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CRASH COURSE

神经系统 第二版

Nervous System

SECOND EDITION

Briar, Lasserson, Gabriel, Sharrack 著

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Nervous System

SECOND EDITION

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Preface

Welcome to *Crash Course: Nervous System*! Whether you are revising for preclinical exams, coming up for finals or simply looking for an integrated course text, this book should have something for you. It has been designed with tired, stressed out and coffee-deprived students in mind, and contains enough core information to help you sail through your exams. Along with core facts, I have tried to include clinically relevant material to add interest to what can often be a dry and complex topic. There are many unanswered questions in the field of neurology and I hope this book gives you a taste for discovering more about this fascinating topic.

I hope you get as much out of using this book as I have gained from writing it.

Charlie Briar

Crash Course: Nervous System offers an innovative approach to the education of medical students combining, in one text, the basic science required to understand the nervous system with an introduction to its pathology and pharmacology. In addition guidelines on taking a neurological history and performing a neurological examination are also included.

This second edition, updated by a senior medical student, represents the knowledge that a student at the top end of the academic spectrum sees as essential for a good understanding of the nervous system, its clinical problems and clinical neurological assessment. It is sufficiently comprehensive to allow a medical student to become conversant with the essential knowledge needed to understand how the nervous system functions and how it is affected by the various diseases it is vulnerable to. Students will be able to use this book as a revision source and, additionally, as a basis from which to explore the subject further.

Prof Anthony Angel
Faculty Advisor

In the six years since the first editions were published, there have been many changes in medicine, and in the way it is taught. These second editions have been largely rewritten to take these changes into account, and keep *Crash Course* up to date for the twenty-first century. New material has been added to include recent research and all pharmacological and disease management information has been updated in line with current best practice. We've listened to feedback from hundreds of students who have been using *Crash Course* and have improved the structure and layout of the books accordingly: pathology material has been closely integrated with the relevant basic medical science; there are more MCQs and the clarity of text and figures is better than ever.

The principles on which we developed the series remain the same, however. Medicine is a huge subject, and the last thing a student needs when exams are looming is to waste time assembling information from different sources, and wading through pages of irrelevant detail. As before, *Crash Course* brings you all the information you need, in compact, manageable volumes that integrate basic medical science with clinical practice. We still tread the fine line between producing clear, concise text and providing enough detail for those aiming at distinction. The series is still written by medical students with recent exam experience, and checked for accuracy by senior faculty members from across the UK.

I wish you the best of luck in your future careers!

Dr Dan Horton-Szar
Series Editor (Basic Medical Sciences)

Acknowledgements

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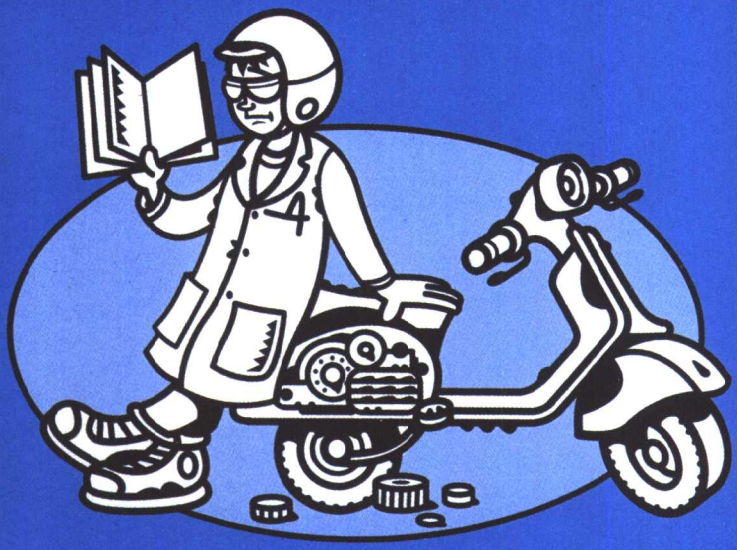

BASIC MEDICAL SCIENCE OF THE NERVOUS SYSTEM

1. Overview of the Nervous System

In this chapter, you will learn about:

- The anatomy of the central nervous system.
- The development of the central nervous system.
- The blood supply, and venous drainage of the central nervous system, cerebrospinal fluid and supporting cells of the central nervous system.

Introduction

The nervous system is divided up into two anatomically different parts. These are:

- Central nervous system, including all the nerves contained within the cranium and spinal column.
- Peripheral nervous system, which contains the nerves and ganglia (groups of nerve cell bodies) outside the brain and spinal cord. The peripheral nervous system is further divided into somatic and autonomic branches:
  - The somatic portion contains the sensory and motor supply to skin, muscles and joints.
  - The autonomic division supplies smooth muscle and glands along with some specialized structures, such as the pacemaker cells of the heart. One of its main function is the control of the internal environment.

The nervous system is designed to detect features of the internal and external environments, to process this information and to use it to direct behaviour and body processes. There are three basic processes that work together to achieve this.

Perception

Specialized receptors in the skin respond to touch, pain and temperature. Those in muscle respond to muscle length and others in joints respond to the position of the joint. These, together with information gathered by the special sense organs (for sight, hearing, smell and taste), provide the brain with information about the immediate and remote external environment and the body's position in space. There are also receptors which monitor the state of the internal environment (e.g. baroreceptors for blood pressure).

Information transfer and processing

Neurons (nerve cells) have specialized projections called axons that can conduct trains of electrical impulses over long distances. The information delivered to neurons can be modified by, or integrated with, other inputs from related areas. In the central nervous system, neurons have many complex connections, allowing the brain to use the information in several different ways at once.

Output to body

Once the information has been collated and processed by the brain, it is then used to drive the outputs of the central nervous system. This includes supply to other excitable cells, such as muscles, internal organs and glands (e.g. the diaphragm, heart and hormone producing centres such as the adrenals). In this way, the brain can control movement of the body and also modify the circulation and respiration.

Anatomy of the central nervous system

The fully developed central nervous system is shown in Fig. 1.1.

The cerebral cortex is divided into four lobes on the basis of the folds (sulci) in the surface, as shown in Fig. 1.2.

- The frontal lobe is separated from the parietal lobe by the central sulcus.
- The temporal lobe is separated from these by the lateral sulcus.
- Demarcation of the occipital lobe is difficult to appreciate from a lateral view but, on the medial (mid-sagittal) view (Fig. 1.3), the parieto-occipital sulcus can be seen. You can also see the leaf-like folia of the cerebellum, sitting behind the midbrain, pons and medulla, can also clearly be seen.

The paired lateral ventricles (Fig. 1.4) are shaped like the jaws of an animal, with anterior, posterior and inferior horns. The lateral ventricles

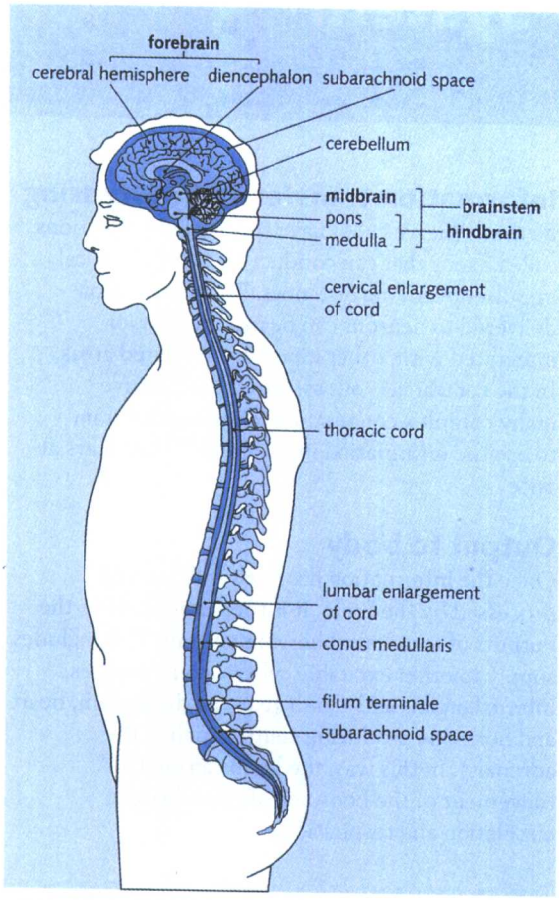

Fig. 1.1 Midsagittal section of the central nervous system showing components of the forebrain, midbrain, hindbrain and spinal cord.

are connected to the third ventricle, which lies posterior and inferior, through the interventricular foramen of Monro. The ventricles of the brain contain cerebrospinal fluid and are joined together to allow the fluid to circulate around the brain.

The ventricles can sometimes be distorted by pressure exerted upon them by, for example, a tumour. Computed tomography or magnetic resonance imaging are good investigations to see this 'mass effect'.

Blood supply to the central nervous system

Fig. 1.5 shows the arteries which provide the blood supply to the brain. These form an anastomosis (different arteries supply blood to the same area), known as the Circle of Willis. Fig. 1.6 shows the territories of the major arteries supplying the cortex. A broad knowledge of these is helpful when assessing a person with a stroke.

Four vessels supply the brain—the right and left internal carotid arteries, and the vertebral arteries.

- The internal carotid arteries send off two branches (anterior and posterior communicating arteries) before becoming the middle

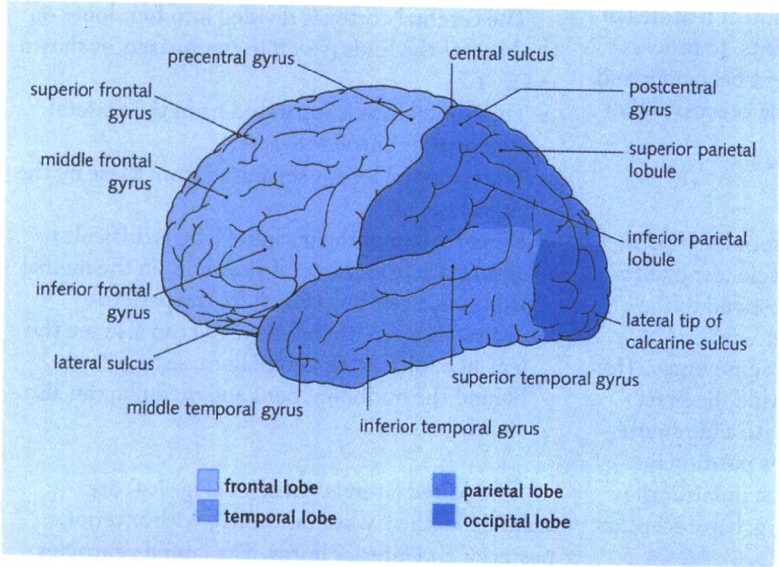

Fig. 1.2 Left cerebral hemisphere, lateral view showing major lobes.

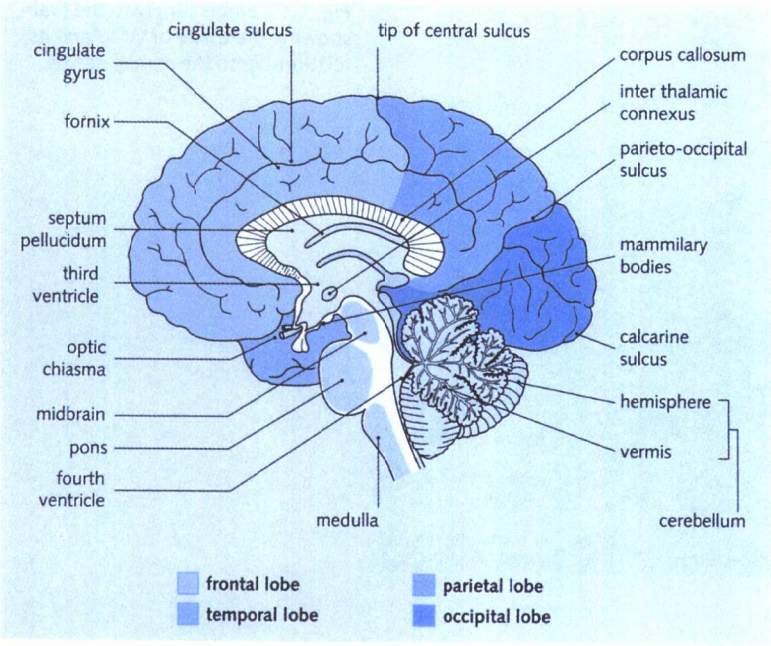

Fig. 1.3 Medial view of the right side of the brain, showing deep structures, midbrain and hindbrain.

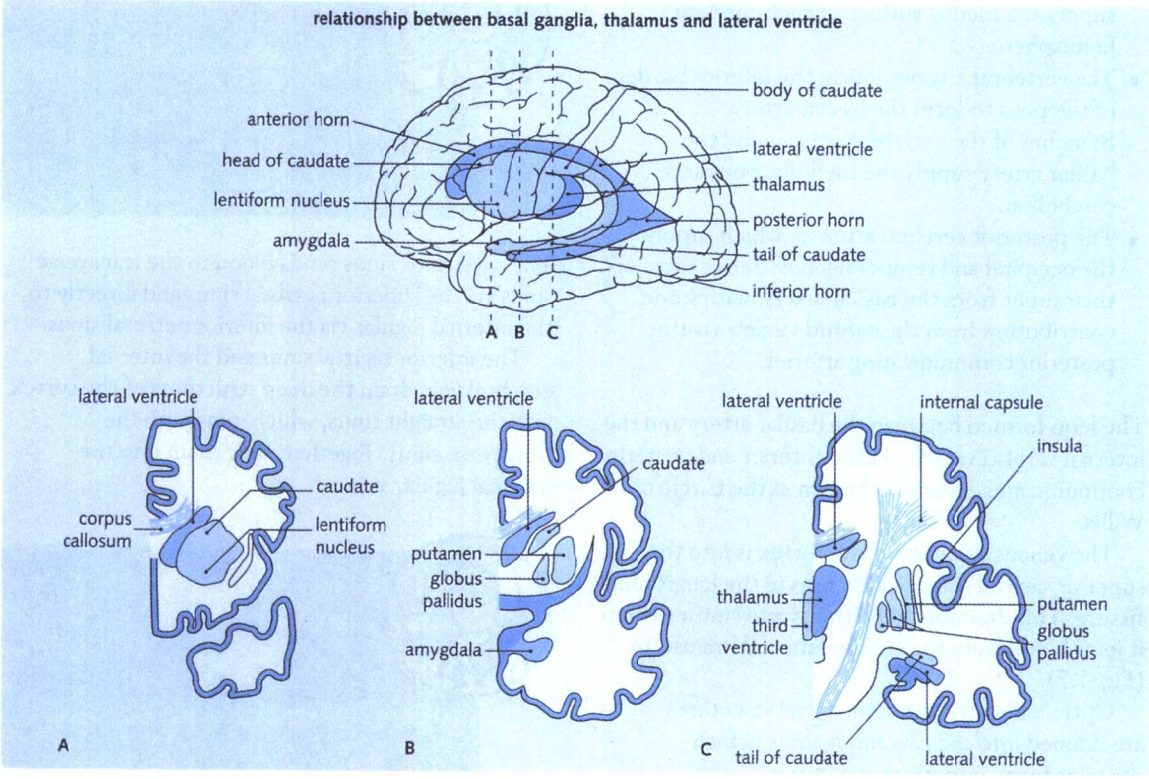

Fig. 1.4 The lateral ventricle, and its relationship to the basal ganglia and thalamus.

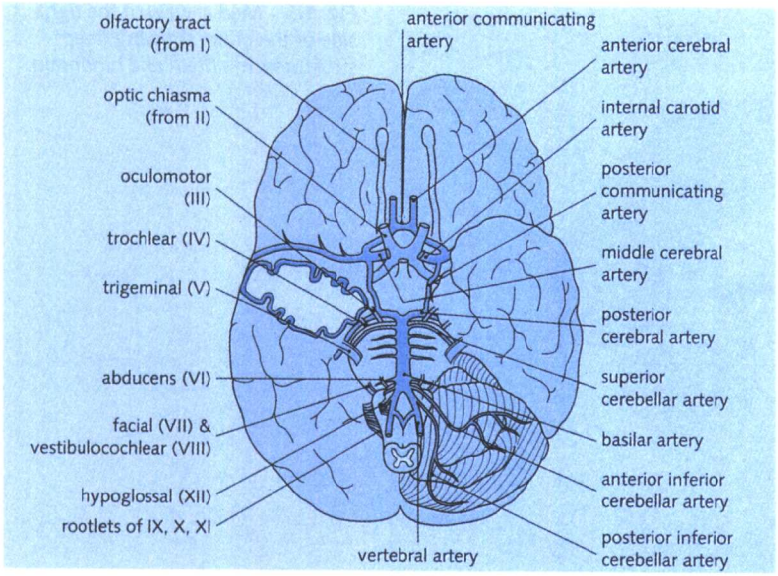

Fig. 1.5 Blood supply to the brain, showing the Circle of Willis and its relationship to the cranial nerves.

cerebral artery. This artery has an extensive territory, covering the majority of the surface of the brain and also some of the basal ganglia.

- The anterior cerebral arteries travel forwards on either side of the longitudinal fissure to supply the medial surface of each cerebral hemisphere.
- The vertebral arteries join at the inferior border of the pons to form the basilar artery. Branches of the vertebral arteries and the basilar artery supply the medulla, pons and cerebellum.
- The posterior cerebral arteries, which supply the occipital and temporal lobes, derive most of their input from the basilar artery, with some contribution from the carotid vessels via the posterior communicating arteries.

The loop formed between the basilar artery and the internal carotid vessels via the anterior and posterior communicating arteries is known as the Circle of Willis.

The venous drainage of the cortex is into the superior sagittal sinus, which runs in the longitudinal fissure. This drains into the transverse sinuses where it joins blood from the cerebellum and brainstem (Fig. 1.7).

Optic, olfactory and some facial structures are drained into the cavernous sinus, which contains many important structures, including:

- Internal carotid artery.
- Cranial nerves III, IV, VI and the ophthalmic and maxillary divisions of V.

Atherosclerosis in the common carotid artery may cause blood clots to travel up the internal carotid artery. Due to its anatomy, it is most likely that the clot will end up in the middle cerebral artery territory and cause a stroke.

The cavernous sinus sends blood to the transverse sinus via the superior petrosal sinus and directly to the internal jugular via the inferior petrosal sinus.

The inferior sagittal sinus and the internal cerebral vein drain the deep structures of the cortex into the straight sinus, which joins with the transverse sinus. Together, they drain into the internal jugular vein.

Infection spread from the face or orbit may result in cavernous sinus thrombosis, producing a red swollen eye, and palsies of the nerves running through it. On fundoscopy, papilloedema may be seen.

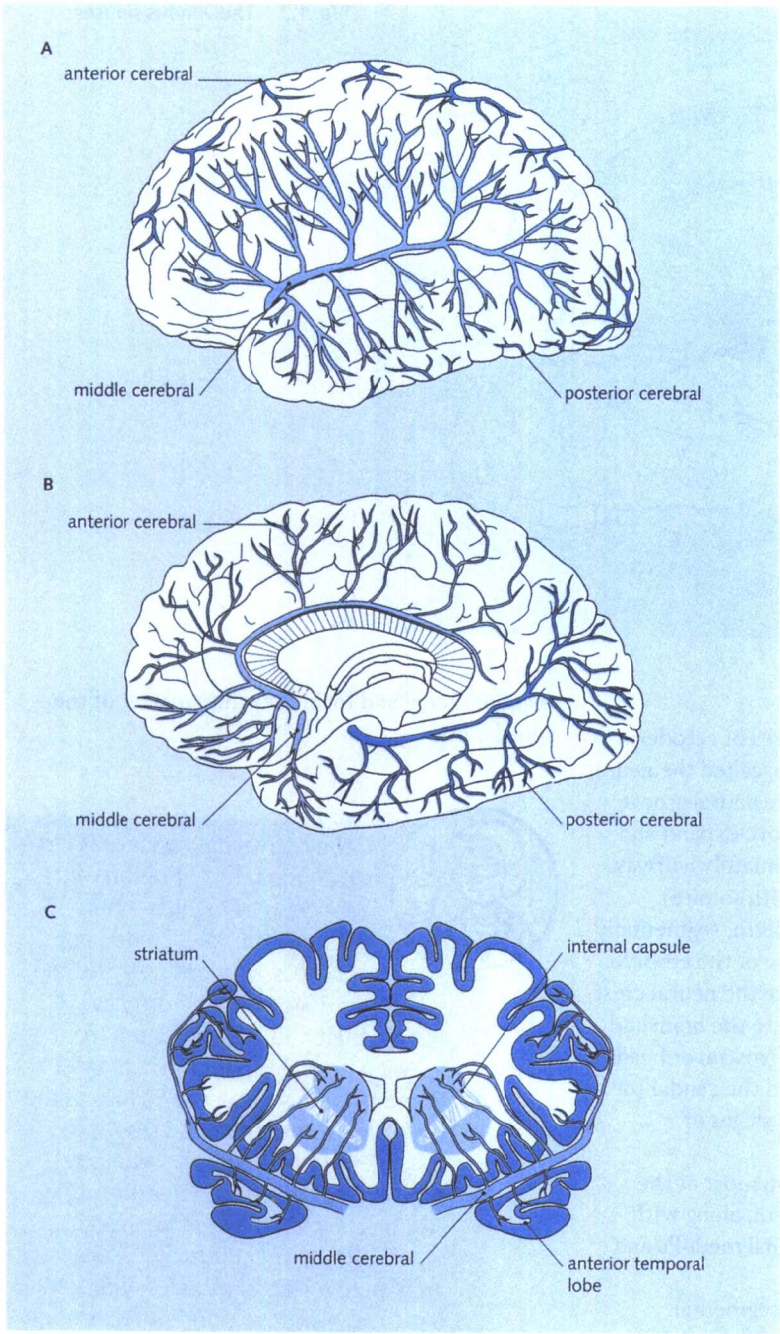

Fig. 1.6 Territories of the cerebral arteries. (A) Lateral and (B) medial views of the left and right cerebral hemispheres respectively. (C) Coronal (transverse) section of the cerebral hemispheres.

Overall development of the nervous system

Development of the nervous system begins early in gestation, at approximately 3 weeks. There are three layers to the embryo at this stage:

- Endoderm (which forms the gastrointestinal tract among other things).
- Mesoderm (which becomes muscles, connective tissues and blood vessels).
- Ectoderm (which forms the whole nervous system and the skin).

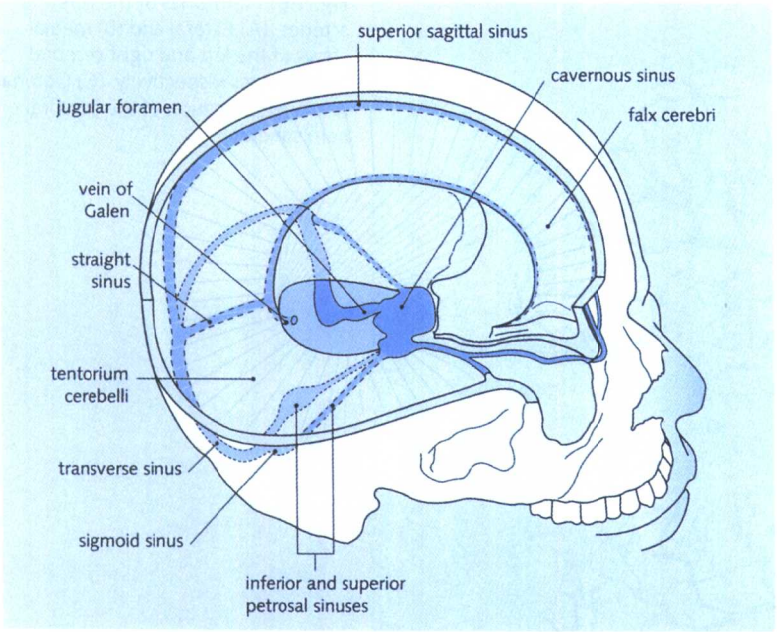

Fig. 1.7 The venous sinuses.

Neurulation

At around day 22 of gestation, an area of ectoderm on the dorsal surface of the embryo, called the neural plate, thickens and folds to form the neural groove. The ridges on either side of the groove expand and begin to fuse in the midline approximately halfway along its length (at the level of the 4th somite). Somites are paired blocks of mesoderm, segmentally arranged alongside the neural groove of the embryo. The very tips of these ridges become the neural crest, and the fused neural tube gives rise to the brain and spinal cord. The tube at the cranial (rostral or head-end) neuropore fuses on day 25, and the caudal (or tail-end) neuropore on day 27. The stages of neurulation are shown in Fig. 1.8 .

Neural crest cells migrate to form most of the cells in the peripheral nervous system, along with autonomic ganglia, cells of the adrenal medulla and melanocytes in the skin.

By the end of development, the segmental arrangement of the nervous system determined by the somites is retained only in the spinal cord.

Embryology of the spinal cord

The neural tube is hollow, with the centre becoming the spinal canal. Neuroblast cells, which surround the canal, divide and move outwards within the neural tube to ultimately form nerve cells and the grey matter of the spinal cord. These cells then send out nerve fibres that grow out peripherally into the marginal zone, and form the white matter of the spinal cord.

If the cranial neuropore fails to close, the fatal condition of anencephaly results—the embryo continues to develop but the brain does not, and the structures which would normally overlie the brain are prevented from forming normally. This normally results in spontaneous abortion. Failure of the caudal neuropore to close results in disruption of the lumbar and sacral segments of the cord. Structures that lie superficial to the cord are also involved (e.g. meninges, vertebral arch, paravertebral muscles and skin) because their development relies upon closure of the neural tube. Malformations involving the vertebral arch and the cord are called spina bifida.

The neuroblasts in the primitive grey matter form two populations—a dorsal alar plate and a ventral basal plate separated by a shallow groove (sulcus limitans).

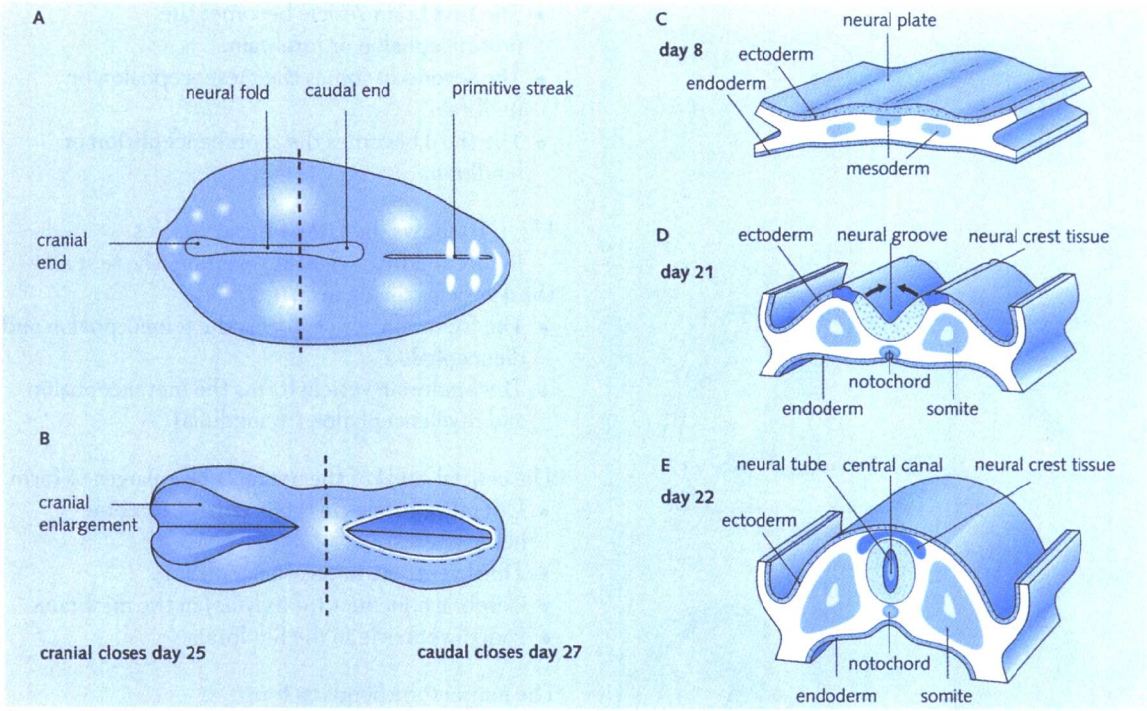

Fig. 1.8 Stages of neurulation. (A) Early embryonic disc. (B) Progression to formation of brain vesicles and spinal canal. (C–E) Transverse sections of neural tube taken at different stages of development.

- The alar plate cells form the sensory cells of the posterior (dorsal) horn.
- The basal plate cells form the motor cells of the anterior (ventral) horn along with sympathetic (in the thoracic region) and parasympathetic (in the lumbar and sacral regions) preganglionic neurons.

Fig. 1.9 shows the formation and development of the alar and basal plates.

The mesenchymal tissue around the neural tube forms the coverings of the brain and spinal cord:

- Pia mater (nearest the neural tube).
- Arachnoid mater.
- Dura mater (outer layer).

In the first 8 weeks of gestation, the spinal cord is the same length as the vertebral column. After this time, the vertebral column grows at a faster rate so that, by 40 weeks of gestation (term), the spinal cord stops at the level of L3 and, in adults, it ends at L1. The spinal nerve roots below this level in the adult descend within the vertebral canal until they reach the appropriate exit foramen. The pia mater remains attached to the coccyx and therefore elongates with respect to the spinal cord. The strand of pia mater between the coccyx and the lower end of the spinal cord is known as the filum terminale, and collectively with the individual nerve roots below L1, as the cauda equina (literally 'horse's tail').

Cauda equina syndrome. A prolapsed intervertebral disc or fracture can cause compression of the cauda equina. The symptoms of this include pain in the nerve distribution of the root affected, saddle anaesthesia (around the anus) and disturbance of bladder/bowel function. It is a neurosurgical emergency and the pressure must be relieved to preserve the function of the nerves.

Embryology of the brain

General arrangement

The neural groove rostral to the 4th pair of somites enlarges before it fuses to form three primary brain vesicles or swellings.