receptors, here.

Enteric Nervous System (ENS)

The ENS is composed of two ganglionated plexuses: the myenteric (Auerbach) and the submucosal (Meissner). The myenteric plexus sits in between the longitudinal and circular smooth muscle of the GI tract, while the submucosal plexus is present within the submucosa. The ENS is self-contained, functioning through local reflex activity, but often receives input from, and provides feedback to, the SNS and PNS. The ENS may receive input from postganglionic sympathetic neurons or preganglionic parasympathetic neurons.

The submucosal plexus governs the movement of water and electrolytes across the intestinal wall, while the myenteric plexus coordinates the contractility of the circular and longitudinal muscle cells of the gut to produce peristalsis.

Motility is produced in the ENS through a reflex circuit involving the circular and longitudinal muscles. Nicotinic synapses between interneurons mediate the reflex circuits. When the circuit activates by the presence of a bolus, excitatory neurons in the circular muscle and inhibitory neurons in the longitudinal muscle fire producing a narrow section of bowel proximal to the bolus; this is known as the propulsive segment. Simultaneously, excitatory neurons in the longitudinal muscle and inhibitory neurons in the circular muscle fire producing the "receiving segment" of the bowel in which the bolus will continue. This process repeats with each subsequent section of the bowel. The ENS maintains several similarities to the CNS. As in the CNS, enteric neurons can be bipolar, pseudounipolar, and multipolar, between which neuromodulation via excitatory and inhibitory communication. Likewise, ENS neurons use over 30 neurotransmitters that are similar to those of the CNS, with cholinergic and nitrergic transmitters being the most common.

While much of this discussion has focused on the efferent functions of the ANS, the afferent fibers are responsible for numerous reflex activities that regulate everything from heart rate to the immune system. Feedback from the ANS is usually processed at a subconscious level to produce reflex actions in the visceral or somatic portions of the body. The conscious sensation of the viscera is often interpreted as diffuse pain or cramps that may correlate with hunger, fullness, or nausea. These sensations most commonly result from sudden distention/contractions, chemical irritants, or pathological conditions such as ischemia.

Embryology

The peripheral nervous system derives from neural crest cells. The neural crest is divided axially into the cranial, vagal, truncal, and lumbosacral neural crest cells. Truncal neural crest cells contribute to the dorsal root of the spinal cord and the sympathetic ganglia. The parasympathetic innervation of the heart forms from the vagal neural crest. The majority of the parasympathetic nervous system, including all of the ganglia of the head, has been shown to arise from glial cells, rather than neural crest cells.

The ENS originates from the vagal neural crest with cells that migrate in a rostral-to-caudal pattern through the intestinal wall, forming a network of glia and neurons of various subtypes. Cells of the ENS complete their migration by four to seven weeks of development and express all varieties of ENS neurotransmitters by gestational week 24. However, mature gut motility is not realized until at least late gestation to shortly after birth.

Practice 14. The organ of sight. The organ of hearing, smell and taste

Functional anatomy of the sensory organs.

Aristotle (384 BC - 322 BC) is credited with the traditional classification of the five sense organs: sight, smell, taste, touch, and hearing. As far back as the 1760's, the famous philosopher Immanuel

Kant proposed that our knowledge of the outside world depends on our modes of perception. In order to define what is "extrasensory" we need to define what is "sensory". Each of the 5 senses consists of organs with specialized cellular structures that have receptors for specific stimuli. These cells have links to the nervous system and thus to the brain. Sensing is done at primitive levels in the cells and integrated into sensations in the nervous system. Sight is probably the most developed sense in humans, followed closely by hearing.

Sight.

The eye is the organ of vision. It has a complex structure consisting of a transparent lens that focuses light on the retina. The retina is covered with two basic types of light-sensitive cells-rods and cones. The cone cells are sensitive to color and are located in the part of the retina called the fovea, where the light is focused by the lens. The rod cells are not sensitive to color, but have greater sensitivity to light than the cone cells. These cells are located around the fovea and are responsible for peripheral vision and night vision. The eye is connected to the brain through the optic nerve. The point of this connection is called the "blind spot" because it is insensitive to light. Experiments have shown that the back of the brain maps the visual input from the eyes.

The brain combines the input of our two eyes into a single three-dimensional image. In addition, even though the image on the retina is upside-down because of the focusing action of the lens, the brain compensates and provides the right-side-up perception. Experiments have been done with subjects fitted with prisms that invert the images. The subjects go through an initial period of great confusion, but subsequently they perceive the images as right side up.

The range of perception of the eye is phenomenal. In the dark, a substance produced by the rod cells increases the sensitivity of the eye so that it is possible to detect very dim light. In strong light, the iris contracts reducing the size of the aperture that admits light into the eye and a protective obscure substance reduces the exposure of the light-sensitive cells. The spectrum of light to which the eye is sensitive varies from the red to the violet. Lower electromagnetic frequencies in the infrared are sensed as heat, but cannot be seen. Higher frequencies in the ultraviolet and beyond cannot be seen either, but can be sensed as tingling of the skin or eyes depending on the frequency. The human eye is not sensitive to the polarization of light, i.e., light that oscillates on a specific plane. Bees, on the other hand, are sensitive to polarized light, and have a visual range that extends into the ultraviolet. Some kinds of snakes have special infrared sensors that enable them to hunt in absolute darkness using only the heat emitted by their prey. Birds have a higher density of light-sensing cells than humans do in their retinas, and therefore, higher visual acuity.

Color blindness or "Daltonism" is a common abnormality in human vision that makes it impossible to differentiate colors accurately. One type of color blindness results in the inability to distinguish red

from green. This can be a real handicap for certain types of occupations. To a colorblind person, a person with normal color vision would appear to have extrasensory perception. However, we want to reserve the term "extrasensory perception" for perception that is beyond the range of the normal.

Hearing.

The ear is the organ of hearing. The outer ear protrudes away from the head and is shaped like a cup to direct sounds toward the tympanic membrane, which transmits vibrations to the inner ear through a series of small bones in the middle ear called the *malleus*, *incus* and *stapes*. The inner ear, or cochlea, is a spiral-shaped chamber covered internally by nerve fibers that react to the vibrations and transmit impulses to the brain via the auditory nerve. The brain combines the input of our two ears to determine the direction and distance of sounds.

The inner ear has a vestibular system formed by three semicircular canals that are approximately at right angles to each other and which are responsible for the sense of balance and spatial orientation. The inner ear has chambers filled with a viscous fluid and small particles (otoliths) containing calcium carbonate. The movement of these particles over small hair cells in the inner ear sends signals to the brain that are interpreted as motion and acceleration.

The human ear can perceive frequencies from 16 cycles per second, which is a very deep bass, to 28,000 cycles per second, which is a very high pitch. Bats and dolphins can detect frequencies higher than 100,000 cycles per second. The human ear can detect pitch changes as small as 3 hundredths of one percent of the original frequency in some frequency ranges. Some people have "perfect pitch", which is the ability to map a tone precisely on the musical scale without reference to an external standard. It is estimated that less than one in ten thousand people have perfect pitch, but speakers of tonal languages like Vietnamese and Mandarin show remarkably precise absolute pitch in reading out lists of words because pitch is an essential feature in conveying the meaning of words in tone languages. The Eguchi Method teaches perfect pitch to children starting before they are 4 years old. After age 7, the ability to recognize notes does not improve much.

Taste.

The receptors for taste, called taste buds, are situated chiefly in the tongue, but they are also located in the roof of the mouth and near the pharynx. They are able to detect four basic tastes: salty, sweet, bitter, and sour. The tongue also can detect a sensation called "umami" from taste receptors sensitive to amino acids. Generally, the taste buds close to the tip of the tongue are sensitive to sweet tastes, whereas those in the back of the tongue are sensitive to bitter tastes. The taste buds on top and on the side of the tongue are sensitive to salty and sour tastes. At the base of each taste bud there is a nerve that sends the sensations to the brain. The sense of taste functions in coordination with the sense of smell. The number of taste buds varies substantially from individual to individual, but greater numbers increase

sensitivity. Women, in general, have a greater number of taste buds than men. As in the case of color blindness, some people are insensitive to some tastes.

Smell.

The nose is the organ responsible for the sense of smell. The cavity of the nose is lined with mucous membranes that have smell receptors connected to the olfactory nerve. The smells themselves consist of vapors of various substances. The smell receptors interact with the molecules of these vapors and transmit the sensations to the brain. The nose also has a structure called the vomeronasal organ whose function has not been determined, but which is suspected of being sensitive to pheromones that influence the reproductive cycle. The smell receptors are sensitive to seven types of sensations that can be characterized as camphor, musk, flower, mint, ether, acrid, or putrid. The sense of smell is sometimes temporarily lost when a person has a cold. Dogs have a sense of smell that is many times more sensitive than man's.

Touch.

The sense of touch is distributed throughout the body. Nerve endings in the skin and other parts of the body transmit sensations to the brain. Some parts of the body have a larger number of nerve endings and, therefore, are more sensitive. Four kinds of touch sensations can be identified: cold, heat, contact, and pain. Hairs on the skin magnify the sensitivity and act as an early warning system for the body. The fingertips and the sexual organs have the greatest concentration of nerve endings. The sexual organs have "erogenous zones" that when stimulated start a series of endocrine reactions and motor responses resulting in orgasm.

Beyond the five sense organs.

In addition to sight, smell, taste, touch, and hearing, humans also have awareness of balance (equilibrioception), pressure, temperature (thermoception), pain (nociception), and motion all of which may involve the coordinated use of multiple sensory organs. The sense of balance is maintained by a complex interaction of visual inputs, the proprioceptive sensors (which are affected by gravity and stretch sensors found in muscles, skin, and joints), the inner ear vestibular system, and the central nervous system. Disturbances occurring in any part of the balance system, or even within the brain's integration of inputs, can cause the feeling of dizziness or unsteadiness.

Kinesthesia is the precise awareness of muscle and joint movement that allows us to coordinate our muscles when we walk, talk, and use our hands. It is the sense of kinesthesia that enables us to touch the tip of our nose with our eyes closed or to know which part of the body we should scratch when we itch.

Synesthesia.

Some people experience a phenomenon called synesthesia in which one type of stimulation evokes the sensation of another. For example, the hearing of a sound may result in the sensation of the visualization of a color, or a shape may be sensed as a smell. Synesthesia is hereditary and it is estimated that it occurs in 1 out of 1000 individuals with variations of type and intensity. The most common forms of synesthesia link numbers or letters with colors.

Glossary

- **abdomen**: Latin abdomen = the belly, the part of the trunk between thorax and the perineum, adjective - abdominal.
- **abducent**: Latin ab = from, and ducens = led, hence, moving from, or effecting separation.
- **abduction**: Latin ab = from, and ductum = led, hence, movement from; verb - abduct.
- **aberrant**: Latin ab = from, and errare = to wander, hence, deviating from normal.
- **accessory**: adjective, Latin accessum = added, hence, supplementary.
- **accommodation**: Latin ad = to, and modus = measure, hence, adaptation of the optical power (focussing) of the eye for shorter distances.
- **acetabulum**: Latin acetum = vinegar (cf. acetic), and abulum = small receptacle, hence, a vinegar cup, hence, the socket for the head of the femur, adjective - acetabular.
- **acoustic**: adjective, Greek akoustikos, related to hearing.
- **acromion**: Greek akros = summit (cf. Acropolis) and omos = shoulder, hence, the tip of the shoulder.
- **adduction**: Latin ad = to, and ductum = led, hence, movement towards; verb - adduct.
- **adenoid**: Greek aden = a gland, eidos = shape or form.
- **adhesion**: Latin ad = to, and haesus = stuck, hence, stuck to, e.g., interthalamic adhesion - variable and functionally insignificant.
- **adipose**: Latin adeps = fat, hence fatty
- **aditus**: Latin ad = to, towards, iter = a way, hence an opening or entrance.
- **adrenal**: Latin ad = towards, at, ren = kidney, hence situated near the kidney (see suprarenal)
- **adrenergic**: adjective, Latin ad = at, ren = kidney, and Greek ergon = work, hence, stimuli which cause the adrenal (suprarenal) gland to produce adrenaline. Used to specify neurons or pathways which use adrenaline as a transmitter.
- **afferent**: adjective, Latin ad = to, and ferent = carrying (cf. ferry), hence, carrying to, e.g., axons carrying information from retina to lateral geniculate nucleus are afferents to that nucleus.
- **agger nasi**: Latin = eminence of the nose.

- **agonist**: Greek agonistes = rival, hence, a muscle in apparent contest with another. Used for a prime mover.
- **ala**: Latin wing, hence a wing-like process; plural - alae.
- **alaeque**: Latin ala = wing (ala of nose), suffix -que = and, hence levator labii superioris alaeque nasi muscles = lifter of the upper lip and ala of nose.
- **alba**: Latin albus = white
- **albicans**: Latin = becoming white; albus = white
- **albuginea**: Latin albus = white, Greek gen = form, hence, like boiled white of an egg.
- **alimentary**: adjective, Latin alimentum = food, e.g., alimentary canal.
- **allantois**: Greek allantos = sausage, eidos = like, form.
- **allocortex**: Greek allos = other (than usual), and Latin cortex = bark, hence non-laminated external grey matter. It refers to paleo- or archi-cortex, as distinct from neocortex.
- **alveolus**: Latin a basin, hence any small hollow. Plural - alveoli, adjective - alveolar.
- **alveus**: Latin = tray. The allusion is unclear. The alveus is a layer of fibres on the free surface of the hippocampus.
- **ambiguus**: adjective, Latin = doubtful (nucleus ambiguus).
- **ampulla**: Latin = a two-handed flask, a local dilatation of a tube.
- **amygdaloid**: adjective, Greek amygdala = almond, and eidos = shape or form, hence, amygdaloid body is an almond-shaped mass.
- **amylacea**: Greek amylon = starch, hence, starchy.
- **anaesthesia**: Greek an = negative, and aisthesis = sensation, hence, loss of sensation; adjective - anaesthetic.
- **analgesia**: Greek an = negative, and algesis = pain, hence insensibility to pain; adjective - analgesic.
- **analogous**: Greek ana = up, apart, towards, and logos = word. A part with similar function through different morphology e.g., fish gills and mammalian lungs (c.f. homologous).
- **anastomosis**: Greek ana = of each, and stoma = mouth, hence the end-to-end continuity of 2 vessels; adjective - anastomotic.
- **anatomy**: Greek ana = up, and tome = a cutting, hence cutting up of a body (c.f. dissection).
- **anconeus**: Greek ancon = elbow, hence the muscle attached to the (lateral surface of the) olecranon.
- **aneurysm**: Greek angeion = blood vessel, and eurys = wide, hence a pathological dilatation of a blood vessel.
- **angiography**: Greek angeion (v.s.) and graphe = a record, hence a picture of a blood vessel which has been injected with a dye or radiopaque material.
- **anhidrosis**: (anhydrosis, anidrosis) Greek an = negative, and hidros = sweat, hence absence of sweating, typical of skin deprived of its sympathetic innervation.
- **ankle**: the region between the leg and the foot.
- **annulus**: diminutive of Latin anus = ring, hence little ring.
- **ansa**: Latin a handle or loop. Applicable to nerves.
- **anserinus**: Latin anser = a goose, hence like a goose, plural - anserina.

- **antagonist**: Greek anti = against, and agonistes = rival, hence a muscle which may oppose an agonist.
- **anteflexion**: Latin ante = before, and flexere = to bend, hence anterior angulation between the body and cervix of the uterus.
- **anterior**: comparative of Latin ante = before, in front.
- **anteversion**: Latin ante = before, and versum = turned, hence, the anterior angulation between cervix uteri and the vagina.
- **antidromic**: adjective, Greek a = negative, and dromos = current, hence conducting in the opposite direction to the usual.
- **antrum**: Greek antron - cave, hence a space in a bone or organ.
- **anulus**: diminutive of Latin anus = ring, hence little ring.
- **anus**: Latin = ring, adjective - anal.
- **aorta**: Latin aorta, from Greek aorte = literally 'what is hung up,' from aeirein 'to lift, heave, raise,' of uncertain origin. Originally applied by Aristotle to the great artery of the heart, earlier by Hippocrates to the bronchial tubes.
- **aponeurosis**: Greek apo = from, and neuron = tendon (later applied to nerve cell and its fibres), used for sheet-like tendons. Adjective - aponeurotic.
- **apophysis**: Greek apo = from, and physis = growth, hence, a bony process - reserved for the articular process of a vertebra; adjective - apophysial.
- **appendage**: Latin appendere = to hang on, supplement.
- **appendix**: Latin appendere = to hang on, supplement.
- **apposition**: Latin appositus = placed at, hence, in contact, in juxtaposition.
- **aqueduct**: Latin aqua = water, and ductus = drawn or led off, hence a channel for conducting fluid, e.g. the cerebral aqueduct of the midbrain, which transmits fluid from the 3rd to the 4th ventricle.
- **arachnoid**: adjective, Greek arachne = spider, and eidos = shape or form, hence like a spiders web. This middle layer of the three meninges is spread web-like over the brain when the dura has been removed.
- **arbor vitae**: Latin arbor = tree, and vita = life, hence, resembling the tree of life. This colourful term is used to describe the pattern of cerebellar folia seen in a median section.
- **archaeocerebellum**: Greek archi = first, hence the oldest part of the cerebellum, which is the flocculonodular lobe.
- **archaeopallium**: Greek archi = first, and pallium = cloak, hence the cortex which developed first in vertebrates. Often synonymous with hippocampal formation.
- **archicerebellum**: Greek archi = first, hence the oldest part of the cerebellum, which is the flocculonodular lobe.
- **archipallium**: Greek archi = first, and pallium = cloak, hence the cortex which developed first in vertebrates. Often synonymous with hippocampal formation.
- **archistriatum**: Greek archi = first, and Latin striatum = streaked or fluted.
- **arcuate**: Latin arcuatum = curved or arched.
- **arcus**: Latin an arch, Latin arcuatum = curved or arched.
- **area**: a part of a surface.
- **areola**: Latin small, open space.
- **arm**: the upper limb, between shoulder and elbow.

- **arrector**: Latin adrectus = raised, hence, arrector pili = a hair-raising muscle.
- **artery**: Latin arteria (which originally meant air- or wind-pipe, and later a blood vessel carrying blood away from the heart).
- **articulation**: Latin artus = joint, hence, articulate - to form a joint.
- **arytenoid**: Greek arytaina = pitcher, and eidos = shape or form, hence the arytenoid cartilage because it curves like a spout.
- **aspect**: a view of more than one surface.
- **aspera**: Latin rough.
- **asterion**: Greek asterios = starry.
- **astrocyte**: Greek astron = star, and kytos = cell, hence a star-shaped (neuroglial) cell.
- **ataxia,**: Greek a = negative, and taxis = order, hence inability to co-ordinate the voluntary muscles.
- **atlas**: Greek atlao = I sustain. Atlas was a mythical god who sustained the globe on his shoulders. The 1st vertebra sustains the skull, and its upper surface bears 2 concavities which suggest Atlas' palms, not shoulders.
- **atresia**: Greek a = negative, and tresis = a hole, hence an absence or closure of a body orifice or tubular organ
- **atrium**: Latin = entrance hall, adjective - atrial.
- **atrophy**: Greek a = negative, and trophe = food, hence wasting from starvation.
- **auditory**: Latin audire = to hear, hence, pertaining to the ear.
- **auricle**: Latin auricula = a little ear.
- **auscultate**: Latin ausculto = to listen to, hence, auscultation, the act of listening to a bodily activity.
- **autonomic**: adjective, Greek auto = self, and nomos = law, hence self-regulating.
- **axilla**: Latin armpit.
- **axis**: Latin axis = the central line of a body or part thereof, especially the imaginary line around which rotation takes place.
- **axon**: Latin axis = axis, hence the main process of a neuron conducting impulses away from the cell body.
- **azygos**: adjective, Greek a = negative, and zygos = paired, hence, unpaired.
- **basilar**: adjective, Latin basis = base.
- **basilic**: adjective, Arabic al-basilik = inner; the basilic vein is on the inner side of the forearm and arm. Previously thought to be of Greek origin, basilikos = royal (king-sized).
- **biceps**: Latin bis = double, and caput = head, hence 2-headed, adjective - bicipital.
- **bifid**: adjective, Latin bis = double, and findo = to split.
- **bifurcate**: Latin bis = double, and furco = fork, hence to divide into two.
- **bilateral**: Latin bi = two, lateral = side, hence, pertaining to two (both) sides.
- **bipennate**: adjective, Latin bis = double, and pinna = feather, hence converging from 2 sides.
- **body**: the main part.
- **border**: see margin.
- **brachiocephalic**: Latin brachium = arm, and Greek kephale = head, hence a blood vessel related to the upper limb and head.
- **brachium**: Latin = arm, adjective - brachial.

- **branchia**: Greek = gills, adjective - branchial.
- **bregma**: from a Greek word implying moist, referring to the site of the anterior fontanelle (q.v.), a little fountain, the site of junction of the coronal and sagittal sutures, where the brain can be felt pulsating in infancy.
- **brevis**: Latin = short - cf. brief.
- **bronchiole**: diminutive of bronchus, hence a small bronchus (bronchi have cartilage in their walls, bronchioles have no cartilage).
- **bronchus**: derivation unhelpful - a branch of the trachea, adjective - bronchial.
- **buccal**: adjective, Latin bucca = cheek.
- **buccinator**: Latin = trumpeter - hence the muscle which blows air out from the cheek under pressure.
- **bulbus**: Latin = bulb or onion.
- **bulla**: Latin = bubble.
- **bursa**: Greek = a purse, hence a flattened sac containing a film of fluid.
- **caecum**: Latin = blind.
- **calcaneus**: Latin calx = heel, hence the bone of the heel.
- **calcar**: Latin = a spur.
- **calcar avis**: Latin the spur of a bird, hence a spur-like elevation.
- **calcarine**: Latin calcar = spur, hence spur-shaped.
- **calf**: the soft tissue swelling at the back of the leg.
- **calix**: Latin = a wine-cup (plural - calices).
- **callosum**: Latin callum = hard.
- **calvaria**: Latin calva = bald head, hence the part of the skull containing the brain - i.e. cranium minus the facial skeleton.
- **calyx**: Latin = a wine-cup (plural - calyces).
- **canal**: Latin canalis = a water-pipe or canal.
- **canaliculus**: diminutive of canal.
- **cancellous**: adjective, Latin cancelli = grating or lattice.
- **canine**: adjective, Latin canis = dog.
- **canthus**: Greek kanthos - used at first for rim of eye, then angle between ends of rims.
- **capillary**: Latin capillaris = hair-like, hence a very thin blood vessel.
- **capitate**: adjective, having a caput from Latin capitis = of a head (q.v.).
- **capitulum**: diminutive of caput, Latin = head.
- **capsule**: Latin capsa = box, hence an enclosing sheet.
- **caput**: Latin = head. Capitis - of a head, adjective - capitate = having a head (cf. decapitate).
- **caput medusae**: Latin caput = head, Medusa = Greek mythical female with snake like hair.
- **cardiac**: adjective, Greek kardia = heart.
- **cardinal**: Latin cardinalis = principal, of primary importance.
- **carina**: Latin = a keel.
- **carneae**: Latin carnea = fleshy.
- **carotid**: Greek karoo, to put to sleep (heavy sleep), because compression of the common or internal carotid artery may cause coma.

- **carpus**: Greek = wrist, adjective - carpal.
- **cartilage**: Latin = gristle; adjective - cartilaginous.
- **caruncle**: diminutive of Latin caro = flesh, hence, a small fleshy elevation.
- **cauda**: Latin = tail, adjective - caudate - having a tail.
- **cauda equina**: Latin = a horse's tail.
- **caudal**: Latin cauda = tail, hence toward the tail, inferior (in human anatomy).
- **caudate**: Latin cauda = tail, hence having a tail.
- **cava**: Latin cavum = cave, hollow.
- **cavernous**: Latin containing caverns or cave-like spaces.
- **cavity**: Latin cavitas = a hollow.
- **cavum**: Latin = cave.
- **cecum**: Latin = blind.
- **celiac**: adjective, Greek koilia = belly.
- **celom**: Greek koilos = a hollow
- **central**: adjective, Latin centrum = centre.
- **centrum**: Latin = centre.
- **cephalic**: adjective, Greek kephale = head. The term cephalic, as applied to the cephalic vein, was a mistranslation of Arabic and interpreted to be from the Greek term kephale = head. Arabic al-kifal = outer; the cephalic vein is on outer side of the forearm and arm (compare to basilic).
- **cerebellum**: diminutive of Latin cerebrum = brain.
- **cerebrum**: Latin = brain, adjective - cerebral.
- **cerumen**: Latin cera = wax.
- **cervical**: adjective, Latin cervix = neck, hence, pertaining to the neck.
- **cervix**: Latin = neck, adjective - cervical.
- **chiasma**: Greek kiasma = cross. (The Greek letter chi = c).
- **choana**: Greek = funnel, plural - choanae.
- **chondral**: adjective, Greek chondros = cartilage.
- **chorda**: Latin = cord.
- **choroid**: adjective, Greek chorion = skin and eidos = shape or form, hence, like a membrane.
- **chyle**: Greek = juice.
- **chyli**: Greek = juice.
- **ciliary**: adjective, Latin cilia = eyelashes.
- **cilium**: Latin = eyelid, hence, an eyelash; adjective - ciliary, or ciliated.
- **cinereum**: Latin cineris = of ashes.
- **cingulum**: Latin girdle or belt, adjective - cingulate.
- **circumflex**: verb and adjective, Latin circum = around, and flexere = to bend, hence, bend or bent around.
- **cisterna**: Latin = a cistern.
- **claustrum**: Latin clausum = closed, hence a barrier.
- **clavicle**: diminutive of Latin clavis = key - old Roman key was S-shaped.
- **cleido**: Greek, cleis = key, a combining form denoting relationship to the clavicle.
- **clinoid**: adjective, Greek kline = bed, eidos = shape or form, hence, like a bed-post.
- **clivus**: Latin = slope (cf. declivity).

- **cloaca**: Latin = a drain, sewer; common opening for intestinal, urinary and genital tracts in lower vertebrates, it is a transitory structure in human embryological development.
- **coccyx**: Greek kokkyx = cuckoo, whose bill the coccyx resembles.
- **cochlea**: Latin = snail, hence the spiral cochlea, adjective - cochlear.
- **coeliac**: adjective, Greek koilia = belly.
- **coeruleus**: adjective, Latin = blue, hence, locus coeruleus, a group of nerve cells in the rostral pons coloured blue or black by melanin.
- **coli**: Latin = of the colon.
- **collateral**: adjective, Latin con = together, and latus = side, hence, alongside.
- **colli**: genetive (possessive case) of collum, Latin = neck
- **colliculus**: diminutive of Latin collis = hill.
- **collum**: Latin = neck (cf. collar).
- **colon**: Greek kolon = large intestine.
- **columna**: Latin = column, or pillar.
- **comitans**: adjective, Latin = accompanying.
- **commissure**: Latin con = together, and missum = sent, hence fibres which cross between symmetrical parts.
- **communicans**: adjective, Latin = communicating.
- **concha**: Latin = shell.
- **condyle**: Greek kondylos = knuckle.
- **confluens**: Latin con = together, and fluens = flowing, hence the meeting of more than one stream.
- **conjunctiva**: Latin con = with, and junctus = joined (cf. junction), hence the continuous bulbar and palpebral lining membrane.
- **conoid**: Greek konoeides = resembling a cone, cone shape
- **constrictor**: Latin con = together, and strictum = drawn tight, hence, producing narrowing.
- **contour**: Greek tornos = lathe, hence a line which turns - an outline.
- **contralateral**: Latin contra = against, latus = side, hence, the opposite side (as opposed to ipsilateral)
- **conus**: Latin = cone, conus medullaris - the lower end of the spinal cord.
- **coracoid**: adjective, Greek korax = a crow, and eidos = shape or form, hence, like a crow's beak.
- **cornea**: Latin cornu = horn, hence, the dense tissue forming the front of the eyeball.
- **corniculate**: Latin = shaped like a small horn.
- **cornu**: Latin = horn.
- **corona**: Latin = crown. adjective - coronary or coronal; hence a coronal plane is parallel to the main arch of a crown which passes from ear to ear (cf. coronal suture).
- **coronal**: Latin corona = crown; hence a coronal plane is parallel to the main arch of a crown which passes from ear to ear (cf. coronal suture).
- **coronary**: adjective, Latin = crown, hence, encircling like a crown.
- **coronoid**: adjective, Greek korone = a crown, eidos = shape or form, hence, shaped like a crown.
- **corpus**: Latin = body, plural - corpora.

- **corpuscle**: Latin = a little body.
- **corrugator**: Latin con = together, and ruga = wrinkle, hence a muscle that produces wrinkles.
- **cortex**: Latin = bark, adjective, cortical.
- **costa**: Latin = rib. adjective - costal.
- **coxa**: Latin = hip, hence os coxae = the hip bone.
- **cranium**: Greek kranion = skull. (In anthropology = skull minus mandible) adjective - cranial.
- **cremaster**: Greek = suspender, hence the muscle which suspends the testis.
- **cribriform**: adjective, Latin cribrum = sieve, hence, sieve-like.
- **cricoid**: adjective, Greek krikos = ring, and eidos = shape or form, hence, ring-like, i.e. circular.
- **crista**: Latin = crest, crista galli = the (median) crest of a cock.
- **cruciate**: adjective, Latin crux = cross, hence, crossed like the letter X.
- **crus**: Latin = leg, plural - crura.
- **cubital**: adjective, Latin cubitus = elbow.
- **cuboid**: adjective, Greek kuboides = cube-shaped.
- **culmen**: Latin = summit (cf. culminate).
- **cuneate**: adjective, Latin = a wedge.
- **cuneiform**: adjective, Latin cuneus = wedge, hence wedge-shaped.
- **cuneus**: Latin = a wedge, adjective - cuneate.
- **cupola**: Latin = little dome.
- **cupula**: Latin = little dome.
- **cusp**: Latin cuspis = a pointed elevation.
- **cutaneous**: adjective, Latin cutis = skin.
- **cyst**: Greek kystis = bladder, adjective - cystic.
- **dartos**: Greek = flayed or skinned.
- **declive**: Latin declivitas = slope (cf. clivus).
- **decussation**: Latin decussatus = crossed like the letter X.
- **deep**: further from the surface.
- **deferens**: adjective, Latin = carrying down.
- **deglutition**: Latin deglutire = to swallow, hence the act of swallowing.
- **dehiscence**: Latin de = away, hiscere = to gape, hence, a separation, a splitting away.
- **deltoid**: adjective, Greek delta (D). The capital has a triangular shape (cf. the delta of the Nile river).
- **dendrite**: or dendron, Greek = a tree, hence like the branches of a tree.
- **dens**: Latin = tooth (cf. dentist), adjective - dental.
- **dentate**: Latin dens = tooth, hence, having a toothed margin.
- **denticulate**: Latin dens = tooth, hence, having small tooth-like projections.
- **dentine**: from Latin dens = tooth; the substance of the tooth surrounding the pulp.
- **depress**: Latin de = prefix implying descent, and pressum = pressed, hence to press down, and depression = downward movement or a concavity on a surface.
- **dermatome**: Greek derma = skin, tome = a cutting or division, hence a segment of skin supplied by a single spinal ganglion.
- **dermis**: Greek = skin, adjective - dermal.

- **detrusor**: Latin detrusio = thrust away.
- **diaphragm**: Greek dia = across, and phragma = wall, hence, a partition, adjective - diaphragmatic (see also phrenic).
- **diaphysis**: Greek dia = apart, and physis = growth, hence, the body of a long bone between the growing regions near the ends.
- **diastole**: Greek dia = apart, and stellein = sending, hence sending the walls of the heart apart, i.e. relaxation or dilatation. Adjective - diastolic.
- **diencephalon**: Greek dia = between, and enkephalos = brain, hence in general the structures surrounding the 3rd ventricle. adjective - diencephalic.
- **digastric**: adjective, Greek dia = double, and gaster = belly, hence, 2-bellied.
- **digit**: Latin digitus = a finger or toe, usually excepting the pollex (thumb) or hallux (big toe), adjective - digital.
- **diplopia**: Greek diploos = double, and opsis = vision, hence double vision.
- **diplo**: Greek = fold, hence the cancellous bone between the inner and outer tables of the skull, adjective - diploic.
- **discus**: Latin = disc.
- **dissection**: Latin disssecare = to cut up, from dis = apart, sectum = cut (c.f. anatomy).
- **distal**: adjective, Latin di = apart, and stans = standing, hence, standing apart, implying farther from a given point, usually the root of a limb.
- **diverticulum**: Latin = by-road, hence a blind tubular process or sac.
- **dorsal**: adjective, Latin dorsum = back.
- **dorsum**: Latin = back.
- **ductus**: Latin = duct.
- **duodenum**: Latin duodenarius = twelve, because it is 12 fingerbreadths long.
- **dura**: adjective, Latin = hard (cf. durable); dura mater, the tough covering membrane of the central nervous system.
- **dysphagia**: Greek dys = difficult, and phagein = to eat, hence, difficulty in swallowing.
- **ectoderm**: Greek ektos = outside, and derm = skin, hence, the outermost germ layer of the embryo.
- **ectopic**: Greek ek = out, and topos = place, hence out of place.
- **edge**: border or margin of a surface.
- **efferent**: adjective, Latin ex = out, and ferens = carrying, hence, conducting from.
- **ejaculatory**: Latin ex = out, and jacere = to throw, hence throwing out.
- **elbow**: the junction between arm and forearm.
- **elevate**: Latin elevatus = raised up, hence, to raise up, and elevation = a raised part.
- **emboliformis**: adjective, Greek embolus = wedge or blocking matter.
- **embryo**: Greek en = within, and bryein = to swell or grow, hence the early stage of intrauterine development.
- **eminence**: Latin eminens = projecting, hence, a projection (usually smooth).
- **emissary**: adjective, Latin e = out, and emissum = sent out; emissary vein, one connecting intra- with extra-cranial venous channels.
- **encephalon**: Greek en = within, and kephalos = head, hence, the brain.

- **endocardium**: Greek endo = within, and kardia = heart, hence, the endothelial lining of the chambers of the heart.
- **endocranium**: Greek endo = within, and kranion = skull, hence, the outer endostial layer of the dura mater.
- **endocrine**: Greek endo = within, and krinein = to separate, hence, the organs that ductlessly secrete their products into the bloodstream.
- **endoderm**: Greek endo = within, and derm = skin, hence, the germ layer of the embryo that gives rise to epithelium of the gastrointestinal and respiratory tracts.
- **endolymph**: Greek endo = within, and Latin lympha = clear water, hence the fluid within the membranous labyrinth of the internal ear.
- **endometrium**: Greek endo = within, and metra = uterus, hence the mucosal lining of the uterine cavity.
- **endothelium**: Greek endo = within, and thele = the nipple; the squamous epithelium lining the heart and blood vessels.
- **ependyma**: Greek = an upper garment. It may refer to a vest or singlet, i.e. an under-garment, hence, the lining membrane of the ventricles of the brain and central canal of the spinal cord.
- **epicanthus**: Greek epi = upon, and kanthos = corner, hence, the fold of skin over the inner angle of the upper eyelid, a normal characteristic in certain races, and a congenital anomaly in others.
- **epicardium**: Greek epi = upon, and kardia = heart, hence, the visceral layer of serous pericardium which covers the heart.
- **epicondyle**: Greek epi = upon, and kondylos = knuckle, hence a prominence on a condyle of the humerus or femur.
- **epicranial**: adjective, Greek epi = upon, and kranion = skull, hence, the epicranial aponeurosis (galea) connecting frontalis to occipitalis muscles.
- **epidermis**: Greek epi = upon, and derm = skin, hence, the most external layer of the skin.
- **epididymis**: Greek epi = upon, and didymos = testis, hence, the organ perched posterosuperior to the testis.
- **epidural**: adjective, Greek epi = upon, Latin dura = tough, hence, external to dura mater.
- **epigastrium**: Greek epi = upon, and gaster = belly, hence, the upper median zone of the abdomen.
- **epiglottis**: Greek epi = upon, and glottis = larynx, hence the uppermost part of the larynx.
- **epimysium**: Greek epi = upon, and mys = muscle, hence the connective tissue surrounding an entire muscle.
- **epiphysis**: Greek epi = upon, and physis = growth, hence, the end of a long bone beyond the cartilaginous growth disc, adjective - epiphysial.
- **epiploic**: adjective, Greek epiploon = a net, which the greater omentum resembles with fat entangled in it.
- **epithelium**: Greek epi = upon, and thele = the nipple; the cell layer lining the internal and external surfaces of the body.
- **erector**: Latin erectus = straight or upright.

- **erigentes**: plural, Latin erigere = to erect.
- **ethmoid**: adjective, Greek ethmos = sieve, and eidos = shape or form, hence, like a sieve; an unpaired skull bone.
- **eversion**: Latin e = out, and versum = turned, hence turned outwards.
- **exophthalmos**: Greek exo = out, and ophthalmos = eye, hence, prominent eyeball.
- **extend**: Latin extendo = extend or stretch out, hence, extension = extended or straightened; the position opposite to the flexed or bent.
- **external**: adjective, Latin externus = outward, hence, further from the inside.
- **extraperitoneal**: adjective, Latin extra = outside, Greek peri = around and teinein = stretched, hence outside the serous membrane stretched around the inside of the abdominal wall and around the viscera.
- **extrapyramidal**: Latin extra = outside, and pyramidal (q.v.), hence descending nerve tracts that do not traverse the pyramids of the medulla.
- **extrinsic**: Latin extrinsecus = from without, hence (usually) a muscle (usually) originating outside the part on which it acts.
- **fabella**: diminutive of Latin faba = a bean, hence, a sesamoid bone found in the lateral head of gastrocnemius.
- **facet**: Latin facies = face, hence a small smooth bony surface, either coated with articular cartilage or the site of a tendinous attachment (cf. a facet on a diamond).
- **facilitate**: Latin facilis = easy, hence, to make easy.
- **falciform**: adjective, Latin falx = a sickle, and forma = form, hence, shaped like a sickle.
- **falx**: Latin = sickle, hence, the sickle-shaped falx cerebri and falx cerebelli, adjective - falciform.
- **fascia**: Latin = band or bandage, hence the fibrous wrapping of muscles - deep fascia, or the subcutaneous layer of fatty connective tissue - superficial fascia, adjective, fascial.
- **fasciculus**: diminutive of Latin fascis = bundle, hence, a bundle of nerve or muscle fibres.
- **fastigius**: Latin fastigium = summit, hence the peak of the 4th ventricle, adjective - fastigial.
- **fauces**: Latin = throat, adjective - faucial.
- **femur**: Latin = thigh, adjective - femoral.
- **fenestra**: Latin = window.
- **fetus**: the developing mammal in utero; in Man, after the 2nd month in utero, adjective - foetal or fetal.
- **fibre**: Latin fibra = a fibre, adjective, Latin fibrosus = fibrous.
- **fibril**: diminutive of Latin fibra = a fibre.
- **fibula**: Latin = brooch, which the tibia and fibula resemble, the fibula representing the movable pin, adjective - fibular.
- **filament**: Latin filamentum = a delicate fibre, adjective - filamentous.
- **filum**: Latin = a thread. Filum terminale - a thread of pia continuous with the lower end of the spinal cord.
- **fimbria**: Latin = a fringe, hence, fimbria hippocampi, a scalloped band of fibres alongside the hippocampus.

- **fissure**: Latin = a cleft.
- **fixator**: Latin fixus = fixed, hence, a muscle which fixes a part.
- **flaccid**: adjective, Latin flaccidus = weak or slack.
- **flavum**: adjective, Latin flavus = yellow.
- **flex**: Latin flexum = bent, hence, flexor, a muscle which bends a part of the body, and flexion = the act of flexing.
- **flexure**: Latin flexura = a bending.
- **flocculus**: diminutive of Latin floccus, a tuft. Hence resembling a picture of a little cloud, with a woolly top and a flat base, as in flocculus cerebelli.
- **foetus**: the developing mammal in utero; in Man, after the 2nd month in utero, adjective - foetal or fetal.
- **folia**: plural of Latin folium = leaf.
- **follicle**: Latin folliculus = a little bag, adjective - follicular.
- **fontanelle**: French diminutive of Latin fons = fountain, associated with the palpable pulsation of the brain in the anterior fontanelle of an infant.
- **foramen**: Latin = hole.
- **forceps**: Latin = tongs.
- **forearm**: the upper limb between the elbow and the wrist.
- **fornix**: Latin = arch (hence fornication, because the Roman prostitutes plied their profession beneath the arches of the bridges over the river Tiber).
- **fossa**: Latin = a ditch or trench, hence a concavity in bone, or an organ, or on a lining surface.
- **fovea**: Latin = a pit (usually smaller than a fossa).
- **foveola**: diminutive of fovea.
- **frenulum**: diminutive of frenum.
- **frenum**: Latin = bridle or curb.
- **frontal**: adjective, Latin frontis = of the forehead, or coronal.
- **fundiform**: adjective, Latin fundus = bottom or base (cf. fundamental), hence, sling-shaped.
- **fundus**: Latin = bottom or base. (But note that the fundus of the stomach and uterus are at the top, and the fundus of the eye and of the bladder are posterior!).
- **funiculus**: diminutive of Latin funis = cord (used usually for bundles of nerve fibres).
- **fusiform**: adjective, Latin fusus = spindle, hence, spindle-shaped.
- **galea**: Latin = helmet, hence, galea aponeurotica - the aponeurosis of occipitofrontalis muscle.
- **galli**: genetive (possessive case) of Latin = cock, hence, crista galli, the cock's comb.
- **gallus**: Latin = cock, hence, crista galli, the cock's comb.
- **gamma**: the 3rd letter of the Greek alphabet, typically used in a naming sequence - alpha, beta, gamma, delta, etc.
- **ganglion**: Greek = swelling, referring to a peripheral collection of nerve cells, adjective - ganglionic.
- **gastric**: Greek gaster = belly or stomach.
- **gastro**: Greek gaster = belly or stomach.

- **gastrocnemius**: Greek gaster = belly, and kneme = leg, hence, the bulging muscle of the calf.
- **gelatinosa**: Latin gelatus = frozen.
- **gemellus**: Latin diminutive of geminus = twin.
- **genial**: adjective, Greek geneion = chin.
- **geniculate**: Latin geniculare = to flex the knee, hence, a bent knee.
- **geniculum**: Latin geniculare = to flex the knee, hence, a bent knee.
- **genital**: adjective, Latin genitalis = reproductive, hence, genitalia, the sexual organs.
- **genu**: Latin = knee.
- **gingiva**: Latin = gum (of tooth).
- **girdle**: a ring of bones which may be complete or incomplete.
- **glabella**: diminutive of Latin glaber = bald, hence a smooth bony prominence between the eyebrows.
- **gladiolus**: diminutive of Latin gladius = a sword, hence, hance a small sword, term applied to the body of the sternum.
- **gland**: Latin glans = an acorn, adjective - glandular; a secreting organ.
- **glandula**: diminutive of Latin glans = acorn.
- **glans**: Latin = acorn.
- **glenoid**: adjective, Greek glene = socket, and eidos = shape or form.
- **glia**: Greek = glue, hence, an adhesive connective tissue.
- **globus**: Latin = a globe.
- **glomerulus**: Latin glomerare = to roll up, from glomus = a ball of thread (cf. conglomeration).
- **glossal**: adjective, Greek glossa = tongue.
- **glottic**: adjective, Greek = larynx.
- **glottis**: Greek = larynx, hence, the boundaries of rima glottidis.
- **gluteal**: adjective, Greek gloutos = rump or buttock.
- **gluteus**: Greek gluteos = rump or buttock. One of 3 muscles of the buttock, adjective - gluteal.
- **gonad**: Greek = reproduction, hence a gland producing gametes - ovary or testis, adjective - gonadal.
- **gracile**: adjective, Latin gracilis = slender.
- **gracilis**: adjective, Latin = slender.
- **granulation**: diminutive of Latin granum = a grain.
- **gravid**: adjective, Latin gravida = pregnant.
- **griseum**: adjective, Latin griseus = bluish or pearly grey.
- **gubernaculum**: Latin something which governs or directs, like a rudder (cf. gubernatorial).
- **gustatory**: adjective, Latin gustatio = taste, hence, pertaining to the sense of taste.
- **gyrus**: Greek gyros = circle, hence a coil of brain cortex.
- **habenula**: diminutive of Latin habena = rein.
- **haemorrhoid**: Greek haima = blood, and rhoia = to flow, hence likely to bleed.
- **hallux**: Latin hallex = great toe (hallucis = of the great toe).
- **hamate**: adjective, Latin hamus = a hook, hence, hooked.

- **hamstrings**: the tendons of the muscles of the ham - i.e. of the back of the thigh - felt behind the knee when the leg is flexed against resistance (semimembranosus, semitendinosus and biceps femoris).
- **hamulus**: diminutive of Latin hamus = hook.
- **haustra**: Latin = saccules.
- **helicine**: Greek helix = a coil, spiral.
- **helicotrema**: Greek helix = a coil, and trema = hole, hence the aperture at the apex of the bony cochlea whereby scala vestibuli communicates with scala tympani.
- **helix**: Greek = coil.
- **hemianopia**: Greek hemi = half, an = negative, opsis = vision, hence loss of half of the field of vision.
- **hemianopsia**: Greek hemi = half, an = negative, opsis = vision, hence loss of half of the field of vision.
- **hemiparesis**: Greek hemi = half, paresis = paralysis, used usually to denote weakness rather than paralysis.
- **hemiplegia**: Greek hemi = half, plegia = stroke, hence, paralysis of one half of the body.
- **hemisphere**: Greek hemi = half, sphaira = ball, hence, half of a sphere.
- **hepar**: Greek = liver, adjective - hepatic.
- **hepatic**: adjective, Greek hepar = the liver.
- **hernia**: Latin = a protrusion, adjective - hernial.
- **hiatus**: Latin = a gap (like that between some people's ears).
- **hilum**: Latin = the point of attachment of a seed, hence the part of an organ where the vessels and nerves are attached; adjective - hilar.
- **hindbrain**: the part of the brain below tentorium cerebelli, comprising medulla oblongata, pons and cerebellum.
- **hip**: the lateral prominence of the hip bone and greater trochanter.
- **hippocampus**: Greek hippokampos = a sea-horse, hence, the curled shape of the hippocampus in coronal section; adjective - hippocampal.
- **homologous**: adjective, Greek homos = same, and logos = word, hence a part with similar morphology but different function.
- **horizontal**: adjective - parallel to the horizon.
- **horn**: a projection, often pointed.
- **humerus**: Latin = the arm-bone.
- **humour**: Latin humor = liquid, hence the aqueous and vitreous humour of the eyeball.
- **hyaline**: adjective, Greek hyalos = glassy.
- **hydrocephalus**: Greek hydor = water, koilos = head. (cf. cephalic).
- **hymen**: Greek = membrane; across the virginal vagina.
- **hyoid**: adjective, Greek = U-shaped.
- **hyperacusis**: Greek hyper = over, and akousis = hearing, hence excessive sensitivity to sound.
- **hypoglossal**: adjective, Greek hypo = under, and glossa = tongue.

- **hypophysis**: Greek hypo = down, physis = growth, hence, a downgrowth (from the brain). However, this is not the whole truth. Part is an upgrowth from the pharynx, adjective - hypophysial.
- **hypothalamus**: Greek hypo = under, and thalamus (q.v.), refers to part of diencephalon.
- **ileum**: Greek eilein = twisted. adjective - ileal.
- **ilium**: Latin the bone of the flank, adjective - iliac.
- **ima**: adjective, Latin = lowest, hence artery thyroidea ima.
- **impar**: Latin = unpaired.
- **incisor**: Latin incisum = cut up.
- **incisura**: Latin = notch.
- **incus**: Latin = anvil, hence the anvil-shaped ossicle of the middle ear.
- **index**: Latin = a pointer, hence, the fore-finger.
- **indicis**: genitive of Latin index = a pointer, hence, of the fore-finger.
- **indusium**: Latin = tunic.
- **inferior**: adjective, Latin = lower down, hence, farther from the head end.
- **infra**: Latin = below.
- **infundibulum**: Latin = funnel.
- **inguinal**: adjective, Latin inguen = groin.
- **inhibition**: Latin inhibitus = restrained, hence, reduction of the excitability of a synapse.
- **innervate**: Latin in = into, and nervus = nerve, hence, to supply a nerve to a part.
- **innominate**: Lain in = not, and nomen = name, hence, without a name.
- **insert**: Latin insertio = to join into, implant, hence, to attach; noun - insertion.
- **inspection**: Latin inspectus = examined, hence, visual examination.
- **insula**: Latin = island.
- **integument**: Latin in = on, tegmen = roof, hence the skin coat.
- **intercalated**: adjective, Latin inter = between, and calatum = inserted, hence interposed.
- **interdigitate**: Latin inter = between, and digitus = a digit. Hence, to interlock like fingers.
- **internal**: adjective, Latin internus = inward, hence, nearer the inside.
- **internuncial**: adjective, Latin inter = between, nuncius = messenger.
- **interstitial**: adjective, Latin inter = between, and sistum = set, hence, set between.
- **intestine**: Latin intestinum = the digestive tube beyond the stomach.
- **intima**: Latin = innermost.
- **intra**: Latin = within.
- **intrafusal**: adjective, Latin intra = within, fusus = spindle.
- **intrinsic**: adjective, Latin = on the inside.
- **introitus**: Latin intro = within, and ire = to go, hence, an orifice or point of entry to a cavity or space.
- **inversion**: Lain in = in, and vertere = to turn, hence to turn inward, inside out, upside down.
- **ipsilateral**: Latin ipsi = self, the same, and latus = side, hence on the same side.
- **iris**: Latin = a rainbow.

- **ischium**: Greek ischion = socket, because the ischium contributes more than either the ilium or pubis to the acetabulum.
- **iso**: Greek = equal.
- **isthmus**: Greek isthmos - a narrow passage.
- **jejunum**: Latin jejunus = empty, adjective - jejunal.
- **joint**: the meeting of 2 or more bones or cartilages, at which movement is possible.
- **jugular**: adjective, Latin jugulum = neck.
- **jugum**: Latin = yoke (cf. conjugal).
- **juxta**: Latin = near.
- **keratin**: Greek keras = horn.
- **kinocilium**: Greek kineo = to move (cf. kinetic), and cilium Latin = eyelash, hence protoplasmic thread of hair process in cupula of crista ampullaris of a semicircular duct.
- **knee**: the junction of the thigh and the leg.
- **koniocortex**: Greek konis = dust, and Latin cortex = bark, hence, sensory cortex containing mostly granular layers.
- **kyphosis**: Greek kyphos = bent or bowed forward.
- **labium**: Latin = lip (plural labia), adjective - labial.
- **labrum**: Latin = rim.
- **labyrinth**: Greek labyrinthos = maze, adjective - labyrinthine.
- **lacerum**: Latin lacer = mangled, hence, lacerated, torn.
- **lacrimal**: adjective, Latin lacrima = a tear (drop).
- **lactation**: Latin lactans = suckling. Hence, the act of secreting milk.
- **lacteal**: adjective, Latin lac = milk, hence, resembling milk.
- **lactic**: adjective, Latin lac = milk.
- **lactiferous**: adjective, Latin lac = milk, and ferre = to carry.
- **lacuna**: Latin lacus = lake, hence, a small pond or gap, adjective, lacunar.
- **lambda**: Greek letter representing a capital 'L' and written as an inverted V.
- **lambdoid**: adjective, Greek lambda, representing a capital 'L' and written as an inverted V; hence, like that letter.
- **lamella**: diminutive of Latin lamina = plate; hence, a small plate.
- **lamina**: Latin = plate, either a layer of nervous tissue, like the laminae of the lateral geniculate body, or a connective tissue membrane, like lamina cribrosa sclerae, or of bone, as in vertebral laminae; hence, laminectomy = lamina + Greek ektome = excision - excision of the vertebral laminae to give access to the spinal cord; adjective - laminar.
- **lanugo**: Latin lana = wool, hence, the fine downy hair on the skin of the foetus, or cheeks.
- **larynx**: Greek = voice-box, adjective - laryngeal.
- **lata**: Latin latus = side.
- **lateral**: adjective, Latin latus = side, hence, nearer the side.
- **latissimus**: superlative of adjective, Latin latus = wide, hence, latissimus dorsi muscle, the widest muscle of the back; earlier name was anitersor - wiper of the anus.
- **leg**: the lower limb between the knee and the ankle.
- **lemniscus**: Greek lemniskos = a band or ribbon (applied to nerve fibres).

- **lens**: Latin = lentil - a transparent body with one or both surfaces curved to re-direct light rays, adjective - lentiform or lenticular.
- **lentiform**: adjective, Latin lens = lentil, and forma = shape, hence, lentil-shaped.
- **leptomeninx**: Greek lepto = delicate, and meninx = membrane. Usually refers to pia and arachnoid. Plural leptomeninges.
- **levator**: Latin = elevator.
- **lien**: Latin = spleen, adjective - lienal.
- **ligament**: Latin ligamentum = bandage, usually tying parts to each other, adjective - ligamentous.
- **limbic**: adjective, Latin limbus = a margin, usually curved.
- **limbus**: Latin = a margin, usually curved, hence, limbus of cornea, its circular junction with the sclera, adjective - limbic; limbic lobe of the brain comprises structures which encircle the junction of the diencephalon and telencephalon.
- **limen**: Latin = a threshold, hence, subliminal - below threshold.
- **linea**: Latin = line.
- **lingua**: Latin = tongue, adjective, lingual.
- **lingula**: diminutive of lingua, hence, a little tongue, adjective - lingular.
- **lissencephalic**: adjective, Greek lissos = smooth, hence, a cerebrum lacking sulci.
- **lobule**: diminutive of lobus.
- **lobulus**: Latin diminutive of lobus, hence, a lobule.
- **lobus**: Greek lobos = lobe, adjective - lobar.
- **locus**: Latin a place (cf. location, locate, dislocate).
- **loin**: Latin lumbus - the part of the back between the ribs and the hip bone.
- **longissimus**: superlative of Latin longus = long, hence, the longest.
- **longitudinal**: adjective, Latin longitudo = length, hence, lengthwise.
- **longus**: adjective, Latin = long, hence, longissimus (superlative) = the longest.
- **lucidum**: Latin lucidus = clear.
- **lumbar**: adjective - see loin.
- **lumbrical**: Latin lumbricus = worm, hence worm-shaped muscles of the palm.
- **lumen**: Latin = opening, hence the space within a tube.
- **lunate**: adjective, Latin luna = moon, hence, crescentic.
- **luteum**: adjective, Latin = yellow.
- **lymph**: Latin lympha - clear spring water.
- **lymphatic**: a vessel carrying lymph.
- **macroscopic**: adjective, Greek makros = large, and skopein = to examine; hence, large enough to be seen with the naked eye, e.g., pertaining to gross anatomy.
- **macula**: Latin = spot (cf. immaculate - spotless); adjective - macular.
- **magna**: Latin = great.
- **malleolus**: diminutive of Latin malleus = hammer, adjective - malleolar.
- **malleus**: Latin = a hammer.
- **mamma**: Latin = breast; adjective - mammary.
- **mammilla**: diminutive of mamma; adjective - mammillary.
- **mandible**: Latin mandere = to chew; hence, the movable lower jaw; adjective - mandibular.
- **manubrium**: Latin = handle; adjective - manubrial.

- **manus**: Latin = hand (cf. manual).
- **margin**: the edge or border of a surface; adjective - marginal.
- **masseter**: Greek = chewer; adjective - masseteric.
- **mastication**: Latin masticere = to chew.
- **mastoid**: adjective, Greek mastos = breast or teat, and eidos = shape or form.
- **matrix**: Latin = a female animal used for breeding, womb; refers to ground substance of connective tissue, and nail bed.
- **maxilla**: Latin = jaw-bone; now used only for the upper jaw; adjective - maxillary.
- **meatus**: Latin = passage; adjective - meatal.
- **medial**: adjective, Latin medius = middle; hence, nearer the median plane.
- **median**: Latin medianus = in the middle.
- **mediastinum**: derivation doubtful, but possibly from Latin medius = middle, and stans = standing; hence, a median vertical partition, adjective - mediastinal.
- **medius**: Latin = middle.
- **medulla**: Latin = marrow; applied to part of an organ deep to its cortex, and to the spinal cord and adjoining part of brain stem, which may have been thought to be the marrow of the vertebral column, adjective - medullary pertains to the medulla of an organ or medulla oblongata.
- **membrane**: Latin membrana = a thin sheet; adjective - membranous.
- **meninges**: plural of Greek meninx = a membrane; adjective - meningeal.
- **meniscus**: Latin menis - a small crescent.
- **mental**: adjective - Latin mentum = chin; or Latin mens = mind.
- **mesencephalon**: Greek mesos = middle, and enkephalos = brain; adjective - mesencephalic.
- **mesenchyme**: Greek mesos = middle, and chymos = juice; the embryonic connective tissue of the mesoderm.
- **mesentery**: Greek mesos = middle, and enteron = intestine; hence, the peritoneal fold which tethers the centrally situated small intestine; adjective - mesenteric.
- **mesial**: adjective - medial, used in dental anatomy.
- **mesoderm**: Greek mesos = middle, and derma = skin; the middle germ layer of the embryo.
- **mesosalpinx**: Greek mesos = middle, and salpinx = tube; hence, the intermediate part of the broad ligament.
- **metacarpus**: Greek meta = after, and karpus = wrist; adjective - metacarpal.
- **metaphysis**: Greek meta = after, and physis = growth; hence, the end of the shaft of a bone alongside the epiphysial or growth cartilage; adjective - metaphysial.
- **metatarsus**: Greek meta = after, and tarsos = ankle; hence, the bones beyond the tarsus, adjective - metatarsal.
- **metencephalon**: Greek meta = beside, behind, or after, and enkephalos = brain; hence the parts of the hindbrain immediately caudal to the fore- and midbrain, namely the pons and cerebellum.
- **metopic**: adjective, Greek metopon = forehead.
- **micturition**: Latin micturare = to desire to pass urine.
- **minimus**: Latin = smallest.
- **miosis**: Greek meiosis = lessening; hence, pupillary constriction; adjective - miotic.

- **modality**: Latin modus = mode; hence, a form of sensation - e.g. touch, pain, sight.
- **modiolus**: Latin a cylindrical borer with a serrated edge; hence, like a screw; the central stem of the bony cochlea.
- **molar**: adjective, Latin mola = mill.
- **mons**: Latin = mountain; mons pubis, the soft tissue bulge over the female pubes.
- **morphology**: Greek morphos = form, and logos = word or relation; hence, study of pattern of structure; adjective - morphological.
- **multifidus**: Latin multus = much, and findere = to split.
- **muscle**: Latin musculus, diminutive of Greek mus = mouse, the body and head of which represent the main belly of a muscle, and the tail, the tendon.
- **mydriasis**: Greek = dilatation of the pupil.
- **myelencephalon**: Greek myelos = marrow (= Latin medulla), and enkephalos = brain; hence the medulla oblongata. See also medulla.
- **myelin**: Greek myelos = marrow; hence, white fatty sheath of an axis cylinder; adjective - myelinated.
- **myenteric**: Greek mys = muscle, and enteron = intestine, hence, pertaining to the muscle of the gut.
- **mylohyoid**: Greek mylo = molar, and hyoeides = U-shaped.
- **myocardium**: Greek mys = muscle, and kardia = heart, adjective - myocardial.
- **myotome**: Greek mys = muscle, and tome = a cutting or division; hence, a group of muscles innervated by a single spinal segment.
- **nares**: plural, Latin naris = nostril.
- **naris**: Latin = nostril, plural - nares.
- **nasal**: adjective, Latin nasus = nose; hence, pertaining to the nose.
- **natal**: adjective, Latin natus = born; hence, relating to birth.
- **navicular**: adjective, Latin navicula = a little ship (cf. naval); hence, the tarsal bone which is concave posteriorly, resembling a boat.
- **neo-**: Greek prefix - neos = new.
- **neonatal**: adjective, Greek neos = new, and Latin natos = born; hence, new-born.
- **neopallium**: Greek neos = new, and Latin pallium = cloak; hence, the cerebral cortex which developed more recently than the archipallium or olfactory cortex.
- **nerve**: Latin nervus = tendon; later reserved for a peripheral bundle of fibres which conduct impulses from or to the central nervous system.
- **neural**: adjective, Greek neuron = nerve.
- **neuroglia**: Greek neuron = nerve, and gloia = glue; hence, the connective tissue of the central nervous system; adjective - neuroglial.
- **neurohypophysis**: or posterior lobe of hypophysis - Greek hypo = down, and physis = growth; hence, the posterior part of the hypophysis evaginated downwards from the diencephalon, and its stalk.
- **neurolemma**: Greek neuron = nerve, and lemma = peel or rind; hence, the covering layer of a nerve.
- **neuron**: Greek = nerve; refers to the nerve cell body, with its axon and dendrites; adjective - neuronal.
- **nigra**: Latin niger = black, dark.
- **node**: Latin nodus = knot.

- **nodule**: diminutive of Latin nodus = knot, hence, a little knot.
- **norma**: Latin = pattern or rule, or aspect; adjective, normal - according to rule.
- **notch**: an indentation in the margin of a structure. Etymology uncertain.
- **notochord**: Greek notos = back, and chorde = cord; hence, the primitive axial skeleton around which the vertebrae develop, parts persisting in the nuclei pulposi.
- **nucha**: French nuque = nape or back of the neck; adjective - nuchal.
- **nucleus**: Latin = kernel or nut; may refer to the vital centre of a cell body, or to a cluster of neuron cells in the central nervous system; adjective - nuclear.
- **nystagmus**: Greek = drowsiness, to nod, hence, involuntary, rapid, rhythmic eye movements.
- **obex**: Latin = barrier; hence, the coronal fold of ependyma over the lower angle of the 4th ventricle.
- **oblique**: adjective, Latin obliquus; slanting, or deviating from the perpendicular or the horizontal.
- **oblongata**: Latin oblongus = oblong; medulla oblongata.
- **obturator**: Latin obturatus = stopped up; hence, a structure which closes a hole.
- **occiput**: Latin ob = prominent (cf. obvious), and caput = head; hence, the prominent convexity of the back of the head; adjective - occipital.
- **occlusion**: Latin occlusum = closed up; hence, apposition of reciprocal teeth, or the blocking of any tubular structure; adjective - occlusal.
- **oculomotor**: Latin oculus = eye, and movere = to move, hence, pertaining to moving the eye.
- **oculus**: Latin = eye.
- **odontoid**: Greek odous = tooth, and eidos = form, shape, hence, tooth-like.
- **oesophagus**: Greek = gullet (passage from pharynx to stomach); adjective - oesophageal.
- **olecranon**: Greek olene = ulna, and kranion = upper part of head; hence, the upper end of the ulna.
- **olfactory**: adjective, Latin olfacto = smell.
- **olive**: Latin oliva - the oval fruit of the olive tree; oval eminence on medulla oblongata; adjective - olivary.
- **omentum**: Latin = apron; adjective - omental.
- **omohyoid**: Greek omos = shoulder; hence, a muscle attached to the scapula and hyoid.
- **operculum**: Latin = lid or cover; hence, operculum insulae, the cerebral cortex covering and hiding the insula (the 5th lobe of cerebral cortex).
- **ophthalmic**: adjective, Greek ophthalmos = eye.
- **opponens**: Latin = placing against, opposing.
- **oppose**: Latin oppositum = put against; hence, to resist or place in contact with, and opposition - the action of opposing.
- **optic**: adjective, Greek optos = seen; hence, pertaining to sight.
- **ora**: Latin ora = margin or edge.
- **ora serrata**: Latin ora = margin, and serra = saw; hence, the serrated anterior edge of the functional part of the retina.
- **oral**: Latin oris = a mouth, hence, pertaining to the mouth.

- **orbit**: Latin orbis = circle; the name given to the bony socket in which the eyeball rotates; adjective - orbital.
- **orifice**: Latin orificium = opening.
- **os, oris**: Latin os = mouth; plural - ora, adjective - oral.
- **os, ossis**: Latin os = bone; plural - ossa, adjective - osseous.
- **ossicle**: Latin ossiculus, diminutive of os = bone.
- **ossify**: Latin os = bone, and facio = make; hence, to form bone; and ossification, the process of bone formation.
- **osteology**: Greek osteon = bone, and logy = a field of study.
- **ostium**: Latin = a door, an opening, an orifice.
- **otic**: adjective, Greek otos = ear.
- **otolith**: Greek otos = ear, and lithos = stone; hence, calcareous particles in the utricle and saccule of the membranous labyrinth.
- **ovary**: Latin ovum = egg; hence, the organ containing ova (the largest cells in the female).
- **ovum**: Latin = egg, plural - ova.
- **pachymeninx**: Greek pachys = thick, and meninx = membrane; hence, the thick membrane covering the central nervous system, i.e., dura mater.
- **palaeo**: Greek palaios = old; hence, palaeocerebellum, the earliest stage in the evolution of the cerebellum.
- **palate**: Latin palatum = palate, adjective - palatal or palatine.
- **paleo**: Greek palaios = old; hence, paleocerebellum, the earliest stage in the evolution of the cerebellum.
- **pallidus**: adjective, Latin = pale.
- **pallium**: Latin = cloak; hence, the cerebral cortex forming the outer covering of the cerebral hemisphere.
- **palma**: Latin palma = palm; adjective, palmar - Latin palmaris.
- **palpate**: Latin palpare = to touch, and palpatus = touched; hence, to examine by feeling, and palpation, such an examination.
- **palpebra**: Latin = eyelid, probably from palpitare = to flutter.
- **pampiniform**: adjective, Latin pampinus = tendril, and forma = shape.
- **pancreas**: Greek = sweetbread, derived from Greek pan = all, and kreas = flesh; adjective - pancreatic.
- **panniculus**: diminutive of Latin pannus = cloth.
- **papilla**: Latin = nipple or teat; adjective - papillary.
- **paradidymis**: Greek para = beside of near, and didymis = twinned or paired, refers to testes; hence the collection of convoluted tubules in the spermatic cord, above the head of the epididymis.
- **paraesthesia**: Greek para = beside, and aisthesia = sensation; hence, abnormal sensation, usually burning or pricking.
- **paralysis**: Greek para = beside, near, lyein = to loosen; hence loss or impairment of muscle function.
- **parametrium**: Greek para = beside, and metra = womb; hence, connective tissue alongside the body of the uterus, within the broad ligament.

- **paraplegia**: Greek para = beside, and plege = a stroke; hence, paralysis of the lower limbs.
- **pararenal**: adjective, Greek para = beside, Latin ren = kidney; hence, beside the kidney, e.g., pararenal fat, the fatty capsule of the kidney.
- **parasternal**: adjective, Greek para = beside, and sternon = chest; hence, the parasternal line is a vertical line about midway between the sternal edge and the midclavicular line.
- **parasympathetic**: adjective, Greek para = beside, syn = with, and pathos = feeling; hence, the division of the autonomic nervous system complementary to the sympathetic system.
- **parathyroid**: adjective, Greek para = beside, and thyroid; hence, beside the thyroid gland.
- **parenchyma**: Greek para = beside or near, en = in, and chein = to pour; hence a general term to designate the functional elements of an organ, as opposed to the framework or stroma.
- **paresis**: Greek = relaxation, but has come to mean partial paralysis.
- **parietal**: adjective, Latin parietalis, pertaining to paries = wall.
- **parotid**: adjective, Greek para = beside, and otos = of the ear; hence, beside the ear.
- **parous**: adjective, Latin pario = I bear (children); hence, adjective, applied to woman who has borne one or more children (cf. nulliparous, multiparous).
- **pars**: Latin = part.
- **patella**: Latin a small pan; adjective - patellar.
- **pecten**: Latin = comb.
- **pectinate**: adjective, from Latin pecten = a comb; applied to structures having the appearance of parallel teeth arising from a straight back (musculi pectinati), or the sellar appearance of the superior pubic ramus, which may have resembled the body of antique combs.
- **pectineal**: adjective, from Latin pecten = a comb; applied to structures having the appearance of parallel teeth arising from a straight back (musculi pectinati), or the sellar appearance of the superior pubic ramus, which may have resembled the body of antique combs.
- **pectineus**: Latin, pecten = a comb; hence the muscle attaching to the pecten (pectineal line) of the pubic bone.
- **pectoral**: adjective, Latin pectoris = of the front of the chest.
- **pectoralis**: adjective, Latin pectoris = of the front of the chest.
- **pedicle**: diminutive of Latin pedis = of the foot.
- **pedis**: Latin = of the foot.
- **peduncle**: variation of pedicle.
- **pellucidum**: adjective, Latin per = through, and lucere - to shine; hence, translucent.
- **pelvis**: Latin = basin, adjective - pelvic.
- **penis**: Latin = tail, the male organ of copulation (cf. appendix, appendage).
- **pennate**: Latin penna = feather; hence, a muscle whose fibres approach the tendon from one direction is unipennate; from two, bipennate, and from more than two, multipennate.

- **pennatus**: (pinnate) - adjective, Latin penna = feather; hence, a muscle whose fibres approach the tendon from one direction is unipennate; from two, bipennate, and from more than two, multipennate.
- **perianal**: adjective, Greek peri = around, and Latin anus = lower opening of alimentary canal.
- **pericardium**: Greek peri = around, and kardia = heart; hence, the membranes enclosing the heart.
- **perichondrium**: Greek peri = around, and chondros = cartilage; hence, the membrane covering cartilage.
- **pericranium**: Greek peri = around, and kranion = skull; hence, the external periosteum of the skull.
- **perilymph**: Greek peri = around, and lympha - Latin = clear water; hence, the fluid in the bony labyrinth surrounding the membranous labyrinth (and continuous with the cerebrospinal fluid).
- **perineum**: Greek the caudal aspect of the trunk between the thighs, or, the region of the trunk below the pelvic diaphragm; adjective - perineal.
- **periodontal**: adjective, Greek peri = around, and odont = tooth.
- **periosteum**: Greek peri = around, and osteon = bone; hence, the membrane around a bone.
- **peripheral**: adjective, Greek peri = around and phero = carry; hence, away from the centre (cf. periphery).
- **peristalsis**: Greek peri = around, and stellein - to constrict; hence, a circular constriction passing as a wave along a tube; adjective - peristaltic.
- **peritoneum**: Greek periteino = to stretch around; hence, the membrane stretched around the internal surface of the walls and the external aspect of some of the contents of the abdomen; adjective - peritoneal.
- **peroneal**: adjective, Greek perone = clasp, brooch - see fibula.
- **pes**: Latin = foot.
- **petrosal**: adjective, Latin petrosus = rocky.
- **petrous**: adjective, Latin petrosus = rocky.
- **phalanx**: Latin = row of soldiers; hence, one of the small bones of a digit, plural - phalanges, adjective - phalangeal.
- **phallus**: Greek phallos = penis.
- **pharynx**: Greek = throat; adjective - pharyngeal.
- **philtrum**: Greek philtron - the median sulcus of the upper lip. Derivation doubtful.
- **phonation**: Greek phone = sound or voice; hence, the production of either.
- **phrenic**: Greek phren = diaphragm or mind; hence, diaphragmatic (cf. schizophrenic).
- **pia**: Latin = faithful, hence, the membrane which faithfully follows the contour of the brain and spinal cord.
- **pilomotor**: Latin pilus = a hair, and movere = to move; hence the action of the arrectores pilorum muscles.
- **pilus**: Latin = a hair.
- **pineal**: adjective, Latin pinea = a pine cone; hence, the pineal gland which is cone-shaped.

- **piriform**: adjective, Latin pirum = a pear; hence, pear-shaped.
- **pisiform**: adjective, Latin pisum = a pea; hence, pea-shaped.
- **pituitary**: Latin pituita = mucous or phlegm, the gland was thought to produce mucous that discharged through the nose.
- **placenta**: Latin = a flat, round cake.
- **placode**: Greek plax = plate or flat, and eidos = shape or form.
- **plane**: Latin planus = flat; hence, a real or imaginary flat surface.
- **planta**: Latin the sole of the foot; adjective - plantar or plantaris.
- **plantar**: adjective, Latin planta = the sole of the foot.
- **platysma**: Greek = flat object; hence, the flat subcutaneous muscle extending from below the clavicle to the mouth.
- **pleura**: Greek = a rib. Later used to name the serous membrane lining the chest walls and the lung on each side.
- **plexus**: Latin = a network or plait.
- **plica**: Latin plicare = to fold; hence, a fold.
- **pneumon**: Greek pneuma = air.
- **pollex**: Latin = thumb.
- **pollicis**: genitive (possessive case) of Latin pollex = thumb; hence of the thumb.
- **pons**: Latin = bridge; adjective - pontine; part of the brain stem.
- **popliteus**: Latin poples = the ham or thigh, and sometimes, the knee; adjective, popliteal, referring to the fossa behind the knee or its contents.
- **porta**: Latin = a gate, also Latin portare = to carry; hence, the portal system carries venous blood from the alimentary tract to the porta hepatis; adjective - portal.
- **porus**: Latin a pore or foramen; hence, the openings of the acoustic meatuses.
- **posterior**: adjective, Latin post = behind (in place or time).
- **posture**: Latin positus = placed; hence, the position of the body as a whole at a given moment, e.g. erect, recumbent, prone, supine, sitting, kneeling.
- **precuneus**: Latin pre = before, and cuneus = wedge; hence, the parietal lobule anterior to the cuneus.
- **prepuce**: Latin praeputium = foreskin (of penis or clitoris).
- **princeps**: Latin primus = chief, and capere = to take; hence chief or principal.
- **procerus**: Latin = slender, elongated; hence, the vertical slip of muscle between the medial part of frontalis and the root of the nose.
- **process**: Latin = going forwards, used to indicate growing out, i.e., an outgrowth, usually of bone, e.g., the zygomatic process of the temporal.
- **processus**: Latin going forwards, used to indicate growing out, i.e., an outgrowth, usually of bone, e.g., the zygomatic process of the temporal.
- **profundus**: Latin pro = before, and fundus = bottom; hence profundus = deep.
- **prominens**: Latin = projecting.
- **promontory**: Latin promontorium = a headland, i.e., part of land jutting into the sea - used for a bony prominence.
- **pronate**: Latin pronatus = bent forwards; hence to pronate = to turn the hand so that the palm faces posteriorly.
- **prone**: Latin pronatus = bent forwards; hence, recumbent face-down posture.

- **proprioceptive**: Latin proprius = one's own, and captum = taken; hence, sensory impulses received by the joints and muscles within one's own body.
- **prosection**: Latin pro = before, and sectum = cut. A dissection prepared for demonstration of anatomic structures.
- **prosector**: Latin pro = before, and sectum = cut. One who prepares a dissection for demonstration.
- **prosencephalon**: Latin pro = in front, and Greek enkephalos = brain; hence, the part of the brain rostral to the midbrain.
- **prostate**: Greek pro = before, and Latin = statum = stood; hence, something which stands before - the prostate stands before the urinary bladder.
- **protract**: Latin protractus = drawn out; hence, to put forwards (e.g., shoulder or mandible). Protraction - the act of protracting.
- **protrude**: Latin protrudo = thrust forwards, e.g. the tongue; protrusion - the act of protruding.
- **protuberance**: Latin protubero = I bulge out; hence, a bulging bony feature (see tuber).
- **proximal**: adjective, Latin proxime = nearest; hence, nearer to the root of a limb.
- **psoas**: Greek = loin.
- **pterion**: Greek pteron = wing; hence, the region where the tip of the greater wing of the sphenoid meets or is close to the parietal, separating the frontal from the squamous temporal; alternatively the region where these 4 bones meet.
- **pterygoid**: adjective, Greek pteryx = wing, and eidos = shape; hence, wing-shaped.
- **ptosis**: Greek = fall; hence, drooping of an eyelid, or descent of an internal organ.
- **puberty**: Latin puber = adult; hence, the time when hair appears in the pubic region - i.e., near the pubis - as a secondary sexual characteristic.
- **pubes**: Latin = adult or signs of manhood, hence the lower abdominal secondary sexual hair.
- **pubis**: Latin pubes (see pubes)
- **pudendal**: adjective, Latin pudendus = shameful; hence, pertaining to the external genitalia.
- **pulmonary**: adjective, Latin pulmo = lung.
- **pulp**: Latin pulpa = a soft part of the body or tooth.
- **pulposus**: Latin pulpa = a soft part of the body or tooth, hence pulpy or soft.
- **pulvinar**: Latin pulvinus = rounded cushion; the posterior end of the thalamus.
- **punctum**: Latin = a sharp point; hence a very small point or orifice.
- **pupil**: Latin pupilla = the central black orifice in the iris; adjective - pupillary.
- **putamen**: Latin = peel, husk or shell of fruit or seed (the external part of the lentiform nucleus).
- **pyelogram**: Greek pyelos = basin, and gramma = diagram; hence, radiograph of the renal pelvis (and usually of the ureter) after filling with contrast medium.
- **pylorus**: Greek = gate-keeper; hence, the part of the pyloric canal containing the sphincter, which guards the opening into the duodenum; adjective - pyloric.
- **pyramid**: Greek pyramis = a pyramid (solid with 3- or more-sided base, and flat sides meeting at the apex), adjective - pyramidal.
- **quadrangular**: Latin quadri = four and angulus = angle; hence square or rectangular.

- **quadratus**: Latin = square or rectangular.
- **quadriceps**: Latin quadri = four, and caput = head; hence, a 4-headed muscle.
- **quadrigeminus**: Latin quadri = four, and gemini = paired or twinned; hence four-fold.
- **radiation**: Latin radiatus = radiant; hence, divergence from a common centre (cf. radius).
- **radicle**: diminutive of Latin radix = root; hence a small root, adjective - radicular.
- **radius**: Latin = spoke of a wheel, which rotates around the hub; hence, the lateral bone of the forearm, which rotates (though around an almost vertical axis); adjective - radial.
- **radix**: Latin = root.
- **ramify**: Latin ramus = a branch; and facere = to make; hence, to branch.
- **ramus**: Latin = branch; hence, a branch of a nerve.
- **raphe**: Greek a seam; hence, the line of junction of the edges of 2 muscles or areas of skin.
- **recess**: Latin recessus = a secluded area or pocket; hence, a small cavity set apart from a main cavity.
- **rectum**: adjective, Latin rectus = straight. (The rectum was named in animals where it is straight - which it is not in Man).
- **rectus**: Latin rectus = straight.
- **recurrent**: Latin re = back, and currere = to run; hence a structure that bends, and runs back toward its source.
- **reflex**: an involuntary response - muscular or secretory - to a stimulus mediated by the central nervous system.
- **renal**: adjective, Latin ren = kidney.
- **rete**: Latin = a net; hence, a network of veins or tubules.
- **reticular**: adjective, Latin reticulum = small net; hence having a network.
- **reticulum**: diminutive of Latin rete = net; adjective - reticular.
- **retina**: derivation uncertain - the innermost of the 3 layers of the eyeball.
- **retinaculum**: Latin = a tether; hence, a thickened band of deep fascia which retains tendons or the patella.
- **retract**: Latin re = back, and tractum = pulled; hence, to pull something back, and retraction - the act of retracting.
- **retro**: prefix - Latin = backwards.
- **retroflexion**: Latin retro = backwards, and flexion = bent; hence, the position of being bent backwards, applied to the angulation of the body of the uterus on the cervix.
- **retroversion**: Latin retro = backwards, and version = turned; hence, the position of being turned backwards, applied to the angulation of the cervix uteri on the vagina.
- **rhinencephalon**: Greek rhinion = nostril, and enkephalos = brain; hence, the part of the brain concerned with smell (relatively large in lower animals).
- **rhombencephalon**: Greek rhombos = rhomboid, and enkephalos = brain; hence, the hind-brain - the medulla oblongata, pons and cerebellum, which enclose the rhomboid fossa (the floor of the 4th ventricle).

- **rhomboid**: Greek rhombus = a figure with 4 equal sides, not at right angles, and eidos = shape or form, hence, the shape of a rhombus.
- **rima**: Latin = chink; hence, e.g., rima palpebrarum = the chink between the free edges of the eyelids.
- **risorius**: Latin risor = scoffer; hence, muscle risorius is the facial muscle which expresses laughter by drawing the corner of the mouth laterally.
- **rostral**: adjective, Latin rostrum = beak, implying nearness to the corpus callosum.
- **rostrum**: Latin beak, which decorated the Roman orator's platform; hence, a platform or beak-like structure; adjective - rostral.
- **rotate**: Latin rota = wheel; hence, to turn, and rotation, the act of turning.
- **rotundum**: Latin rotnudus = round.
- **rubro**: prefix, Latin rubrum = red.
- **ruga**: Latin = a wrinkle.
- **rugose**: adjective, Latin ruga = a wrinkle, hence, wrinkled.
- **sac**: Latin saccus = a sack.
- **sacciform**: Latin saccus = sac-shaped
- **saccule**: Latin sacculus, diminutive of saccus.
- **sacrum**: Latin os sacrum = sacred, via Greek hieron osteon = sacred bone. Called so either because the sacrum was the part of an animal offered in sacrifice or because of the belief that the soul of the man resides there. A different origin is suggested by an alternate translation of the heron, which can also mean ﷺstrong,' and that the Latin stems from a mistranslation of Galen, who was calling it 'the strong bone.'
- **sagittal**: adjective, Latin sagitta = arrow, because the sagittal suture is notched posteriorly, like an arrow, by the lambdoid sutures.
- **salivary**: adjective, Latin saliva = spit.
- **salpinx**: Greek = trumpet; hence, the uterine or auditory tube, each of which is trumpet-shaped.
- **saphenous**: adjective, Greek saphenes = obviously visible. The saphenous veins become very apparent when varicose.
- **sartorius**: Latin = tailor; hence, sartorius muscles, which produce the posture in which tailors once worked, squatting on the floor.
- **scala**: Latin = stairs; hence the parallel spiral passages which wind up to, or down from, the cupula of the bony cochlea.
- **scalene**: adjective, Greek skalenos = uneven, hence a triangle with unequal sides, an apt description of the shape of scalenus anterior and scalenus medius muscles.
- **scalenus**: adjective, Greek skalenos = uneven, hence a triangle with unequal sides, an apt description of the shape of scalenus anterior and scalenus medius muscles.
- **scaphoid**: adjective, Greek skaphe = skiff, and eidos = shape or form; hence the carpal which is hollowed out on its distal surface for the head of the capitate; also the fossa occupied by tensor veli palatini muscle.
- **scapula**: Greek skapto = I dig, because of the resemblance to a spade.
- **sciatic**: adjective, Greek ischion = hip-joint. Ischiadikos meant pertaining to the ischium or hip - later changed to sciatic. (The ischium earns its name because it forms > 2/5 of the acetabulum, whereas the ilium contributes < 2/5, and the pubis only 1/5). The sciatic nerve lies on the ischium.

- **sclera**: Greek skleros = hard; hence the tough, outer layer of the eyeball; adjective - scleral.
- **sclerotome**: Greek skleros = hard, and tome = a cutting.
- **scoliosis**: Greek skolios = crooked or curve, and -osis = condition, hence, the lateral curvature of the spine.
- **scrotum**: possibly derived from Latin scorteus = leather; adjective - scrotal.
- **secrete**: Latin secretus = separated; hence, to produce a chemical substance by glandular activity - adjective, secretory; noun, secretion.
- **sella**: Latin = saddle; adjective - sellar, sella turcica = Turkish saddle.
- **semen**: Latin = seed; adjective - seminal (seminal vesicle).
- **semilunaris**: adjective, Latin semi = half, and luna = moon; hence, having a half-moon shape.
- **semimembranosus**: adjective, Latin semi = half, and membrana = membrane; hence, the hamstring muscle of which the upper half is membranous.
- **seminiferous**: Latin semen = seed and ferre = to carry, to bear; hence, the sperm-producing tubules in the testes.
- **semitendinosus**: adjective, Latin semi = half, and tendo = I stretch; hence, the hamstring muscle of which the lower half is tendinous.
- **septum**: Latin saeptum = fenced in; hence, a dividing fence or partition.
- **serous**: Latin = like serum.
- **serratus**: adjective, Latin = notched like the edge of a saw (serrate).
- **sesamoid**: adjective, Greek sesamodes, eidos = shape or form; like grains of sesame, hence, small bone in tendon at site of friction.
- **sialogram**: Greek sialon = saliva, and gramma = a diagram; hence, a radiograph of a salivary duct.
- **sigmoid**: adjective, Greek sigma, the form used at the end of a word having an S-shape; hence, S-shaped.
- **sinister**: adjective, Latin = left-sided.
- **sinus**: Latin = a hollow or space which may contain air, venous or arterial blood, lymph or serous fluid; adjective, sinusoid.
- **sole**: the lower surface of the foot - see soleus.
- **soleus**: adjective, Latin solea = flatfish or sandal; hence soleus muscle which does not enter the sole of the foot, but resembles the fish.
- **solitarius**: Latin = solitary, alone.
- **soma**: Greek = the body.
- **somatic**: adjective, Greek soma = the body; hence, pertaining to the body frame but not to its viscera.
- **somite**: Greek soma = body, hence an embryonic body segment.
- **spasm**: Greek spasmos = an involuntary contraction of a muscle; adjective - spastic, or spasmodic.
- **sperma**: Greek = seed or semen, adjective, spermatic.
- **sphenoid**: adjective, Greek sphen = wedge, and eidos = shape or form; hence the unpaired bone which is wedged into the base of the skull between the unpaired frontal and occipital.

- **sphincter**: Greek sphinkter = a tight binder; hence, a circular muscle which closes an orifice; adjective - sphincteric.
- **spine**: Latin spina = a thorn; hence, a sharp process, or a lay term for the vertebral column; adjective, spinous, spinal.
- **splanchnic**: adjective, Greek splanchnon = a viscus or internal organ; hence pertaining to viscera.
- **spleen**: Latin splen = the spleen; hence; adjective - splenic (Latin - lien).
- **splenium**: Greek splenion = a bandage. The splenium of corpus callosum resembles a partly rolled bandage.
- **splenius**: Greek splenion = a bandage. Hence, splenius capitis muscle, with its finely-woven fibres and its quarter-spiral twist from a coronal to a sagittal plane.
- **spongiosum**: adjective, Greek spongia = a sponge.
- **squama**: Latin = a scale (as of fish or reptile); adjective - squamous.
- **squamous**: adjective, Latin squama = a scale (as of fish or reptile), hence scale-like.
- **stapes**: Latin = stirrup; adjective - stapedial, stapedius.
- **stellate**: adjective, Latin stella = star.
- **stereocilia**: Greek stereos = solid, and cilium = eyelash, hence non-motile microvilli.
- **sternebra**: Greek sternon = chest or breast, and -bra = from vertebra, hence the segments of the sternum that fuse in later life.
- **sternum**: Greek sternon = chest or breast; adjective, sternal.
- **stoma**: Greek = a mouth.
- **stomach**: Greek stomachos = gullet or oesophagus, later applied to the wider part of the digestive tract just below the diaphragm; adjective - gastric.
- **strabismus**: Greek strabismos = squinting; hence, inability to focus both eyes on a given point.
- **stratum**: Latin = a covering sheet, or layer.
- **stria**: Latin = furrow, applied to a streak or stripe.
- **striatum**: adjective, Latin striatus = furrowed; hence, corpus striatum, the caudate and lentiform nuclei connected by grey strands which traverse the internal capsule, giving the strands a striated appearance.
- **stroma**: Greek = bed or mattress, deep to the covers; hence, the supporting framework of an organ, as distinct from its special parenchyma.
- **styloid**: adjective, Greek stylos = an instrument for writing, and eidos = shape or form; hence a pen- or pencil-like structure.
- **subclavian**: Latin sub = under or below, and clavis = a key, hence under the clavicle.
- **subiculum**: diminutive of Latin subix = a support.
- **sublimis**: Latin = superficial.
- **substantia**: Latin = a substance.
- **succus**: Latin = juice (succus entericus, the secretion of the small intestine).
- **sudomotor**: Latin sudor = sweat, and movere = to move, hence stimulating the sweat glands.
- **sulcus**: Latin = a groove.
- **superciliary**: adjective, Latin super = above, and cilia = eyelid; hence, pertaining to the eyebrow.

- **superficial**: adjective, Latin super = above, and facies = surface; hence, nearer the surface.
- **superior**: adjective, comparative of Latin superus = above.
- **supination**: the act of turning the back of the hand to face posteriorly; verb - supinate.
- **supine**: adjective, Latin supinus, recumbent on the back. Hence, also, the position of the hand with the dorsum facing posteriorly.
- **supra**: Latin prefix = superior to.
- **suprarenal**: Latin supra = above, over, superior to, and ren = the kidney.
- **sural**: adjective, Latin sura = the calf.
- **sustentaculum**: Latin = a support, which sustains; sustentaculum tali - the ledge on the calcaneus supporting part of the talus.
- **suture**: Latin sutura = a seam; the fibrous joints between cranial bones.
- **sympathetic**: Greek syn = with, and pathos = feeling; hence, the peripheral part of the autonomic nervous system which arises in the thoracolumbar region of the spinal cord and communicates with other nerves.
- **symphysis**: Greek syn = with, and physis = growth; hence a joint where union between the bones is by fibrocartilage - used for median joints. (Symphysis of the mandible is exceptional, the 2 halves fusing before the age of 2).
- **synapse**: Greek syn = with, and aptein = to join; hence, the zone through which an impulse passes from one neuron to another.
- **synchondrosis**: Greek syn = with, and chondros = cartilage; hence, the union of 2 bones by cartilage.
- **syncytium**: Greek syn = with, and kytos = cell, hence a multinucleate mass of protoplasm, formed by the merging of cells.
- **syndesmosis**: Greek syn = with, and desmos = a band; hence, the union of 2 bones by fibrous tissue.
- **syndrome**: Greek syn = with, and dromos = running; hence, a group of signs and symptoms which is characteristic of a certain pathology.
- **synergist**: Greek syn = with, and ergon = work; hence a muscle which cooperates with others in producing a given movement.
- **synovia**: Greek syn = with, and ovum = egg; hence the fluid in freely movable joints resembling egg-white; adjective, synovial.
- **synovial**: adjective, Greek syn = with, and ovum = egg; hence pertaining to the fluid in freely movable joints resembling egg-white.
- **systole**: Greek = contraction; hence the contraction of cardiac muscle.
- **taenia**: Latin = a tape or ribbon.
- **talus**: Latin = ankle-bone; hence, the tortoise-shaped tarsal of the talocrural (ankle) joint.
- **tapetum**: Latin = a carpet or coverlet; hence the roof of the posterior horn of the lateral ventricle.
- **tarsus**: Greek tarsos = a flat surface; hence the flat part of the foot, and later, the bones of the foot behind the metatarsals, adjective, tarsal.
- **tectorial**: adjective, Latin tectorium = an overlying surface like plaster, a covering or roof.

- **tectum**: Latin = roof; hence the roof of the midbrain.
- **tegmen**: Latin = covering (cf. integument = the skin).
- **tegmentum**: Latin = covering.
- **tela**: Latin = a web; e.g., a fold of pia mater containing a choroid plexus.
- **telencephalon**: Greek telos = end, and enkephalos = brain; hence the rostral part of the developing brain. (With the diencephalon, it makes up the prosencephalon).
- **temporal**: Latin tempus = time; hence, the temporal area of the scalp, where grey hair first appears, marking the progress of ageing.
- **tendon**: Latin tendo = I stretch out.
- **tenia**: Latin = a tape or ribbon.
- **tensor**: Latin tensus = stretched; hence a muscle which produces tension.
- **tentorium**: Latin = tent; tentorium cerebelli.
- **teres**: Latin = rounded, cylindrical.
- **testicle**: Latin testiculus = the male gonad (see testis).
- **testis**: Latin testiculus = the male gonad. From Latin testis = a witness. Under Roman law, no man could bear witness (testify) unless he possessed both testes. Plural - testes.
- **tetralogy**: Greek tetra = four, and logos = discourse, hence a combination of four elements e.g., symptoms or defects.
- **tetrology**: Greek tetra = four, and logos = discourse, hence a combination of four elements or symptoms.
- **thalamus**: Greek = bedroom - derivation obscure, though the posterior end of the thalamus is rounded and named pulvinar = cushion.
- **theca**: Greek theka = a capsule, sheath.
- **thenar**: Greek = palm of hand; hence, the ball of the thumb.
- **thorax**: Greek = the chest, adjective, thoracic.
- **thrombus**: Greek = a clot.
- **thymus**: Greek = sweetbread.
- **thyroid**: Greek thyreos = shield, and eidos = shape or form; hence, shaped like a shield (which shields the glottis).
- **tibia**: Latin = the shin-bone, adjective, tibial.
- **tonsil**: Latin tonsilla = tonsil (e.g., palatine tonsil).
- **torus**: Latin = a bulge.
- **trabecula**: diminutive of Latin trabs = a beam; hence the supporting fibres of a structure.
- **trachea**: Greek tracheia = rough, referring to its corrugations.
- **tract**: Latin tractus = an elongated strand of wool or dough; hence a pathway for nerve fibres.
- **tragus**: Latin = goat, because of the beard-like tuft of hair on its internal aspect.
- **transverse**: perpendicular to the long axis.
- **trapezium**: Greek trapezion = a trapezium - a quadrilateral with 2 sides parallel.
- **trapezius**: Greek trapezion = a trapezium - a quadrilateral with 2 sides parallel; hence, trapezius muscle, the diamond-shape of both trapezii muscles together.
- **trapezoid**: Greek trapezion = a trapezium - a quadrilateral with 2 sides parallel, and eidos = shape or form, hence resembling a trapezium.

- **triceps**: Latin tres = 3, and caput = head; hence a 3-headed muscle.
- **trigeminal**: Latin trigeminus = triplets; hence, cranial nerve V, with 3 large divisions.
- **trigone**: Latin trigonum = a triangle.
- **triquetral**: Latin triquetrus = 3-cornered.
- **triticea**: Latin triticum = a grain of wheat; hence, the tiny cartilage in the lateral thyrohyoid ligament.
- **trochanter**: Greek = a runner; hence, the bony landmark, the greater trochanter, which moves so obviously in running.
- **trochlea**: Greek trochilia = a pulley.
- **truncus**: Latin = trunk (of a tree).
- **tuber**: Latin tuber = a swelling or lump.
- **tubercle**: Latin diminutive of tuber, a small prominence, usually bony.
- **tuberculum**: Latin diminutive of tuber, a small prominence, usually bony.
- **tuberosity**: Latin tuber = a swelling or lump, usually large and rough.
- **tunica**: Latin = shirt; hence a covering.
- **turbinate**: Latin turbo = a child's (spinning) top; hence shaped like a top. Old term for nasal conchi.
- **tympanum**: Latin = a drum.
- **ulna**: Latin = elbow or arm; hence, the medial bone of the forearm.
- **umbilicus**: Latin = the navel.
- **umbo**: Latin = the boss on the centre of a shield, umbo of tympanic membrane.
- **uncinate**: Latin uncinatus = hooked.
- **uncus**: Latin = hook; adjective - uncinate.
- **ungual**: pertaining to Latin unguis = finger-nail.
- **urachus**: Greek ouron = urine, and echein = to hold, hence the canal connecting the bladder and umbilicus in the foetus.
- **ureter**: Greek oureter = passage from kidney to bladder.
- **urethra**: Greek ourethra = passage from bladder to exterior.
- **uterus**: Latin = womb.
- **utricle**: diminutive of Latin uterus = womb.
- **uvea**: Latin uva = grape. The pigmented vascular layer of the eyeball (iris, ciliary body and choroid).
- **uvula**: diminutive of Latin uva = grape.
- **agina**: Latin = sheath; hence, invagination is the acquisition of a sheath by pushing inwards into a membrane, and evagination is similar but produced by pushing outwards.
- **vagus**: Latin = wandering; hence, cranial nerve X, which leaves the head and neck to traverse the thorax and upper part of the abdomen.
- **valgus**: Latin = knock-kneed.
- **vallate**: Latin vallatus = walled; hence, the large papillae on the tongue which are depressed below the surface and are surrounded by a groove which is itself bounded by a wall.
- **vallecula**: diminutive of Latin vallis = a fossa.
- **valve**: Latin valva = the segment of a folding-door.

- **valvula**: diminutive of Latin valva.
- **varicocoele**: Latin varix = vein and Greek kele = tumour, hernia, hence a varicose condition of the veins of the pampiniform plexus.
- **varus**: Latin = bow-legged.
- **vas**: Latin = vessel (plural = vasa).
- **vascular**: Latin vasculum, diminutive of vas; hence, pertaining to blood vessels.
- **vastus**: Latin = great, vast, extensive.
- **vein**: Latin vena; adjective - venous.
- **velum**: Latin = curtain; veli = of a curtain.
- **vena cava**: Latin vena = vein + Latin cava, from caves = hollow. It is unclear why the vain was classically termed ﷺhollowﷺ.
- **venter**: Latin = belly; hence, ventral, pertaining to the belly side.
- **ventricle**: diminutive of Latin venter = a small belly.
- **vermiform**: Latin vermis = a worm, and forma = shape; hence, worm-shaped.
- **vermis**: Latin = worm; hence, the segmented median part of the cerebellum.
- **vertebra**: Latin verto = I turn; hence, one of the movable bones of the backbone which seems to be shaped for rotation.
- **vertex**: Latin = summit; hence the highest point on the skull.
- **vertical**: perpendicular (at a right angle) to the horizontal.
- **vesica**: Latin = bladder, adjective - vesical.
- **vesicle**: diminutive of Latin vesica = bladder, hence a little bladder.
- **vesicula**: diminutive of Latin vesica = bladder; seminal vesicle.
- **vestibule**: Latin vestibulum = entrance hall.
- **vibrissa**: Latin vibrare = to vibrate; hence, the hairs in the nasal vestibule which vibrate in the current of air.
- **villus**: Latin a hair; hence, a vascular, hair-like process, usually projecting from a mucous surface.
- **vincula**: Latin = fetters (singular - vinculum); hence, the delicate vascular synovial bands passing to a tendon in the digits.
- **visceral**: adjective, Latin viscus = an internal organ.
- **viscus**: Latin = an internal organ, plural - viscera, adjective - visceral.
- **vital**: Latin vita = life.
- **vitelline**: Latin vitellus = yolk.
- **vitreous**: Latin vitreus = glassy.
- **vocal**: adjective, Latin vox = voice.
- **vomer**: Latin = plough-share; hence, the bone of the nasal septum which is split in two at its upper edge.
- **vorticosae**: Latin vortex = whirl; hence the whirl-like arrangement of the 4 venae vorticosae leaving the eyeball.
- **vulva**: Latin = the external female genitalia.
- **xiphoid**: Greek xiphos = a sword, and eidos = shape or form; hence, sword-shaped.
- **zona**: Latin = a belt; hence, a circular band.
- **zonule**: diminutive of zona.

- **zygapophysis**: Greek zygon = yoke, apo = from, physis = growth; the articular process of a vertebra. The downward "growth" of the vertebra above articulates with the upward "growth" of the vertebra below, forming a zygapophyseal joint.
- **zygoma**: Greek zygon = yoke; hence, the bone joining the maxillary, frontal, temporal and sphenoid bones.
- **zygomatic**: adjective, Greek zygon = yoke; hence, pertaining to the bone joining the maxillary, frontal, temporal and sphenoid bones.
- **zygote**: Greek zygon = yoke; hence the fusion of the male and female gametes.

INDEPENDENT WORK OF STUDENTS

Calendar-themed plan of independent work

№	Theme	Hours
1	The location of the nuclei of the spinal cord and their significance.	3
2	Brain stem nuclei and their meanings	3
3	Nuclei of the cerebellum and their clinical significance.	3
4	The nuclei of the hypothalamus and their clinical significance.	3
5	Venous sinuses and cisterns of the meninges. Liquorodynamics.	3
6	Innervation of the skin of the upper and lower extremities.	3
7	The centers of the autonomic nervous system and their functional significance.	3
8	Functional anatomy of the organs of smell and taste.	3
	TOTAL	**24**

Regulation on the rating system

I. General rules

The purpose of this system is to control, improve, systematize and deepen the existing knowledge, training highly qualified specialists.

The main objectives of the rating system:

A) the formation of a certain range of knowledge, skills and abilities in accordance with the requirements of the program.

B) assessment of students' knowledge according to the criteria of rating.

C) the promotion of the assimilation of objects by students.

D) the organization of work in the classroom visual, abilities.

E) ensuring the systematization of knowledge by students.

F) assessment of students' knowledge in each semester.

G) ensure the conditions for the computerization of the organization of the educational process

II. Types of control

Assessment of students' knowledge on the subject during the semester is carried out on the basis of the table of rating control and evaluation criteria.

Evaluation should be carried out by the following types of work

1) Initial test.

2) Verification

3) The final test.

4) The total score of students' knowledge for the semester is 100 points, which are distributed as follows:

1) Current control - 45 b

2) Independent work– 5 b

3) Intermediate control - 20 b

4) Final control - 30 b

Types of control	**Maximum score**	**Coefficient**	**Passing score**
Current control	45 b	0,45	24,75
Independent work	5 b	0,05	2,75
Intermediate control	20 b	0,2	11,0
Final control	30 b	0,3	16,5
Итого:	100	1	55,0

Current control

The current control of the subject is determined by the knowledge of each topic and practical skills. Students' skills are determined during the period of practical seminars and practical work. Current control can be carried out in the form of an oral survey, tests, conversation, test work, colloquium, homework tests and other ways.

Independent work of student (IWS)

1) Independent work of a student is carried out in accordance with the order of the Ministry of Higher and Secondary Education of the Republic of Uzbekistan dated February 21, 2005 No. 34 by 100 point current control system and in accordance with other types of control

2) the topics of independent work of students on the subject “Human Anatomy” are compiled in accordance with the program approved by the Ministry of Health from 2014 and reviewed at the meeting of the department.

3) independent work on the subject is possible by carrying out the following work on relevant topics: writing notes, making test questions, creating crossword puzzles, and presentations.

In the educational journal of a teacher after the last practical lesson of this academic year, there is one column in which the average points of students for independent work are entered.

Intermediate control.

Intermediate control is carried out on several topics of the subject or after passing theoretical lessons on topics. At the same time, the ability to solve problems by a student or by answering certain questions is determined, and given the above, an assessment is derived. Intermediate control is carried out orally 1 time per semester, but given the extensive material on human anatomy, the department decided to carry out intermediate controls in 3-4 sections in each semester. Intermediate control is carried out orally during the year on a 100 point rating system. An interim control pass is given only to those students who have passed all practical work topics and are not in arrears.

Final control.

On the final control assess the knowledge and skills of the student, acquired in all topics of the subject. The final control is carried out at the end of the II and III semester. At the final control on human anatomy, students are allowed to have a positive assessment (at least 55%) for current and intermediate control, as well as CPC. The final control is carried out orally (in writing) and in the form of tests and is assessed on a 100 point rating system. In case of unsatisfactory delivery of the final control, re-retake is possible only with the permission of the dean's office.
Evaluation of responses is carried out according to the following criteria.

№	Performance	Evaluation	Level of students' knowledge.
1	90-100	Excellent "5"	-able to make independent decisions and conclusion -has creative thinking -can independently think -can apply interactive games more actively -solves situational problems with a full justified answer -understands the meaning of the question and answered with confidence -has a full understanding
2	70-89	Good "4"	-may apply in practice interactive games more actively -solves situational problems,but completely unable to explain -understands the meaning of the question and answered with confidence -has a full understanding
3	60-69	Satisfactory "3"	-solves situational problems ,but can't justify the answer -knows can answer -on certain issues has an idea
4	0-60	Unsatisfactory "2"	-has no representation on this topic -doesn't know the subject

In surveys, it is recommended to rate the student in whole grades.
Student knowledge of human anatomy is assessed by the following formula: R1 = V * O / 100
where V is the total number of hours allotted for the semester. O- level of achievement in the subject.

The procedure for the certification of students in subjects.

CC (51 lessons) C= 0,45	Average CC (65+73+78+85+86+87) / 6=79 Ball CC = 79 x 0,45= 35,5
IWS (34) C = 0,05	Average IWS (90+85+86) / 3=87 Ball IWS = 87 x 0,05 = 4,35
IC C = 0,2	Orally 76 x 0,2 = 15,2
FC orally or in writing Test	FC (orally or in writing) = 80 x 0,15= 12 FC (test) = 84 x0,15 = 12,6
Total ball	35,5 + 4,35 +15,2 + 12 + 12,6 = 79,6 (good)

Intermediate and final controls are carried out in accordance with the approved calendar and thematic plan based on the rating system. The final control is carried out during the last 2 weeks of the 2 and 3 semesters.

Students who have not received enough points or are absent for a good reason during the intermediate control are given a time limit to re-pass the last current and intermediate control to the final control.

Students who do not pass the current, intermediate and final control before the deadline due to illness, given a 2-week period for delivery with the permission of the dean of the faculty.

A student who has not collected 55% of current or intermediate control and is in arrears is considered an academic debtor and is not allowed to take final control. Academic debtors are given a period of one month for liquidation of debts and re-transfer (with the permission of the dean's office).

If a student does not agree with the results of controls, then after announcing grades over the next day, he may turn to the dean of the faculty with a statement. In this case, after the permission of the dean of the faculty, on the basis of the order of the rector, an appeal commission consisting of at least 3 members is organized. On the same day, the appeal commission reviews the student’s application and summarizes the results.

IV. The procedure for recording rating results

The results of students' test papers are recorded in the rating book in whole numbers. In the rating book in a certain column for the selected hours of the curriculum is recorded the number of hours for the subject. And in the grading graph of the subject is rated on a 100 point system. The score below the passing score is not recorded in the rating book.

The results of examinations on the subject are also recorded in educational journals and announced to students on the same day (if the examinations were carried out in writing, they are announced within 2 days)

The teacher of the subject according to the results of the final control of the students determines the rating and writes in the required column of the rating book.

Students rating points are announced at the end of each semester and school year.

The results of the current, intermediate and final controls are discussed at the department meetings and the corresponding decisions are displayed.

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Medulla Spinalis consist of:
*cornu anterior
*cornu posterior
pars anterior
margo medialis

Medulla Spinalis consist of:
*intumescentia cervicalis
*canalis centralis
pars subclaviae
margo lateralis

Medulla Oblongata consist of:
*olive
*pyramis
sulcus subclaviae
margo medialis

Fourth ventricle consist of:
*recessus lateralis
*sulcus medianus
sulcus v. subclaviae
margo lateralis

Cerebellum consist of:
*vermis cerebelli
*nodulus
sulcus subclaviae
margo medialis

Cerebellum consist of:
*pedunculi cerebellaris superior
*nucleus fastigii

nucl.n.abducentis
sulcus v. Subclaviae

Mesencephalon consist of:
*substantia nigra
*tegmentum mesencephali
sulcus subclaviae
margo medialis

Mesencephalon consist of:
*nucleus n.oculomotorius
*colliculis inferior
sulcus subclaviae
margo lateralis

Medulla spinalis consist of:
*substantia alba
*substantia grisea
pars medialis
pars laryngea

Medulla spinalis consist of:
*conus medullaris
*intumescentia cervicalis
lemniscus medialis
pars medialis

Medulla spinalis consist of:
*nucleus thoracicus
*funiculus anterior
nucleus cochlearis dorsalis
nucleus fastigii

Medulla spinalis consist of:
*fissura mediana anterior
*canalis centralis
pars medialis
funiculus inferior,

Medulla spinalis consist of:
*sulcus lateralis posterior
*columna posterior
pars medialis
fissura mediana inferior

Medulla spinalisconsist of:
*cornu laterale
*substantia alba
pars medialis
nucleus gracilis

Medulla oblongata consist of:
*fissura mediana anterior
*olive
pars cervicalis
pars medialis

Medulla spinalis consist of:
*substantia alba
*cornu anterior
pars medialis
nucleus gracilis

Pons consist of:
*formatio reticularis pontis
*corpus trapesoideum
nucl.dentatus
nucleus fastigii

Fourth ventricle consist of:
*colliculus facialis
*artea vestibularis
nucleus fastigii
nucleus globosus

Cerebellum consist of:
*nodulus
*folia cerebelli
colliculus facialis
locus ceruleus

Mesencephalon consist of:
*colliculus superior
*pedunculi cerebri
n. trigeminus
colliculus facialis

Diencephalon consist of:
*corpus pineale
*habenula
colliculus facialis
colliculus superior

Optic conductive pathways:
*colliculus superior
*pulvinar thalami
vermis
colliculis facialis

Trunk of spinale nerve:

*ramus dorsalis
*r.r. communicantes albi
r.r. inferior
r.r. craniales

Trunk of spinale nerve:
*ramus ventralis
*r. dorsalis
r.r. superior
r.r. inferior

Suboccipital nerve innervate:
*m. obliqus capitis
*m. rectus capitis major
m. epicranius
m. teres major

Cervical plexus consist of:
*n. transversus colli
*n.n. supraclaviculares
n. occipitalis major
n.clunium medius

Brachial plexus consist of:
*n. axillaris
*n. suprascapularis
n.clunium medius
n. phrenicus

Brachial plexus consist of:
*n. medianus
*n. axillaris
n.clunium medius
n. iliohypogastricus

Brachial plexus consist of:
*n. cutaneus brachii medialis
*n. n. radialis
n. pudendus
n.phrenicus

Brachial plexus consist of:
*n. medianus
*n. dorsalis scapulae
n.clunium medius
n. femoralis

Diencephalon consist of:
*corpus pineale
*habenula

colliculis facialis
fossa rhomboidea

Trunk of spinale nerve:
*r. meningeus
*n.spinalis
r.caudalis
n. Phrenicus

Brachial plexus consist of:
*n. musculocutaneus
*n. axillaris
sulcus subclaviae
n. Auriculotemporalis

Ulnar nerve consist of:
*m. flexor digitorum profundus
*r.profundus
m. phrenicus
m. auricularis magnus

Radial nerve consist of:
*m. extensor digiti minimi
*m. supinator
m. pectoralis major
m. subscapularis

Intercostal nerves consist of:
*m.m. serrati posteriores superiors
*m. transversus abdominis
sulcus v. subclaviae
m. triceps brachii

Intercostal nerves consist of:
*m. transversus thoracis
*m. transversus abdominis
sulcus subclaviae
m. biceps brachii

Intercostal nerves consist of:
*m. transversus abdominis
*m. obliquus internus abdominis
m. palmaris longus
sulcus subclaviae

Hypoglossal nerve innervate:
*m. transversus linguae
*m.verticalis linguae
m. palatopharyngeus
m.temporalis

Hypoglossal nerve innervate:
*m. genioglossus
*m. styloglossus
m. temporalis
m.masseter

Ophtalmic nerve consist of:
*n. frontalis
*n. supraorbitalis
n. hypoglossus
n. maxillaris

Maxillary nerve consist of:
*n. alveolaris superior
*n.zygomaticus
n. frontalis
n. medialis

Mandibular nerve consist of:
*n. alveolaris inferior
*n. auriculotemporalis
n. olfactorius
n. hypoglossus

Mandibular nerve consist of:
*n. mentalis
*n. tensoris tympani
n. olfactorius
n. hypoglossus

Mandibular nerve consist of:
*n. mentalis
*n. mylohyoideus
n. olfactorius
n. hypoglossus

Mandibular nerve consist of:
*n. temporalis profundus
*n. pterigoideus lateralis
n. hypoglossus
n. frontalis

Facial nerve consist of:
*n. petrosus major
*r. buccales
n. palatopharyngeus
n. hypoglossus

Facial nerve consist of:

*r. buccales
*n. stapedius
n. palatopharyngeus
n. hypoglossus

Facial nerve consist of:
*chorda tympani
*nucleus tractus solitarii
n. palatopharyngeus
n. hypoglossus

Glossopharyngeal nerve consist of:
*rami pharyngei
*rami tonsillares
n. massetericus
n. mylohyoideus

Glossopharyngeal nerve consist of:
*ramus sinus carotici
*n. petrosus minor
n. frontalis
n. massetericus

Vagus nerve consist of:
*ramus meningeus
*rami pharyngei
n. mylohyoideus
n. frontalis

Musculocutaneus nerve innervate:
*m. brachialis
*m. biceps brachii
m. brachioradialis
m.clunium medius

Median nerve innervate:
*m. flexor capri ulnaris
*m. flexor pollicis longus
m. auricularis magnus
m.clunium medius

Radial nerve innervate:
*m. supinator
*m. extensor carpi radialis brevis
m. obliquus externus abdominis
m.pronator teres

Intercostale nerves innervate:
*m. rectus abdominis
*m. transversus thoracis

m.pronator teres
m. triceps brachii

Diaphragma innervated by:
*n. phrenicus
*plexus cervicalis
n.clunium medius
n. intercostalis

Brachial biceps innervated by:
*n. musculocutaneus
*plexus brachialis
n. vagus
n. intercostalis

Brachial triceps muscle innervated by:
*n. radialis
*c5 c8, th1
c1 c4, th1
plexus cervicalis

Vagus nerve consist of:
*ramus auricularis
*rami pharyngei
ramus auriculotemporalis
n. mylohyoideus

Medulla spinalis consist of:
*funiculus anterior
*conus medullaris
pars medialis
pars dorsalis

Medulla oblongata consist of:
*nuambiguus
*fissura mediana anterior
pedunculi cerebellaris superior
pedunculi cerebellaris medialis

Fourth ventricle consist of:
*colliculus facialis
*fossa rhomboidea
nucleus fastigii
nucleus dentatus

Cerebellum consist of:
*folia cerebelli
*nucleus fastigii
colliculus facialis
fossa rhomboidea

Cerebellum consist of:
*pedunculi cerebellaris medius
*pedunculi cerebellaris inferior
colliculus facialis
fossa rhomboidea

Mesencephalon consist of:
*pedunculi cerebri
*aqueductus cerebri
colliculus facialis
fossa rhomboidea

Mesencephalon:
*nucleus ruber
*aqueductus cerebri
colliculus facialis
fossa rhomboidea

Diencephalon:
*epithalamus
*thalamus opticus
colliculus facialis
ossa rhomboidea

Truncus n. spinalis:
*ramus dorsalis
*ramus ventralis
r.r. inferior
r.caudalis

Plexus brachialis:
*n. axillaris
*n. subclavius
n.clunium medius
n auricularis magnus

Plexus brachialis:
*n. medianus
*n. axillaris
n.clunium medius
n. auricularis magnus

N. ulnaris:
*m. ramus palmaris
*m. ramus dorsalis
m.clunium medius
m. auricularis magnus

N. radialis:

*m extensor carpi radialis brevis
*m. triceps brachii
m. obliquus externus abdominis
m. pectoralis major

N. medianus:
*m. pronator teres
*m. palmaris longus
m. triceps brachiii
m. biceps brachii

N. hypoglossus:
m. longitudinalis linguae
*m. genioglossus
m. palatopharyngeus
m.masseter

N. hypoglossus:
*m. longitudinalis linguae
*m. transversus linguae
m. palatopharyngeus
m.masseter

Mesencephalonconsists of:
*nucleus ruber
*aqueductus cerebri
colliculus facialis
fossa rhomboidea

Diencephalon consists of:
*epithalamus
*thalamus opticus
colliculus facialis
ossa rhomboidea

Truncus n. spinalis consists of:
*ramus dorsalis
*ramus ventralis
r.r. inferior
r.caudalis

Plexus brachialis consists of:
*n. axillaris
*n. subclavius
n.clunium medius
n auricularis magnus

Plexus brachialisconsists of:
*n. medianus
*n. axillaris

n.clunium medius
n. auricularis magnus

N. ulnarisconsists of:
*m. ramus palmaris
*m. ramus dorsalis
m.clunium medius
m. auricularis magnus

N. radialisconsists of:
*m extensor carpi radialis brevis
*m. triceps brachii
m. obliquus externus abdominis
m. pectoralis major

N. medianusconsists of:
*m. pronator teres
*m. palmaris longus
m. triceps brachiii
m. biceps brachii

N. hypoglossusconsists of:
*m. longitudinalis linguae
*m. genioglossus
m. palatopharyngeus
m.masseter

N. hypoglossusconsists of:
*m. longitudinalis linguae
*m. transversus linguae
m. palatopharyngeus
m.masseter

N. ophtalmicusconsists of:
*n. frontalis
*n. lacrimalis
n. hypoglossus
n. maxillaris

N. maxillarisconsists of:
*n. infraorbitalis
*r. nasales posteriores superiors
n. olfactorius
n. hypoglossus

N. mandibularisconsists of:
*n. lingualis
*n. buccalis
n. olfactorius
n. hypoglossus

N. mandibularisconsists of:
*n. alveolaris inferior
*n. buccalis
n. olfactorius
n. hypoglossus

N. mandibularisconsists of:
*n. massetericus
*n. pterygoideus lateralis
n. olfactorius
n. hypoglossus

N. facialisconsists of:
*n. petrosus major
*r. buccales
n. palatopharyngeus
n. hypoglossus

N. facialisconsists of
*rami zygomatici
*rami colli
n. palatopharyngeus
n. hypoglossus

N. facialisconsists of:
*nucleus motorius
*rami colli
n. palatopharyngeus
n. hypoglossus

N. glossopharyngeusconsists of:
*n. petrosus minor
*n. tympanicus
n. mylohyoideus
n. frontalis

N. glossopharyngeusconsists of:
*rami pharyngei
*n. petrosus minor
n. mylohyoideus
n. frontalis

N. vagusconsists of:
*ramus meningeus
*ramus auricularis
n. mylohyoideus
n. frontalis

Femoralisconsists of:

*genus descendens
*profunda femoris
sacralis lateralis
sacralis mediana

Femoralisconsists of:
*pudendae externae
*circumflexa ilium superficialis
sacralis mediana
sacralis lateralis

Femoralisconsists of:
*epigastrica superficialis
*pudendae externa
dorsalis
pudendae interna

Tibialis anteriorconsists of:
*reccurens tibialis anterior
*reccurens tibialis posterior
arcuata
tarsea lateralis

Tibialis anteriorconsists of:
*malleolares anteriores medialis
*malleolares anteriores lateralis
tarsea lateralis
tarsea medialis

Tibialis posteriorconsists of:
*plantares lateralis
*plantares medialis
dorsalis
arcuata

Dorsalis pedisconsists of:
*tarseae lateralis
*tarseae medialis
plantaris medialis
plantaris lateralis

Iliaca externaconsists of:
*epigastrica inferior
*circumflexa ilium profunda
uterina
ductus deferentis

Ulnarisconsists of:
*reccurens ulnaris
*interossea communis

princeps pollicis
collateralis

Radialisconsists of:
*reccurens radialis
*princeps pollicis
interossea communis
collateralis

Ophtalmicaconsists of:
*palpebralis lateralis
*palpebralis medialis
cerebri anterior
cerebri media

Ophtalmicaconsists of:
*lacrimalis
*dorsalis nasi
cerebri anterior
cerebri media

Carotis internaconsists of:
*cerebri media
*chorioidea
facialis
lingualis

Carotis internaconsists of:
*choroidea
*cerebri anterior
facialis
lingualis

Vertebralisconsists of:
*spinalis anterior
*spinalis posterior
lingualis
facialis

Axillarisconsists of:
*thoracica superior
*thoracoacromialis
profunda brachii
collateralis ulnaris inferior

Axillarisconsists of:
*thoracica lateralis
*subscapularis
collateralis ulnaris superior
collateralisulnaris inferior

Axillarisconsists of:
*circum flexa humeri anterior
*circum flexa humeri posterior
collateralis ulnaris inferior
profunda brachii

Brachialisconsists of:
*profunda brachii
*collateralis ulnaris superior
thoracica lateralis
thoracica superior

brachialisconsists of:
*collateralis ulnaris superior
*collateralis ulnaris inferior
thoracica lateralis
thoracica superior

Corpus callosumconsists of:
*genu corporis callosi
*truncus corporis callosi
cornu corporis callosi
crura corporis callosi

Fornixconsists of:
*corpus fornicis
*columna fornicis
genu fornicis
truncus fornicis

Fornixconsists of:
*crura fornicis
*corpus fornicis
genu fornicis
truncus fornicis

Fornixconsists of:
*columnae fornicis
*crura fornicis
genu fornicis
truncus fornicis

Corpus callosumconsists of:
*splenium corporis callosi
*genu corporis callosi
cornu corporis callosi
crura corporis callosi

Ventriculus lateralisconsists of:

*cornu inferior
*cornu posterior
genu
corpus

Ventriculus lateralisconsists of:
*cornu anterior
*cornu posterior
genu
corpus

Ventriculus lateralisconsists of:
*pars centralis
*cornu anterior
genu
corpus

popliteaconsists of:
*genus media
*genus superior medialis
tarseae medialis
cremasterica

carotis internaconsists of:
*cerebri media
*communicans posterior
cerebri posterior
ciliares posterior

Medulla Spinalisconsists of:
*cornu anterior
*cornu posterior
pars anterior
margo medialis

Medulla Spinalisconsists of:
*intumescentia cervicalis
*canalis centralis
pars subclaviae
margo lateralis

Medulla Oblongataconsists of:
*olive
*pyramis
sulcus subclaviae
margo medialis

Ventriculus Quartusconsists of:
*recessus lateralis

*sulcus medianus
sulcus v. subclaviae
margo lateralis

Cerebellumconsists of:
*vermis cerebelli
*nodulus
sulcus subclaviae
margo medialis

Cerebellumconsists of:
*pedunculi cerebellaris superior
*nucleus fastigii
nucl.n.abducentis
sulcus v. Subclaviae

Mesencephalonconsists of:
*substantia nigra
*tegmentum mesencephali
sulcus subclaviae
margo medialis

Mesencephalonconsists of:
*nucleus n.oculomotorius
*colliculis inferior
sulcus subclaviae
margo lateralis

Medulla spinalisconsists of:
*substantia alba
*substantia grisea
pars medialis
pars laryngea

Medulla spinalisconsists of:
*conus medullaris
*intumescentia cervicalis
lemniscus medialis
pars medialis

Medulla spinalisconsists of:
*nucleus thoracicus
*funiculus anterior
nucleus cochlearis dorsalis
nucleus fastigii

Medulla spinalisconsists of:
*fissura mediana anterior
*canalis centralis
pars medialis

funiculus inferior

Medulla spinalisconsists of:
*sulcus lateralis posterior
*columna posterior
pars medialis
fissura mediana inferior

Medulla spinalisconsists of:
*cornu laterale
*substantia alba
pars medialis
nucleus gracilis

Medulla oblongataconsists of:
*fissura mediana anterior
*olive
pars cervicalis
pars medialis

Medulla spinalisconsists of:
*substantia alba
*cornu anterior
pars medialis
nucleus gracilis

Ponsconsists of:
*formatio reticularis pontis
*corpus trapesoideum
nucl.dentatus
nucleus fastigii

Ventriculus quartusconsists of:
*colliculus facialis
*artea vestibularis
nucleus fastigii
nucleus globosus

Cerebellumconsists of:
*nodulus
*folia cerebelli
colliculus facialis
locus ceruleus

Mesencephalonconsists of:
*colliculus superior
*pedunculi cerebri
n. trigeminus
colliculus facialis

Diencephalonconsists of:
*corpus pineale
*habenula
colliculus facialis
colliculus superior

Conductive optic tracts include:
*colliculus superior
*pulvinar thalami
vermis
colliculis facialis

Truncus n. spinalisconsists of:
*ramus dorsalis
*r.r. communicantes albi
r.r. inferior
r.r. craniales

Truncus n. spinalisconsists of:
*ramus ventralis
*r. dorsalis
r.r. superior
r.r. inferior

N. suboccipitalisconsists of:
*m. obliqus capitis
*m. rectus capitis major
m. epicranius
m. teres major

Plexus cervicalisconsists of:
*n. transversus colli
*n.n. supraclaviculares
n. occipitalis major
n.clunium medius

Plexus brachialisconsists of:
*n. axillaris
*n. suprascapularis
n.clunium medius
n. phrenicus

Plexus brachialisconsists of:
*n. medianus
*n. axillaris
n.clunium medius
n. iliohypogastricus

Plexus brachialisconsists of:
*n. cutaneus brachii medialis

*n. n. radialis
n. pudendus
n.phrenicus

Plexus brachialisconsists of:
*n. medianus
*n. dorsalis scapulae
n.clunium medius
n. femoralis

Diencephalonconsists of:
*corpus pineale
*habenula
colliculis facialis
fossa rhomboidea

Truncus n. spinalisconsists of:
*r. meningeus
*n.spinalis
r.caudalis
n. Phrenicus

Plexus brachialisconsists of:
*n. musculocutaneus
*n. axillaris
sulcus subclaviae
n. Auriculotemporalis

N. ulnarisconsists of:
*m. flexor digitorum profundus
*r.profundus
m. phrenicus
m. auricularis magnus

N. radialisconsists of:
*m. extensor digiti minimi
*m. supinator
m. pectoralis major
m. subscapularis

N.n. intercostalesconsists of:
*m.m. serrati posteriores superiors
*m. transversus abdominis
sulcus v. subclaviae
m. triceps brachii

N.n. intercostalesconsists of:
*m. transversus thoracis
*m. transversus abdominis
sulcus subclaviae

m. biceps brachii

N.n. intercostalesconsists of:
*m. transversus abdominis
*m. obliquus internus abdominis
m. palmaris longus
sulcus subclavia

Medulla spinalis:
corpora mamillaria
*conus medullaris
aqueductus cerebri
pyramis
pedunculi cerebri

Medulla spinalis:
*intumescentia cervicalis
corpora mamillaria
aqueductus cerebri
pyramis
pedunculi cerebri

Medulla spinalis:
*fasciculus cuneatus
corpora mamillaria
aqueductus cerebri
pyramis
pedunculi cerebri

Cerebellum:
pyramis
corpora mamillaria
aqueductus cerebri
infundibulum
*flocculus

Medulla spinalis:
substantia perforata anterior
infundibulum
tuberculum nuclei gracilis
*canalis centralis
corpora mamillaria

Medulla spinalis:
corpora mamillaria
*fissura mediana anterior
tubrculum nuclei cuneati
tractus olfactorius
nucleus ruber

Cerebellum:
nucleus ruber
infundibulum
*nodulus
corpus pineale
corpora mamillaria

Cerebellum has:
pyramis
colliculus inferior
pedunculi cerebri
nucleus ruber
*nucleus dentatus

Ventriculus quartus:
nucleus ruber
infundibulum
corpus pineale
*fossa rhomboidea
corpora mamillaria

Fossa rhomboidea has:
*trigonum nervi hypoglossy
nucleus ruber
infundibulum
corpus pineale
corpora mamillaria

Fossa rhomboidea has:
nucleus globosus
globus pallidus
nucleus dentatus
*eminentia medialis
colliculus inferior

Fossa rhomboidea has:
*trigonum nervi vagi
globus pallidus
nucleus globosus
nucleus dentatus
colliculus inferior

Fossa rhomboidea has:
colliculus inferior
globus pallidus
nucleus globosus
nucleus dentatus
*area vestibularis

Fossa rhomboidea has:

colliculus inferior
nucleus emboliformis
oliva
nucleus fastigii
*trigonum nervi vagi

Mesencephalon has:
infundibulum
corpus pineale
trigonum nervi hypoglossy
corpora mamillaria
*nucleus ruber

Mesencephalon has:
trigonum nervi hypoglossy
infundibulum
corpus pineale
*colliculi superiores
corpora mamillaria

Mesencephalon has:
trigonum nervi hypoglossy
infundibulum
corpus pineale
*nucleus accessorius
corpora mamillaria

Mesencephalon has:
nucleus globosus
trigonum nervi hypoglossy
*substantia nigra
eminentia medialis
infundibulum

Mesencephalon has:
colliculus facialis
*pedunculi cerebri
trigonum nervi vagi
corpus striatum
infundibulum

Mesencephalon has:
*formatio reticularis
nucleus caudatus
claustrum
infundibulum
corpus pineale

Mesencephalon has:
nucleus dentatus

trigonum nervi hypoglossy
corpus pineale
infundibulum
*nucleus accessorius

Prosencephalon has:
hemispheria cerebelli
mesencephalon
*diencephalon
ventriculus quartus
tubrculum nuclei cuneati

Prosencephalon has:
hemispheria cerebelli
mesencephalon
*telencephalon
ventriculus quartus
tubrculum nuclei cuneati

Where situated neurons of Tr. Corticospinalis:
girus postcentralis,cornu posterius medullae spinalis
lobus frontalis,medulla spinalis
girus frontalis superior,cornu anterius medullae spinalis
*girus precentralis,cornu anterius medullae spinalis
nucleus dentatus cerebelli

Neurons of simple reflector arch:
thalamus opticus
gyrus postcentralis
*ganglion spinale
girus postcentralis,cornu posterius medullae spinalis
lobusfrontalis,medullaspinalis

Sensory neurons of pain and temperature:
thalamus opticus
*ganglion spinale
gyrus postcentralis
girus postcentralis,cornu posterius medullae spinalis
lobusfrontalis,medullaspinalis

Sensory neurons of pain and temperature:
nucleus ruber
cornu anterior medullae spinalis
gyrus precentralis
*nucleus lateralis thalami
nucleus dentatus cerebelli

Sensory neurons of pain and temperature of the face:
nucleus tractus spinalis
nucleus lateralis thalimi

*ganglion semilunare
nucleus dentatus cerebelli
cornu anterior medullae spinalis

Sensory neurons of pain and temperature of the face:
*cornu posterior medullae spinalis
ganglion spinale
cornu posterior medullae spinalis
nucleus gracilis et cuneatus
substantianigra

Sensory neurons of pain and temperature of the face:
substantia nigra
substantia alba
colliculus inferior
corpus geniculatum mediale
*ganglion trigeminale

Sensory proprioreceptive neurons:
substantia nigra
colliculus inferior
*ganglion spinale
corpus geniculatum mediale
gyrus temporalis superior

Sensory proprioreceptive neurons:
*cornu posterius medullae spinalis
substantia nigra
substantia alba
colliculus inferior
corpus geniculatum mediale
gyrus temporalis superior

Sensory proprioreceptive neurons:
*cornu posterius medullae spinalis
nucleus gracilis et cuneatus
substantia nigra
cornu anterius medullae spinalis
thalamus opticus

Neurons of Tr. spinocerebellaris anterior:
*cornu posterius medullae spinalis
substantia nigra
gyrus temporalis superior
colliculis superior
corpus geniculatum laterale

Neurons of Tr. spinocerebellaris anterior:
substantia nigra
*gyrus temporalis superior

cornu anterius medullae spinalis
thalamus opticus
gyrus postcentralis

Neurons of Tr. spinocerebellaris anterior:
substantia nigra
*ganglion spinale
colliculus inferior
corpus geniculatum mediale
gyrus temporalis superior

Neurons of Tr. spinocerebellaris posterior …:
substantia nigra
colliculus inferior
corpus geniculatum mediale
*vermis inferior cerebelli
gyrus temporalis superior

Which plexus gives n.ilioinguinalis:
plexus brachialis
plexus sacralis
plexus cervicalis
nn. intercostales
*plexus lumbalis

Which muscles innervates by n.musculocutaneus:
*m. biceps brachii, m. coracobrachialis, m. Brachialis
m.intercostales, m.pectorales medialis
m. biceps brachii, m.thoracicus longus
m. extensor digitorum, m. supinator
m. coracobrachialis, m. supinator

Which muscles innervates by n.radialis:
*m. extensor digitorum
m.intercostales
m. biceps brachii
m. coracobrachialis
m. brachialis

Which muscles innervates by n. ulnaris:
*m. flexor carpi ulnaris, m. flexor digitorum profundus
mm. interossei, m. extensor digitorum
m.intercostales, m. flexor digitorum profundus
m. biceps brachii
m. coracobrachialis

Which muscles innervates by m.rectus abdominis:
n.thoracicus longus
n.pectoralis lateralis
*nn.intercostales

n.suprascapularis
n.musculocutaneus

Innervation of mm.intercostales externi et mm.intercostales interni:
n.thoracicus longus
n.pectoralis lateralis
*nn.intercostales
n.suprascapularis
n.musculocutaneus

Innervation of mm.serrati posteriores superiores et inferiores:
n.musculocutaneus
n.femoralis
n.pectorales medialis
*nn.intercostales
n.thoracicus longus

Innervation of m.supinator, m.extensor carpi radialis brevis:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.femoralis

Innervation of m.brachioradialis:
n.medianus
n.ulnaris
n.musculocutaneus
*n.radialis
n.axillaris

Innervation of the deep neck muscles:
*rr.rectus capitis anterior et lateralis, rr.longus capitis et colli,rr.scaleni from plexus cervicalis
rr.temporalis et occipitalis major от plexus cervicalis
rr.occipitalis minor,auricularis major
rr.transversus capitis,longus capitis от plexus brachialis
rr.verticalis capitis,r.longus capitis

Which nerve innervates m.serratus anterior:
*n.thoracicus longus
n.thoracicus brevis
n.axillaris
n.dorsalis scapulae
n.radialis

Which nerve innervates m.levator scapulae:
*n.dorsalis scapulae
n.suprascapularis
n.subclavius
n.radialis

n.medianus

Location departs of n.phrenicus:
*plexus cervicalis
n.vagus
plexus brachialis
n.radialis
n.medianus

Which nerve gives nn.supraclaviculares:
*plexus cervicalis
n.vagus
plexus brachialis
n.intercostalis
n.phrenicus

Location departs of n.transversus colli:
plexus brachialis
n.facialis
n.hypoglossus
*plexus cervicalis
n.vagus

Location departs of n.auricularis magnus:
n.radialis
plexus brachialis
n.mandibularis
n.facialis
*plexus cervicalis

Choose muscular branches of cervical plexus which innervate superficaial neck muscles:
rr.platysmae, n.radialis
rr.scaleni,r.levator scapulae
rr.longus colli,scaleni,levator scapulae, n.radialis
*rr.sternocleidomastoidei, rr.trapezii
rr.scaleni,interspinalis, subclavii,rr.longus colli

Innervation of m.sternocleidomastoideus:
plexus brachialis
n.vagus
plexus cervicalis
*n.accesorius
n.facialis

Innervation of m.constrictor pharyngis inferior:
n.facialis
n.glossopharyngeus
*n.vagus
n.mandibularis
n.hypoglossus

Innervation of m.constrictor pharyngis medius:
n.facialis
n.glossopharyngeus
*n.vagus
n.mandibularis
n.hypoglossus

Innervation of m.palatoglossus:
n.hypoglossus
n.glossopharyngeus
*n.vagus
n.mandibularis
n.facialis

Innervation of m.uvulae:
n.mandibularis
n.glossopharyngeus
*n.vagus
n.hypoglossus
n.facialis

Innervation of m.stylopharyngeus:
*n.glossapharingeus
n.hypoglossus
n.vagus
n.facialis
n.mandibularis

Choose the place of leaving of oculomotor nerve from the cranial cavity:
*fissura orbitalis superior
foramen ovale
foramen rotundum
fissura orbitalis inferior
foramen jugulare

Choose muscles of eye ball which innervates by the superior branches of oculomotor nerve:
m.rectus superior et m.obliguus superior
m.levator palpebrae superioris et m.obliguus inferior
rectus superior et m.rectus medialis
*m.rectus superior et m.levator palpebrae superioris
m.m.rectus superior et inferior

Choose muscles of eye ball which innervates by the inferior branches of oculomotor nerve:
*mm.rectus inferior, rectus medialis et obliquus inferior
mm.obliqus inferior et rectus lateralis
mm.rectus lateralis et obliqus superior
mm.rectus inferior et obliqus superior
mm.rectus medialis et obliqus superior

What innetvates the accessory nuclei of oculomotor nerve:
m.levator palpebrae superioris
m.dilatator pupillae
m.ciliaris et m.obliqus oculi superior
*m.sphincter pupillae et m.ciliaris
m.sphincter pupillae et m.rectus superior

Choose the place of leaving of trochlear nerve from the cranial cavity:
*fissura orbitalis superior
foramen rotundum
fissura orbitalis inferior
canalis opticus
foramen ovale

What innervates by the trochlear nerve:
*m.obliqus superior
m.rectus medialis
m.obliqus inferior
m.rectus superior
m.rectuslateralis

The choroid of the eye ball contain:
corpus ciliare
iris
corpus vitreum
*chorioidea
lens

The choroid of the eye ball contain:
*fovea centralis
sclera
corpus vitreum
ornea
lens

The choroid of the eye ball contain:
sclera
*m.ciliaris
cornea
corpus vitreum
lens

External coat of eye ball consists of:
corpus ciliare
sinus venosus sclerae
*retina

Parts of external coat of eye ball:
iris, pupilla
*sclera, cornea

corpus ciliare, processus ciliares
retina, chorioidea
cornea, pupilae

Parts of middle coat of eye ball:
*tunica vasculosa bulbi
tunica fibrosa bulbi
sclera,cornea
chorioidea,pupilae
corpusciliare, retina

Doral part of middle coat of eye ball Задний отдел средней оболочки глазного яблока:
corpus ciliare
iris
sclera
*chorioidea
cornea

Parts of middle coat of eye ball:
*chorioidea,corpus ciliare,iris
chorioidea,sclera,cornea
corpus ciliare,iris,retina
iris,sclera,cornea
retina,chorioidea,cornea

Which parts has conjuctive:
conjunctiva superior et conjunctiva inferior
conjunctiva anterior et conjunctiva posterior
conjunctiva lateralis et conjunctiva medialis
*conjunctiva bulli,conjunctiva palpebrarum
conjunctiva externa et conjunctiva interna

The most ventral part of middle coat of eye ball:
corpus ciliare
cornea
*Iris
chorioidea
retina

There is located pupilla:
processus ciliares
cornea
*iris
sclera
chorioidea

Muscles of iris coat:
*m.sphincter pupillae, m.dilatator pupillae
m.cilliaris pupillae,m.dilatator pupillae
m.sphincter pupillae,m.cilliaris pupillae

m.obliquus oculi,m.rectus oculi
m.orbicularis oculi,m.cilliaris

Inner coat of eye ball Внутренняя оболочка глазного яблока:
sclera
chorioidea
cornea
*retina
discus n.optici

What is located on the white spot of eye floor:
pars pigmentoza
ora serrata
macula
foveacentralis
*discus n.optici

Through which subcortical centre of vision close pupil reflex:
corpus geniculatum laterale
pulvinarthalami
corpus geniculatum mediale
*colliculi superior
colliculiinferior

Where is located cortical center of vision:
gyrus temporalis superior
gyrus parahyppocampalis
*sulcus calcarinus
lobulusparacentralis
gyrusfrontalisinferior

What is between the external and middle ear:
fossa jugularis
*membrana tympani
tegme corpus geniculatum mediale
pulvinarthalami
colliculiinferior

In the eye floor located ovale area in red-brown color:
discus n.optici
pars pigmentoza
*macula
oraserrata
parsnervosa

The best vision place:
ora serrata, macula
discus n.optici, fovea centralis
pars nervosa, pars pigmentoza
*macula, fovea centralis

corpusvintreum, lens

Where concentrated only retinal conuses:
retina
*macula
pars nervosa
discus n.optici
ora serrata

Which parts has:
*pars tensa et pars flaccida
pars anterior et posterior
ars superior et inferior
pars externa et interna
pars medialis et lateralis

Walls of the cavitas timpanica:
*paries membranaceus
paries labirinticus
paries mamillaris
ars extrema
pars frontalis

Walls of the cavitas timpanica:
paries labirinticus
*paries caroticus
paries mamillaris
parsextrema
parsfrontalis

The place on floor of the eye where absente photosensitive cells:
*discus n.optici
macula
ora serrata
ovea centralis
retina

Where in eye ball refrectives light:
corpus ciliare,chorioidea
corpus ciliare,retina
orpus ciliare,m.ciliaris
*orpus vitreum,lens
lens,retina

How named changing of curvature of lens:
Adaptation
*Accomadation
Convergetation
Constipation
Contribution

Labyrinthus osseus contains:
*labyrinthus ethmoidalis
paries labirinticus
paries mamillaris
pars extrema
pars frontalis

Coats of eye ball:
tunica serosa
tunica muscularis
tunica mucosa
*tunica fibrosa
pupilla

Coats of eye ball
tunica serosa
*tunica vasculosa
tunica muscularis
tunica mucosa
pupilla

Coats of eye ball:
tunica serosa
tunica muscularis
*Chorioidea
tunica mucosa
pupilla

What innervates ciliar ganglia:
*m.sphincter pupillae et m.ciliaris
m. rectus superior
m. dilatator pupillae
m. levator palpebrae superioris
m. obliqus superior

From plexus caroticus internus leave:
*n.petrosus profundus
n.vagus
n.petrosus minoris
n.laryngeus inferior
n.mandibularis

What innervates by autonomic nervous system:
smooth muscles of blood vessel
*all answers are right
smooth muscles of inner organs
glands

In which parts divided the autonomic nervous sytem

central and pereferic центральный и периферический
*sympaticandparasympatic симпатический и парасимпатический
strengthens and depress усиливающий и угнетаюший
cranial, lumbarandspinalкраниальный, люмбальный и спинальный
all false

Truncus n. Spinalis divided into:a) ramus dorsalis, b) r.r. superior, c) r.r. communicantes albi, d) r. meningeus, e) r.r. craniales:
a,b,c
*a,c,d
b,c,d
a,d,e
a,c,e

Truncus n. spinalis divided into:a) r.r. inferior, b) ramus ventralis, c) r. communicantes albi, d) r. caudalis , e) r. dorsalis:
*b,c,e
a,c,d
c,d,e
b,d,e
a,b,d

Rami dorsales n. n. spinales:a) n. occipitalis minor, b) n. suboccipitalis, c) n. clunium inferior, d) n. occipitalis major, e) n. clunium medius:
*b,d,e
a,b,e
b,c,d
c,d,e
a,c,d

N. suboccipitalis innervates:a) m. epicranius, b) m. tranezius, c) m. rectus capitis major, d) m. semispinalis capitis, e) m. obliqus capitis:
a,c,e
b,c,e
a,b,d
*c,d,e
a,d,e

Branches of plexus cervicalis:a) n. occipitalis major, b) n. occipitalis minor, c) n. transversus colli, d) n.n. supraclaviculares, e) n. suboccipitalis:
*b,c,d
a,c,e
a,b,c
d,c,a
b,d,e

Branches of plexus cervicalis:a) n. auricularis magnus, b) n. auriculotemporalis, c) n. auricularis minor, d) n. transversus colli, e) n. phrenicus:
b,d,e
*a,d,e

c,d,e
a,c,e
b,c,d

Branches of plexus brachialis:a) n. phrenicus, b) n. subclavius, c) n. suprascapularis, d) n. suboccipitalis, e) n. axillaris:
*b,c,e
a,b,c
b,d,e
a,b,d
d,a,e

Innervations of anterior muscles of antebrachia:
n.radialis, n.ulnaris
n.medianus, n.radialis
n.axillaris, n.medianus
*n.medianus, n.ulnaris
n.ulnaris, n.axillaris

Innervations of dorsal muscles of antebrachia:
n.axillaris
n.ulnaris
n.musculocutaneus
*n.radialis
n.medianus

Innervations of dorsal muscles of brachia:
n.medianus
n.ulnaris
n.axillaris
n.musculocutaneus
*n.radialis

Innervations of anterior muscles of brachia:
*n.musculocutaneus
n.ulnaris
n.radialis
n.axillaris
n.medianus

Innervations of deep neck muscles:
n.axillaris
*plexus cervicalis
plexus brachialis
plexus lumbalis
n.vagus

Innervation ofmuscles of shoulder gilder:
*plexus brachialis
plexus cervicalis

plexus lumbalis
n.brachialis
n.axillaris

Innervations of deltoid muscle:
n.radialis
n.ulnaris
n.musculocutaneus
*n.axillaris
n.subclavius

Innervations of phrenicus:
n.intercostalis
n.axillaris
n.phrenica superior
*n.phrenicus
n.musculophrenica

Innervations of dorsal brachial muscles:
n.femoralis
*n.ischiadicus
n.obturatorius
n.popliteus
n.gluteus superior

Innervations of medial group of brachial muscles:
*n.obturatorius
n.femoralis
n pudendus
n.popliteus
n.ischiadicus

Innervations of anterior group of hip muscles:
n.obturatorius
*n.femoralis
n.ischiadicus
n.poplitea
n pudendus

Innervations of anterior group of leg muscles:
n.peroneus superficialis
n.tibialis
n.femoralis
n.obturatorius
*n.peroneus profundus

Innervation of lateral muscle group of leg. 403 429 489 500 544:
*n.peroneus superficialis
n.peroneus profundus
n.tibialis

n.obturatorius
n.femoralis

Innervation of back group of leg:
n.peroneus superficialis
n.obturatorius
*n.tibialis
n.femoralis
n.peroneus profundus

Innervation of front muscles of abdomen:
n.obturatorius
*nn.intercostales
n.abdominalis
n.epigastrica superior
n.interossea

Innervation of lateral muscles of abdomen:
*n.ilioinguinalis
n.obturatorius
n.abdominalis
n.epigastrica superior
n.interossea

Innervation of back group of abdomen:
plexus sacralis
n.obturatorius
plexus brachialis
*plexus lumbalis
n.subcostalis

Innervation of M.trapezius:
*Pl.cervicalis
Pl.brachialis
X nerve
XII nerve
n.intercostales

Innervation of own muscles of chest:
n.subcostalis
n.thoracica profundus
n.subscapularis
*nn.intercostales
n.axillaris

Innervation of superficial muscles of back:
*Pl.brachialis
Pl.cervicalis
n.thoracica profundus
n.subscapularis

n.axillaris

Innervation of deep muscles of back:
n.intercostalis posterior, n.lumbalis
anterior braches of spinal nerves
n.intercostalis anterior, n.lumbalis
*dorsal branches of spinal nerves
n.iliolumbalis, n.intercostalis

Innervation of superficial muscles of chest:
long branches of Pl.brachialis
long branches of n.intercostalis
short branches of n.intercostalis
*short branches of Pl.brachialis
short branches of n.iliolumbalis

By what orbit connects with pterygopalatine fossa and what happens:
foramen rotundum, n.maxillaris
*fisurra orbitalis inferior, n.infraorbitalis
fissura orbitalis superior, n.mandibularis
foramen ovalae, n.ophtalmicus
foramen sphenopalatinum, n.nasalis posterior

Innervation of liver:
n.vagus, plexus mesentericus
n.phrenicus, n.vagus
n.vagus, plexus hepaticus
*n.vagus, plexus celiacus
n.vagus, plexushepaticus

By what orbit connects with middle cranial fossa and which nerves passes ther:
fissura orbitalis inferior et canalis opticus, n.infraorbitalis, n.opticus
foramen.rotundum, fissura orbitalis superior, n.maxillaris, n.ophthalmicus
foramen.ovale, fissura orbitalis superior, n.mandibularis, n.ophthalmicus
fissura orbitalis superior, fissura orbitalis inferior, n.ophthalmicus, n.infraorbitalis
*fissura orbitalis superior et canalis opticus, n.ophthalmicus, n.opticus

Innervation of bladder.
*nn.splanchnici pelvini, plexus hypogastricus
n.vagus, plexus hypogastricus
n.splanchnici pelvini, n.vagus
n.vagus, n.splanchnici major
n.vesicalis, plexus vesicalis

Innervation of testis:
*plexus hypogastricus inferior, nn.splanchnici pelvini
plexus gastricus inferior, nn.splanchnici vesicalis
plexus hypogastricus, n.pudendus
n.pudendus, nn.splanchnici pelvini
n. iliaca interna, plexus hypogastricus

Innervations of ovarium:
*plexus hypogastricus inferior, nn.splanchnici pelvini
n.vagus, plexus celiacus
n.vagus, plexus hypogastricus
plexus splanchnici pelvini, n.vagus
n.vagus, plexus hypogastricus

Innervation of perineum:
pudenda extern iliaca externa, иннерв:n.pudendus
pudenda superior aorta abdominalis, иннерв:n.vagus
pudenda intern iliaca communis, иннерв:n.femoralis
pudenda externa iliaca interna, иннерв:n.pudendus
*pudenda intern iliaca interna, иннерв:n.pudendus

Innervation of larynx:
n.vagus, plexus celiacus
n.glossopharyngeus, truncus sympaticus
n.vagus, plexus mesentericus
*n.vagus, truncus sympaticus
n.phrenicus, n.glossopharyngeus

Innervation of superficial muscles of neck:
n.trigeminus, n.accessorius, plexus brachialis
*n.facialis, n.accessorius, plexus cervicalis
n.facialis, plexus brachialis
n.accessorius
n.trigeminus, plexus cervicalis

Innervation of bronchi and lungs:
n.vagus, truncus sympaticus
n.vagus, plexus coeliacus
n.pulmonalis, plexus pulmonalis
*n.vagus, truncus sympaticus
n.vagus, plexus coeliacus

Innervation of kidneys:
n.vagus, truncus sympaticus
n.renalis, plexus renalis
n.vagus, plexus mesentericus
*n.vagus, plexus coeliacus
n.phrenicus, plexus coeliacus

Innervation of pancreas:
n.vagus, plexus mesentericus
n.phrenicus, plexus coeliacus
*n.vagus, plexus coeliacus
n.vagus, plexus mesentericus superior
n.caeliacus, plexus pancreaticus

Innervation of sigmoid colon:
*nn.splanchnici pelvini, plexus mesentericus inferior
n.vagus, plexus pancreaticus
n.vagus, plexus mesentericus superior
n.vagus, nn.splanchnici pelvini
n.vagus, plexus mesentericus inferior

Innervation of rising part of the colon:
*n.vagus, plexus mesentericus superior
n.vagus, plexus coeliacus
n.phrenicus, plexus hypogastricus
n.vagus, plexus hypogastricus
n.vagus, nn.splanchnici pelvini

Innervation of transverse colon:
*n.vagus, plexus mesentericus superior
n.vagus, plexus coeliacus
n.vagus, plexus hypogastricus
n.vagus, plexus mesentericus inferior
n.vagus, nn.splanchnici pelvini

Innervation of descending part of colon:
n.vagus, plexus mesentericus superior
n.vagus, plexus coeliacus
plexus mesentericus inferior, n.phrenicus
*n.vagus, plexus mesentericus inferior
n.hypogastricus, n.vagus

Innervation of cecum:
*n.vagus, plexus mesentericus superior
n.vagus, plexus mesentericus inferior
n.ileocolica, plexus coeliacus
n.colica media, n.vagus
n.vagus, plexus coeliacus

Innervation of ileum:
n.hypoglossus, plexus coeliacus
n.phrenicus, plexus coeliacus
*n.vagus, plexus coeliacus
n.vagus, plexus mesentericus
n.pharyngeus, plexus coeliacus

Innervation of stomach:
n.vagus, plexus mesentericus
n.phrenicus, n.gastricus
plexus celiacus, plexus mesentericus
*n.vagus, plexus coeliacus
n.gastricus, n.celiacus

Innervation of submandibular and sublingual salivary glands:

temporalis superficialis, n.chorda tympani
facialis, n.vagus
facialis, IX нерв
*facialis, n.chorda tympani
alveolaris inferior, n.chorda tympani

Innervation of tongue muscles:
*n.hypoglossus
n.facialis
n.abdusens
n.pharyngeus
n.accesorius

Innervation of submandibular and sublingual salivary glands:
n.pharyngeus
n.vagus
n.facialis
*n.chorda tympani
n.alveolaris inferior

What comes out through infraorbital foramen:
n.alveolaris superior
n.palpebralis inferior
*n.infraorbitalis
n.supraorbitalis
n.nasalis lateralis

Innervation of abdomen part of esophagus:
n.vagus plexus mesentericus
n.vagus, plexus coeliacus
n.vagus, n.glossopharyngeus
*n.vagus, truncus sympaticus
n.vagus, plexus aorticus

Innervation of jejunum:
n.vagus, truncus sympaticus
*n.vagus, plexus coeliacus
n.vagus, n.glossopharyngeus
n.vagus, plexus aorticus
n.vagus, plexus mesentericus

Innervation of duodenum:
n.vagus plexus mesentericus
n.vagus, n.phrenicus
n.vagus, truncus sympaticus
*n.vagus, plexus coeliacus
n.glossopharyngeus, n.vagus,

Patient loss skin sensitivity of the back surface of the forearm. Which nerve injured:
n.ulnaris

n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient has disfunction of extension in radiocarpal joint. Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient loss sensitivity of skin of back surface of leg.Which nerve injured:
n.saphenus
n.peroneussuperficialis
*n.suralis
n.peroneusprofundus
n.tibialis

Patient loss skin sensitivity of medial surface of leg. Which nerve injured:
n.peroneus communis
n.obturatorius
*n.saphenus
n.peroneus superficialis
n.peroneusprofundus
n.vagus

Index of patient does not exten Which nerve injured:
n.ulnaris
*n.radialis
n.medianus
n.musculocutaneus
n.axillaris

Patient has disfunction of fingers extension of han Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient has pronation disfunction of forearm and han Which nerve injured:
n.radialis
n.ulnaris
n.musculocutaneus
*n.medianus
n.axillaris

Thumb of patient does not exten Which nerve injured:
n.radialis

n.ulnaris
n.axillaris
n.musculocutaneus
*n.medianus

Patient loss sensitivity of mucosa membrane of cheek. Which nerve injured:
*n.mandibularis
n.maxillaris
n.ophtalmicus
n.facialis
n.glossopharyngeus

Patient has eyeball abduction disfunction. Which nerve injured:
n.trochlearis
n.oculomotorius
n.ophtalmicus
*n.abducens
n.opticus

Innervation of anterior muscle group of forearm:
n.radialis, n.ulnaris
n.medianus, n.radialis
n.ulnaris, n.axillaris
*n.medianus, n.ulnaris
n.axillaris, n.medianus

Innervation of posterior muscle group of forearm:
n.ulnaris
*n.radialis
n.medianus
n.axillaris
n.musculocutaneus

Innervation of posterior muscle group of shoulder:
n.medianus
n.ulnaris
n.axillaris
*n.radialis
n.musculocutaneus

Innervation of anterior muscle group of shoulder:
*n.musculocutaneus
n.ulnaris
n.radialis
n.medianus
n.axillaris

Innervation of deep muscles of neck:
n.axillaris
plexus brachialis

n.musculocutaneus
n.vagus
*plexus cervicalis

Innervation of shoulder girdle muscles:
*plexus brachialis
plexus cervicalis
n. subclavia
n.brachialis
n. axillaris

Innervation of deltoid muscles:
n.radialis
n.ulnaris
n.musculocutaneus
n.intercostalis
*n.axillaris

Innervation of diaphragm:
n.intercostalis
*n.phrenicus
n.phrenica superior
n.axillaris
n.musculophrenica

Innervation of posterior muscle group of hip:
n.femoralis
n.obturatorius
n.popliteus
*n.ischiadicus
n.tibialis

Innervation of medial muscle group of hip:
*n.obturatorius
n.femoralis
n.obturatorius
n.popliteus
n.tibialis

Innervation of anterior muscle group of hip:
n.obturatorius
*n.femoralis
n.ischiadicus
n.tibialis
n.peroneus superficialis

Innervation of anterior muscle group of leg:
n.peroneus superficialis
n.tibialis
n.tibialis anterior

*n.peroneus profundus
n.femoralis

Innervation of lateral muscle group of leg:
*n.peroneus superficialis
n.peroneus profundus
n.tibialis anterior
n.tibialis
n.femoralis

Innervation of posterior muscle group of leg:
n.peroneus superficialis
n.peroneus
*n.tibialis
n.femoralis
n.peroneus anterior

Innervation of anterior muscles of abdomen:
n.lumbalis
n.thoracica
n.abdominalis
*n.intercostales
n.abdominalis lateralis

Innervation of lateral muscles of abdomen:
*n.intercostales, n.iliohypogastricus, n.ilioinguinalis
n.thoracica superior, n.intercostalis
n.intercostalis, n.lumbalis
n.thoracica, n.intercostalis
n.lumbalis, n.abdominalis lateralis

Innervation of posterior muscles of abdomen:
plexus brachialis
plexus sacralis
plexus cervicalis
*plexus lumbalis
n.intercostalis

Innervation of M.trapezius:
Pl.cervicalis, Pl.brachialis
Pl.cervicalis, X nerve
XII nerve, Pl. brachialis
Pl.cervicalis, n.intercostales
*XI nerve, Pl.cervicalis

Innervation of own muscles of chest:
n.subcostalis
*n.intercostales
n.thoracica profundus
n.subcostalis

n.axillaris

Innervation of shoulder girdle muscles:
*plexus brachialis
plexus cervicalis
n. subclavia
n.brachialis,
n. axillaris

Innervation of deep muscles of back:
*posterior branches of spinal nerves
Pl. brachialis
Pl.cervicalis
n.intercostalis anterior, n.lumbalis
n.iliolumbalis, n.intercostalis

Innervation of superficial muscles of chest:
*short branches of Pl.brachialis
long branches of l.brachialis
n.intercostalis
Pl.cervicalis
n.subcostalis

With what orbit connects with pterygopalatine fossa and what happens:
n.maxillaris
n.ophtalmicus
n.mandibularis
*n.infraorbitalis
n.nasalis posterior

Innervation of liver:
n.vagus, plexushepaticus
n.vagus, plexus mesentericus
n.phrenicus, n.vagus
n.vagus, plexus hepaticus
*n.vagus, plexus celiacus

By what orbit connects with middle cranial fossa and which nerves passes there:
n.infraorbitalis, n.opticus
*n.ophthalmicus, n.opticus
n.maxillaris, n.ophthalmicus
n.ophthalmicus, n.infraorbitalis
n.mandibularis, n.ophthalmicus

Innervation of bladder:
*n.splanchnici pelvini, plexus hypogastricus
n.vagus, plexus hypogastricus
n.splanchnici pelvini, n.vagus
n.vagus, n.splanchnici major
n.vesicalis, plexus vesicalis

Innervation of testis:
*n.splanchnici pelvini
n.splanchnici pelvini
n.pudendus
n.pudendus, nn.splanchnici pelvini
n.pudendus, plexus hypogastricus

Innervations of ovarium:
n.vagus, plexus celiacus
n.vagus, plexus hypogastricus
*n.splanchnici pelvini
n. pudendus, plexus celiacus
n. pudendus, plexus hypogastricus

Innervation of perineum:
n.pudendus
n.vagus
n.femoralis
*n.pudendus

Innervation of larynx:
n.vagus, plexus celiacus
*n.vagus, truncus sympaticus
n.glossopharyngeus, truncus sympaticus
n.vagus, plexus mesentericus
n.phrenicus, n.glossopharyngeus

Innervation of superficial muscles of neck:
n.accessorius
n.trigeminus, n.accessorius, plexus brachialis
n.facialis, plexus cervicalis
*n.facialis, n.accessorius, plexus cervicalis
n.trigeminus, plexus cervicalis

Innervation of bronchi and lungs:
n.vagus, truncus sympaticus
n.vagus, plexus coeliacus
n.pulmonalis, plexus pulmonalis
*n.vagus, truncus sympaticus
n.vagus, plexus coeliacus

Innervation of kidneys:
n.vagus, plexus coeliacus
n.renalis, plexus renalis
n.vagus, plexus mesentericus
*n.vagus, plexus coeliacus
n.phrenicus, plexus coeliacus

Innervation of pancreas:

n.vagus, plexus mesentericus
n.phrenicus, plexus coeliacus
*n.vagus, plexus coeliacus
n.vagus, plexus mesentericus superior
n.caeliacus, plexus pancreaticus

Innervation of sigmoid colon:
*n.splanchnici pelvini, plexus mesentericus inferior
n.vagus, plexus mesentericus superior
n.vagus, plexus mesentericus inferior
n.splanchnici pelvini, n.vagus
n.vagus, plexus mesentericus superior

Innervation of rising part of the colon:
*n.vagus, plexus mesentericus superior
n.vagus, plexus mesentericus
n.phrenicus, plexus hypogastricus
n.vagus, plexus hypogastricus
n.vagus, plexus hypogastricus

Innervation of transverse colon:
*n.vagus, plexus mesentericus superior
n.vagus, plexus hypogastricus
n.vagus, plexus mesentericus inferior
n.vagus, plexus mesentericus superior

Innervation of descending part of colon:
n.vagus, plexus mesentericus superior
*n.vagus, plexus mesentericus inferior
n.phrenica, plexus mesentericus inferior
n.hypogastricus, n.vagus

Innervation of cecum:
*n.vagus, plexus mesentericus superior
n.vagus, plexus mesentericus inferior
n.ileocolica, plexus coeliacus
n.colica media, n.vagus
n.vagus, plexus mesentericus inferior

Innervation of tongue muscles:
n.lingualis, a lingualis a carotis externa
*n.hypoglossus, a lingualis a carotis externa
n.glossopharyngeus, a lingualis a maxillaris
n.chorda tympani, a lingualis a carotis interna
n.vagus, a glossopharyngeus a maxillaris

Innervation of ileum:
n.vagus, plexus coeliacus
n.phrenicus, plexus coeliacus
*n.vagus, plexus coeliacus

n.vagus, plexus mesentericus
n.vagus, plexus coeliacus

Innervation of stomach:
n.vagus, plexus mesentericus
plexus celiacus, plexus mesentericus
n.phrenicus, n.gastricus
n.gastricus, n.celiacus
*n.vagus, plexus coeliacus

Innervation of larynx:
n.vagus, plexus celiacus
n.nasalis lateralis, truncus sympaticus
n.vagus, plexus mesentericus
*n.vagus, truncus sympaticus
n.phrenicus, n.glossopharyngeus

Index of patient does not exten Which nerve injured:
n.ulnaris
*n.radialis
n.medianus
n.musculocutaneus
n.axillaris

Innervation of submandibular and sublingual salivary glands:
n.supraorbitalis
*n.chorda tympani
n.vagus
n.palpebralis inferior
n.nasalis lateralis

What comes out throuth infraorbital foramen:
n.alveolaris superior
n.palpebralis inferior
*n.infraorbitalis
n.supraorbitalis
n.nasalis lateralis

Innervation of abdomen part of esophagus:
n.vagus, truncus sympaticus
n.vagus, n.phrenicus
n.vagus, plexus mesentericus
*n.vagus, truncus sympaticus
n.glossopharyngeus, n.vagus

Innervation of jejunum:
n.vagus, truncus sympaticus
n.vagus, n.phrenicus
n.glossopharyngeus, n.vagus
*n.vagus, plexus coeliacus

n.vagus, plexus mesentericus

Innervation of duodenum:
n.vagus, truncus sympaticus
*n.vagus, plexus coeliacus
n.vagus, plexus mesentericus
n.vagus, n.phrenicus
n.glossopharyngeus, n.vagus

Patient loss skin sensitivity of the back surface of the forearm. Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient has disfunction of extension in radiocarpal joint. Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient loss sensitivity of skin of back surface of leg.Which nerve injured:
n.saphenus
n.peroneussuperficialis
*n.suralis
n.peroneusprofundus
n.tibialis

Patient loss skin sensitivity of medial surface of leg. Which nerve injured:
n.peroneus communis
n.obturatorius
*n.saphenus
n.peroneus superficialis
n.peroneusprofundus

Index of patient does not exten Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
n.axillaris
*n.radialis

Patient has disfunction of fingers extension of han Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient has pronation disfunction of forearm and han Which nerve injured:
n.radialis
n.ulnaris
n.musculocutaneus
n.axillaris
*n.medianus

Thumb of patient does not exten Which nerve injured:
n.axillaris
*n.medianus
n.ulnaris
n.radialis
n.musculocutaneus

Patient loss sensitivity of mucose membrane of cheek. Which nerve injured:
*n.mandibularis
n.maxillaris
n.ophtalmicus
n.facialis
n.glossopharyngeus

Patient has eyeball abduction disfunction. Which nerve injured:
n.trochlearis
n.oculomotorius
*n.abducens
n.ophtalmicus
n.opticus

Patient has tongue abduction disfunction. Which nerve injured:
n.trochlearis
*n.hypoglossus
n.oculomotorius
n.ophtalmicus
n.opticus

Patient has disfunction of leg extension. Which nerve injured:
n.trochlearis
n.oculomotorius
*n.femoralis
n.ophtalmicus
n.opticus

Patient has disfunction of hand flexion. Which nerve injured:
n.trochlearis
n.oculomotorius
n.ophtalmicus
*n.medianus
n.opticus

Patient has disfunction of leg extension. Which nerve injured:
n.trochlearis
n.oculomotorius
n.opticus
*n.femoralis
n.ophtalmicus

Patient loss skin sensitivity of the back surface of the forearm. Which nerve injured:
n.ulnaris
n.medianus
n.musculocutaneus
*n.radialis
n.axillaris

Patient loss skin sensitivity of the back surface of the shoulder. Which nerve injured:
n.ulnaris
*n.radialis
n.medianus
n.musculocutaneus
n.axillaris

Patient loss skin sensitivity of the back surface of the han Which nerve injured:
n. cutaneus antebrahi lateralis
n.medianus
*n.radialis
n.musculocutaneus
n.axillaris

Patient loss skin sensitivity of the medial surface of the forearm. Which nerve injured:
*n.cutaneus antebrahi medialis
n.ulnaris
n.medianus
n.musculocutaneus
n.cutaneus antebrahi lateralis

Patient loss skin sensitivity of the lateral surface of the forearm. Which nerve injured:
*n.musculocutaneus
n.radialis
n.ulnaris
n.medianus
n.axillaris

Patient loss skin sensitivity of the anterior surface of the hip. Which nerve injured:
n.ishiadicus
n.tibialis
n.medianus
*n.femoralis
n.axillaris

Patient has disfunction of leg extension. Which nerve injured:

n.trochlearis
*n.femoralis
n.oculomotorius
n.ophtalmicus
n.opticus

Patient has disfunction of hand flexion. Which nerve injured:
n.trochlearis
*n.medianus
n.oculomotorius
n.ophtalmicus
n.opticus

Patient has disfunction of leg flexion. Which nerve injured:
n.trochlearis
*n.ishiadicus
n.oculomotorius
n.ophtalmicus
n.opticus

Rhinencephalon consists of:
*bulbus olfactorius
*trigonum olfactorium
cornu superior
cornu inferior

Rhinencephalon consists of:
*tractus olfactorius
substantia perforata anterior
cornu anterior
cornu posterior

Rhinencephalon consists of:
*gyrus dentatus
*gyrus fornicates
gyrus centralis
gyrus temporalis

Rhinencephalon consists of:
*gyrus hippocampus
*gyrus fornicates
gyrus frontalis
gyrus temporalis

Ventriculus quartus consists of:
*fossa rhomboidea
*tegmen ventriculi quarti
lamina tecti
colliculi superior

Pons consists of:
*sulcus basilaris
*corpus trapezoideum
sulcus lateralis
sulcus medialis

Pons consists of:
*nucleus dorsalis corporis trapezoidei
*pars dorsalis
sulcus lateralis
sulcus medialis

Pons consists of:
*pars ventralis
*sulcus basilaris
sulcus anterior
sulcus posterior

Cerebellumconsists of:
*arbor vitae cerebelli
*nucleus dentatus
nucleus gracilis
nucleus cuneatus

Cerebellumconsists of:
*nucleus fastigii
*nucleus dentatus
nucleus cuneatus
nucleus matorius

Cerebellumconsists of:
*nucleus emboliformis
*nucleus fastigii
pars centralis
cornu superior

Cerebellumconsists of:
*nucleus globosus
*floculus
cornu inferior
pars dorsalis

Mesencephalon consists of:
*brachium colliculi superioris
*brachium colliculi inferioris
pars centralis
cornu inferior

Epitalamusconsists of:
*habenula

*trigonum habenulae
pars ventralis
pars dorsalis

MEDULLA SPINALIS consisnt of:
pars pelvina
*pars cervicalis
pars abdominalis
*pars thoracica
*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
pars pelvina
pars laryngea
*pars sacralis
*pars coccygea
*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
nucleus cuneatus
*conus medullaris
*filum terminalis
*intumescentia cervicalis
lemniscus medialis
pars medialis

MEDULLA SPINALIS has:
*nucleus thoracicus
*funiculus anterior
*intumescentia lumbosacralis
nucleus cochlearis dorsalis
pars medialis
nucleus fastigii

MEDULLA SPINALIS has:
*fissura mediana anterior
funiculus inferior
nucleus vestibularis
*canalis centralis
*substantia grisea
pars medialis

MEDULLA SPINALIS has:
fissura mediana inferior
*sulcus lateralis posterior
columna superior
*funiculus lateralis
*columna posterior

pars medialis

MEDULLA SPINALIS has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

MEDULLA OBLONGATA has:
cornu lateralis
*fissura mediana anterior
*decussatio pyramidum
*olive
pars cervicalis
pars medialis

MEDULLA OBLONGATA has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

MEDULLA OBLONGATA has:
cornu lateralis
*fissura mediana anterior
*decussatio pyramidum
olive
pars cervicalis
nucleus fastigii

PONS has:
*nucl.salivatorius superior
*corpus trapezoideum
*sulcus basillaris
nucl.dorsalis n, vagi
nucl.dentatus
nucleus fastigii

VENTRICULUS QUARTUS has:
nucleus globosus
fossa lateralis
*eminentia medialis
*colliculis facialis
*area vestibularis
nucleus fastigii

CEREBELLUM has:
*folia cerebelli
nucleus lacremalis
locus ceruleus
*vermis cerebelli
*nodulus
colliculis facialis

MESENCEPHALON has:
*colliculus superior
*pedunculis cerebri
nucl.motorius n.trigemini
*colliculus inferior
n. Trigeminus
colliculis facialis

There are in DIENCEPHALON:
*epithalamus
colliculis superior
decussatio trochlearis
*habenula
*corpus pineale
colliculis facialis

TRACTUS OPTICUS has:
sulcus calcarinus
colliculis facialis
*colliculus superior
*pulvinar thalami
*corpus geniculatum laterale
vermis

TRACTUS VESTIBULAE COCHLEARIS has:
*colliculus inferior
*corpus geniculatum mediale
*gyrus temporalis superior
colliculis superior
gyrus precentralis
vermis

Truncus n. Spinalis has:
*ramus dorsalis
r superior
*r.r. communicantes albi
*r. Meningeus
r.r. craniales
r.r. inferior

Truncus n. Spinalis has:
r.r. inferior

*ramus ventralis
*r. communicantes albi
r. Caudalis
*r. Dorsalis
r.r. superior

N. Suboccipitalis has:
m. Epicranius
m. Trapezius
*m. rectus capitis major
*m. semispinalis capitis
*m. obliqus capitis
m. teres major

Plexus cervicalis has:
n. occipitalis major
*n. occipitalis minor
*n. transversus colli
*n.n. supraclaviculares
n. Suboccipitalis
n.clunium medius

Plexus brachialis has:
n. Phrenicus
*n. Subclavius
*n. Suprascapularis
n. Suboccipitalis
*n. Axillaris
n.clunium medius

Plexus brachialis has:
*n. Medianus
*n. Axillaris
*n. Ulnaris
n. Iliohypogastricus
n. Obturatorius
n.clunium medius

Plexus brachialis has:
n.clunium medius
*n. cutaneus brachii medialis
*n. n. Radialis
*n. Musculocutaneus
n. Pudendus
n.phrenicus

Plexus brachialis has
n. Femoralis
*n. Medianus
n. Ilioinguinalis

*n. cutaneus antebrachii medialis
*n. Radialis
n.clunium medius

N. Musculocutaneus supplies:
m. triceps brachii
*m. Coracobrachialis
m. Brachioradialis
*m. biceps brachii
*m. Brachialis
m.clunium medius

N. Medianus supplies:
m.clunium medius
m. auricularis magnus
m. Phrenicus
*m. pronator quadrates
*m. flexor digitorum superficialis
*m. flexor pollicis longus

N. radialis supplies:
*m. extensor carpi radialis brevis
m.pronator teres
*m. extensor digitorum
m. brachialis
*m. supinator
m. obliquus externus abdominis

N. intercostales supplies:
m. biceps brachii
m. triceps brachii
*m. subcostalis
*m.m. intercostales externi
*m. transversus thoracis
m.pronator teres

DIAPHRAGMA is supplied with:
n. vagus
*n. intercostalis
*n. phrenicus
*Plexus cervicalis
C3 C4
n.clunium medius

M. biceps brachii is supplied with:
n. vagus
n. intercostalis
*Plexus brachialis
C3 C4
*C5 C7

*n. Musculocutaneus

M. triceps brachii is supplied with:
*Plexus brachialis
*n. radialis
*C5 C8, Th1
n. musculocutaneus
C1 C4, Th1
Plexus cervicalis

N. Vagus has:
*ramus meningeus
*ramus auricularis
*rami pharyngei
ramus stylophryngeus
ramus auriculotemporalis
n. mylohyoideus

N. Vagus has:
chorda tympani
*n. laryngeus superior
n. Stapedius
*n. laryngeus recurrens
*rami bronchiales
n. mylohyoideus

n. vagus has:
nucleus salivatorius superior
*nucleus solitaries
*nucleus ambiguus
nucleus salivatorius inferior
*nucleus dorsalis
nucleus inferior

N. femoralis supplies:
*m. quadriceps femoris
m. gracilus
m. obturatorius externus
*m. Sartorius
*m. pectineus
m. pyramidalis

N. hypoglossus supplies:
m.digastricus
*m. genioglossus
*m.styloglossus
m. stylopharyngeus
*m. transversus linguae
m. palatopharyngeus

N. hypoglossus supplies:
*m. longitudinalis linguae
m. Mylohyoideus
*m.verticalis linguae
*m. Genioglossus
m. Palatopharyngeus
m. palatopharyngeus

N. Ophtalmicus has:
*n. Frontalis
*n. Lacrimalis
*n. Nasociliaris
n. Zygomaticus
n. nasalis posterior
n. olfactorius

N. Mandibularis has:
*n. Lingualis
n. Nasopalatinus
*n. alveolaris inferior
n. Zygomaticus
*n. Auriculotemporalis
n. olfactorius

N. Mandibularis has:
*n. Lingualis
n. Nasopalatinus
*n. alveolaris inferior
n. Zygomaticus
*n. Auriculotemporalis
n. olfactorius

N. Mandibularis has:
n.n. palatini
*n. Buccalis
*n. pterygoideus medialis
*n. tensoris tympani
n. Pharyngeus
n. olfactorius

N. Mandibularis has:
*n. Massetericus
n. Stylopharyngeus
*n.tensoris veli palatine
n. Uvulae
*n. Mylohyoideus
n. olfactorius

N. Mandibularis has:
*n. temporalis profundus

*n. pterigoideus lateralis
n. Olfactorius
n. Hyoglossus
*n. Mylohyoideus
n. palatopharyngeus

N. Facialis has:
*n. petrosus major
n. petrosus minor
*n.stapedius
n. Lingualis
*n.chorda tympani
n. palatopharyngeus

N. facialis has:
*nucleus motorius
nu salivatorius inferior
*nucl. salivatorius superior
*nucl. Solitaries
nucl. ambigius
n. albus

N. glossopharyngeus has:
n. genioglossus
*n. tympanicus
*ramus m. stylopharyngei
*rami tonsillares
n. buccalis
n. mylohyoideus

N. glossopharyngeus has:
*rami pharyngei
n. alveolaris inferior
n. Zygomaticus
*rami linguales
*ramus sinus carotici
n. mylohyoideus

N. Vagus has:
*ramus meningeus
*ramus auricularis
*rami pharyngei
ramus stylophryngeus
ramus auriculotemporalis
n. mylohyoideus

N. Vagus has:
chorda tympani
*n. laryngeus superior
n. Stapedius

*n. laryngeus recurrens
*rami bronchiales
n. mylohyoideus

N.vagus has:
nucleus salivatorius superior
*nucleus solitaries
*nucleus ambiguus
nucleus salivatorius inferior
*nucleus dorsalis
nucleus inferior

Innervation of eye muscules:
*n. Oculomotorius
*n. Trochlearis
n. Ophthalmicus
n. Opticus
*n. Abducens
n. mylohyoideus

N. Oculomotorius supplies:
m. rectus lateralis
*m. rectus superior
m. obliquus inferior
*m. obliquus superior
*m. rectus medialis
n. mylohyoideus

N. glossopharyngeus has:
nu spinalis
nu salivatorius superior
*nu Solitaries
*nu salivatorius inferior
*nu Ambigius
n. mylohyoideus

Gustatory innervation of tongu:
n. glossopharyngeus
*n. mandibularis
*n. vagus
n. olfactorius
n. facialis
*chorda tympani

Part of spinal cord:
pars pelvina
*pars cervicalis
pars abdominalis
*pars thoracica
*pars lumbalis

pars medialis

Part of spinal cord:
pars pelvina
pars laryngea
*pars sacralis
*pars coccygea
*pars lumbalis
pars medialis

Medulla spinalis has:
nucleus cuneatus
*conus medullaris
*filum terminalis
*intumescentia cervicalis
lemniscus medialis
pars medialis

Medulla spinalis has:
*nucleus thoracicus
*funiculus anterior
*intumescentia lumbosacralis
nucleus cochlearis dorsalis
pars medialis

Medulla spinalis has:
*fissura mediana anterior
funiculus inferior
nucleus vestibularis
*canalis centralis
*substantia grisea
pars medialis

Medulla spinalis has:
fissura mediana inferior
*sulcus lateralis posterior
columna superior
*funiculus lateralis
*columna posterior
pars medialis

Medulla spinalis has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

Medulla spinalis has:

cornu lateralis
*fissura mediana anterior
*decussatio pyramidum
olive
pars cervicalis
pars medialis

Medulla oblongatae has:
*pedunculi cerebellaris inferior
*fasciculus cuneatus
*tuberculum nugracilis
sulcus basilaris
lemniscus trigeminalis
pedunculi cerebellaris superior

Medulla oblongatae has:
*tuberculum nuclei cuneati
nucleus dentatus
flocculus
*lemniscus medialis
*formatio reticularis
pedunculi cerebellaris superior

Medulla oblongatae has:
nucleus fastigii
*nucleus n.hypoglossi
nodulus
*nucleus dorsalis n.vagi
*nucleus ambiguus
pedunculi cerebellaris superior

PONS has:
fissura mediana anterior
nucleus n.hypoglossi
*sulcus basilaris
*pedunculi cerebellaris medius
*formatio reticularis
nucleus fastigii

PONS has:
fissura mediana anterior
nucl.dentatus
*nucl.n.facialis
*nucl.motorius n.trigemini
*nucl.n.abducentis
nucleus fastigii

PONS has:
*nucl.salivatorius superior
*corpus trapesoideum sulcus basilaris

*lemniscus lateralis
nucl.dorsalis n, vagi
nucl.dentatus
nucleus fastigii

PONS has:
*pedunculus cerebellaris medius
*sulcus basilaris
decussatio pyramidum
*nucl.cochleares
nucl.olivaris
nucleus fastigii

VENTRICULUS QUARTUS has:
hilus nuclei dentati
*fossa rhomboidea
decussatio pyramidum
*recessus lateralis
*sulcus medianus
nucleus fastigii

VENTRICULUS QUARTUS has:
nucleus globosus
fossa lateralis
*eminentia medialis
*colliculis facialis
*area vestibularis
nucleus fastigii

VENTRICULUS QUARTUS has:
velum medullare lateralis
*trigonum n.hypoglossi
*trigonum n.vagi
*velum medullare inferius
trigonum n.oculomotorii
nucleus fastigii

VENTRICULUS QUARTUS has:
*tela chorioidea
*plexus choroideus
*apertura mediana ventriculi quarti
velum lateralis
trigonum n.trigemini
nucleus fastigii

CEREBELLUM has:
*folia cerebelli
nucleus lacremalis

trigonum n.vagi
*vermis cerebelli
nodulus
*colliculis facialis

CEREBELLUM has:
*folia cerebelli
pedunculus cerebri
trigonum n.vagi
*arbor vitae
*nucleus dentatus
colliculis facialis

CEREBELLUM has:
colliculis lateralis
trigonum n. Vagi
*nucleus fastigii
*hemispherium cerebelli
*nucleus dentatus
colliculis facialis

CEREBELLUM has:
colliculis lateralis
*nucleus globosus
*nucleus emboliformis
*pedunculus cerebellaris inferior
nucleus ruber
colliculis facialis

CEREBELLUM has:
*pedunculi cerebellaris medius
*pedunculi cerebellaris inferior
*pedunculi cerebellaris superior
pedunculus cerebellaris lateralis
pedunculi cerebellaris intermedialis
colliculis facialis

MESENCEPHALON has:
nucl.n.facialis
*aqueductus cerebri
*colliculis superior
*nucleus n.oculomotorius
foramen interventricularis
colliculis facialis

MESENCEPHALON has:
*nucl.ruber
*colliculis superior
*formatio reticularis
nucleus n.hypoglossus

nucl.caudatus
colliculis facialis

DIENCEPHALON has:
*epithalamus
colliculis superior
decussatio trochlearis
*habenula
*corpus pineale
colliculis facialis

DIENCEPHALON has:
fossa romboidea
*trigonum habenulae
nucl.globosus
*thalamus opticus
*metathalamus
colliculis facialis

DIENCEPHALON has:
nucl. Ruber
cornu laterale
*hypothalamus
*corpus geniculatum laterale
*corpus mamillare
colliculis facialis

DIENCEPHALON has:
colliculis superior
*pulvinar thalami
*corpus geniculatum mediale
*chiasma opticum
nucl.n.vagi
colliculis facialis

DIENCEPHALON has:
*corpus mamillare
*tuber cinereum
*infundibulum
tractus rubrospinalis
nucl.n.trochlearis
colliculis facialis

VENTRICULUS TERTIUS has:
*foramen interventriculare
sulcus centralis
truncus corporis collosi
*recessus infundibula
*recessus opticus
colliculis facialis

LOBUS FRONTALIS CEREBRI has:
*gyrus frontalis inferior
sulcus centralis
operculum temporale
*gyrus precentralis
*gyrus frontalis superior
gyrus temporalis medius

LOBUS FRONTALIS CEREBRI has:
truncus corporis collosi
sulcus lunatus
*sulcus frontalis superior
*gyrus frontalis medius
*sulcus frontalis inferior
gyrus temporalis medius

LOBUS PARIETALIS CEREBRI has:
sulcus precentralis
*sulcus postcentralis
*sulcus intraparietalis
*gyrus postcentralis
gyrus precentraliss
gyrus temporalis medius

LOBUS TEMPORALIS CEREBRI has:
*sulcus temporalis superior
*sulcus temporalis inferior
*gyrus temporalis medius
gyrus temporalis anterior
gyrus temporalis posterior
gyrus frontalis superior

LOBUS OCCIPITALIS CEREBRI has:
*sulcus occipitalis transversus
sulcus temporalis inferior
gyrus temporalis medius
*polus occipitalis
*sulcus calcarinus
gyrus temporalis medius

FACIES MEDIALIS CEREBRI has:
sulcus occipitalis transversus
*sulcus corpori collosi
gyrus olfactorius
*gyrus cinguli
*sulcus cinguli
gyrus frontalis superior

FACIES MEDIALIS CEREBRI has:

sulcus frontalis inferior
*gyrus frontalis superior
gyrus frontalis medialis
*lobulis paracentralis
*precuneus
lobulis frontalis superior

FACIES INFERIOR CEREBRI has:
sulcus frontalis inferior
*sulcus hippocampi
*sulcus collateralis
*sulcus occipetotemporalis
cuneus
gyrus frontalis superior

FACIES INFERIOR CEREBRI has:
*gyrus parahippocampalis
*gyrus occipitotemporalis medialis
*gyrus rectus
sulcus temporalis superior
sulcus corporis collosi
gyrus frontalis superior

FACIES INFERIOR CEREBRI has:
*gyrus occipetotemporalis lateralis
gyrus occipetotemporalis superior
gyrus centralis inferior
*sulcus olfactorius
*gyri orbitalis
gyrus frontalis superior

CORPUS COLLOSUM has:
sulcus corporis collosi
*truncus corporis collosi
uncus corporis collosi
*genu corporis collosi
*rostrum corporis collosi
gyrus frontalis superior

MEDULLA SPINALIS has:
pars pelvina
*pars cervicalis
pars abdominalis
*pars thoracica
*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
pars pelvina
pars laryngea

*pars sacralis
*pars coccygea
*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
nucleus cuneatus
*conus medullaris
*filum terminalis
*intumescentia cervicalis
lemniscus medialis
pars medialis

MEDULLA SPINALIS has:
*nucleus thoracicus
*funiculus anterior
*intumescentia lumbosacralis
nucleus cochlearis dorsalis
pars medialis
lemniscus medialis

MEDULLA SPINALIS has:
*fissura mediana anterior
funiculus inferior
nucleus vestibularis
*canalis centralis
*substantia grisea
pars medialis

MEDULLA SPINALIS has:
fissura mediana inferior
*sulcus lateralis posterior
columna superior
*funiculus lateralis
*columna posterior
pars medialis

MEDULLA SPINALIS has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

MEDULLA OBLONGATA has:
cornu lateralis
*fissura mediana anterior
*decussatio pyramidum
*olive

pars cervicalis
pars medialis

MEDULLA SPINALIS has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

MEDULLA OBLONGATA has:
cornu lateralis
*fissura mediana anterior
*decussatio pyramidum
*olive
pars cervicalis
nucleus fastigi

PONS has:
*nucl.salivatorius superior
*corpus trapesoideum
*sulcus basillaris
nucl.dorsalis n, vagi
nucl.dentatus
nucleus fastigii

VENTRICULUS QUARTUS has:
nucleus globosus
vermis
*eminentia medialis
*colliculis facialis
*area vestibularis
nucleus fastigii

CEREBELLUM has:
*folia cerebelli
nucleus lacremalis
locus ceruleus
*vermis cerebelli
*nodulus
colliculis facialis

MESENCEPHALON has:
*colliculus superior
*pedunculis cerebri
nucl.motorius n.trigemini
*colliculus inferior
n. Trigeminus
colliculis facialis

DIENCEPHALON has:
*epithalamus
colliculis superior
decussatio trochlearis
*habenula
*corpus pineale
*colliculis facialis

TRACTUS OPTICUS has:
*sulcus calcarinus
colliculis facialis
*colliculus superior
*pulvinar thalami
colliculi inferior
vermis

TRACTUS VESTIBULOCOCHLEARIS has:
*colliculus inferior
*pulvinar thalami
gyrus temporalis superior
colliculis superior
gyrus precentralis
vermis

TRUNCUS N.SPINALIS has:
*ramus dorsalis
r.r. superior
*r.r. communicantes albi
*r. Meningeus
r.r. craniales
r.r. inferior

TRUNCUS N.SPINALIS has:
r.r. inferior
*ramus ventralis
*r. communicantes albi
r. Caudalis
*r. Dorsalis
r.r. superior

N. SUBOCOSTALIS has:
m. Epicranius
m. Trapezius
*m. rectus capitis major
*m. semispinalis capitis
*m. obliqus capitis
m. teres major

PLECSUS CERVICALIS has:

n. occipitalis major
*n. occipitalis minor
*n. transversus colli
*n.n. supraclaviculares
n. Suboccipitalis
n.clunium medius

PLECSUS BRACHIALIS has:
n. Phrenicus
*n. Subclavius
*n. Suprascapulari
n. Suboccipitalis
*n. Axillaris
n.clunium medius

PLECSUS BRACHIALIS has:
*n. Medianus
*n. Axillaris
*n. Ulnaris
n. Iliohypogastricus
n. Obturatorius
n.clunium medius

PLECSUS BRACHIALIS has:
n.clunium medius
*n. cutaneus brachii medialis
*n. Radialis
*n. Musculocutaneus
n. Pudendus
n.phrenicus

PLECSUS BRACHIALIS has:
n. Femoralis
*n. Medianus
n. Ilioinguinalis
*n. cutaneus antebrachii medialis
*n. Radialis
n.clunium medius

N. MUSCULOCUTANEUS has:
m. triceps brachii
*m. Coracobrachialis
m. Brachioradialis
*m. biceps brachii
*m. brachialis
m.clunium medius

N. MEDIANUS has:
m.clunium medius
m. auricularis magnus

m. Phrenicus
*m. pronator quadrates
*m. flexor capri radialis
*m. flexor pollicis longus

N. RADIALIS has:
*m. extensor carpi radialis brevis
m.pronator teres
*m. extensor digitorum
m. brachialis
*m. supinator
m. obliquus externus abdominis

N.N. INTERCOSTALES has:
m. biceps brachii
m. triceps brachii
*m. subcostalis
*m.m. intercostales externi
*m. transversus thoracis
m.pronator teres

DIAPHRAGMA has:
n. vagus
n. intercostalis
*n. phrenicus
*Plexus cervicalis
*C3 C4
n.clunium medius

M. BICEPS BRACHII has:
n. vagus
n. intercostalis
*Plexus brachialis
C3 C4
*C5 C7
*n. Musculocutaneus

M. triceps brachii has:
*Plexus brachialis
*n. radialis
*C5 C8, Th1
n. musculocutaneus
C1 C4, Th1
Plexus cervicalis

N. vagus has:
*ramus meningeus
*ramus auricularis
*rami pharyngei
ramus stylophryngeus

ramus auriculotemporalis
n. mylohyoideus

N. vagus has:
chorda tympani
*n. laryngeus superior
n. Stapedius
*n. laryngeus recurrens
*rami bronchiales
n. mylohyoideus

N. n. vagus has:
nucleus salivatorius superior
*nucleus solitaries
*nucleus ambiguous
nucleus salivatorius inferior
*nucleus dorsalis
nucleus inferior

N. Vagus has:
chorda tympani
*n. laryngeus superior
n. Stapedius
*n. laryngeus recurrens
*rami bronchiales
n. mylohyoideus

Nuclei of the n. vagus:
nucleus salivatorius superior
*nucleus solitaries
*nucleus ambiguous
nucleus salivatorius inferior
*nucleus dorsalis
nucleus inferior

N. femoralis has:
*m. quadriceps femoris
m. gracilus
m. obturatorius externus
*m. Sartorius
*m. pectineus
m. pyramidalis

N. hypoglossus has:
m.digastricus
*m. genioglossus
*m.styloglossus
m. stylopharyngeus
*m. transversus linguae
m. palatopharyngeus

N. Hypoglossus has:
*m. longitudinalis linguae
m. Mylohyoideus
*m.verticalis linguae
*m. Genioglossus
m. Palatopharyngeus
m. palatopharyngeus

N. Ophtalmicus has:
*n. Frontalis
*n. Lacrimalis
*n. Nasociliaris
n.zygomaticus
n. nasalis posterior
n. olfactorius

N. Mandibularis has:
*n. Lingualis
n. Nasopalatinus
*n. alveolaris inferior
n. Zygomaticus
*n. Auriculotemporalis
n. olfactorius

N. Mandibularis has:
n. palatini
*n. Buccalis
*n. pterygoideus medialis
*n. temporalis profundus
n. Pharyngeus
n. olfactorius

N. Mandibularis has:
*n. Massetericus
n. Stylopharyngeus
*n.tensoris veli palatine
n. Uvulae
*n. Mylohyoideus
n. olfactorius

N. Mandibularis has:
*n. temporalis profundus
*n. pterigoideus lateralis
n. Olfactorius
n. Hyoglossus
*n. Mylohyoideus
n. palatopharyngeus

N. facialis has:

*n. petrosus major
n. petrosus minor
*n.stapedius
n. Lingualis
*chorda tympani
n. palatopharyngeus

Nuclei of the n. facialis:
*nucleus motorius
nucleus salivatorius inferior
*nucleus salivatorius superior
*nucleus solitaries
nucleus ambiguous
n. palatopharyngeus

N. glossopharyngeus has:
n. genioglossus
*n. tympanicus
*ramus m. stylopharyngei
*rami tonsillares
n. buccalis
F.n. mylohyoideus

N. Glossopharyngeus has:
*rami pharyngei
n. alveolaris inferior
n. Zygomaticus
*rami linguales
*ramus sinus carotici
n. mylohyoideus

N. Vagus has:
*ramus meningeus
*ramus auricularis
*rami pharyngei
ramus stylophryngeus
ramus auriculotemporalis
n. mylohyoideus

N. Vagus has:
chorda tympani
*n. laryngeus superior
n. Stapedius
*n. laryngeus recurrens
*rami bronchiales
n. mylohyoideus

Nuclei of the n. vagus:
nucleus salivatorius superior
*nucleus solitaries

*nucleus ambiguous
nucleus salivatorius inferior
*nucleus dorsalis
nucleus inferior

Supplies of the musles of eyeball:
*n. Oculomotorius
*n. Trochlearis
n. Ophthalmicus
n. Opticus
*n. Abducens
n. mylohyoideus

N. Oculomotorius has:
m. rectus lateralis
*m. rectus superior
m. obliquus lateralis
*m. obliquus superior
*m. rectus medialis
n. mylohyoideus

N. glossopharyngeus has:
nucleus spinalis
nucleus salivatorius superior
*nucleus solitaries
*nucleus salivatorius inferior
*nucleus ambiguous
n. mylohyoideus

Gustatory supplies of the tongue:
*chordatympani
n. mylohyoideus
*n. mandibularis
*n. vagus
n. olfactorius
n. abducens

MEDULLA SPINALIS has:
pars pelvina
*pars cervicalis
pars abdominalis
*pars thoracica
*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
pars pelvina
pars laryngea
*pars sacralis
*pars coccygea

*pars lumbalis
pars medialis

MEDULLA SPINALIS has:
nucleus cuneatus
*conus medullaris
*filum terminalis
*intumescentia cervicalis
lemniscus medialis
pars medialis

MEDULLA SPINALIS has:
*columna anterior
*funiculus anterior
*intumescentia lumbosacralis
nucleus cochlearis dorsalis
pars lateralis
pars medialis

MEDULLA SPINALIS has:
*fissura mediana anterior
funiculus inferior
nucleus vestibularis
*canalis centralis
*substantia grisea
pars medialis

MEDULLA SPINALIS has:
fissura mediana inferior
*sulcus lateralis posterior
columna superior
*funiculus lateralis
*columna posterior
pars medialis

MEDULLA SPINALIS has:
fibrae corticonuclearis
nucleus gracilis
*columna lateralis
*cornu laterale
*substantia alba
pars medialis

MEDULLA OBLONGATA has:
cornu lateralis
*fissura mediana anterior
decussatio pyramidum
*olive
pars cervicalis
pars medialis

MEDULLA OBLONGATA has:
*pedunculi cerebellaris inferior
*fasciculus cuneatus
*tuberculum nuclei gracilis
sulcus basilaris
n.trigeminalis
pedunculi cerebellaris superior

MEDULLA OBLONGATA has:
*tuberculum nuclei cuneati
nucleus dentatus
flocculus
*pyramidae
*formatio reticularis
pedunculi cerebellaris superior

MEDULLA OBLONGATA has:
nucleus fastigii
*nucleus n.hypoglossi
nodulus
*nucleus dorsalis n.vagi
*nucleus ambiguous
pedunculi cerebellaris superior