compressed central canal (see fig. 5). The original ectodermal cells elongate and, radiating outward from the canal, are now known as spongioblasts, while the inner ends of some of them bear cilia and so the canal becomes ciliated. A number of round cells, known as germinal cells, now appear close to the central canal, except at the thin mid-dorsal and mid-ventral laminae (roof-plate and floor­plate). From the division of these the primitive nerve cells or neuroblasts are formed and these later on migrate from the region

The left side of the section shows an earlier stage than the right side. of the canal and shoot out long processes—the axons. The perma­nent central canal of the cord was formerly said only to represent the ventral end of the large embryonic canal, the dorsal part being converted into a slit by the gradual closing in of its lateral walls, thus forming the postero-median fissure. A. Robinson, however, does not believe that the posterior fissure is any remnant of the central canal, and there are many points which bear out his contention *(Studies in Anatomy,* Owens College, 1891). The most modern view (1908) is that the fissure is formed partly by an infolding and partly from the original central canal. The antero-median fissure is caused by the ventral part of the cord growing on each side, but not in the mid-line where no germinal cells are.

The anterior nerve roots are formed by the axons of the neuro­blasts in the developing anterior cornua, but the posterior grow into the cord from the posterior root ganglia (see Nerve: *Spinal),*and, as they grow, form the columns of Goll and Burdach. That part of the grey matter from which the ventral, anterior or motor nerve roots rise is known as the basal lamina of the cord, while the more dorsal part into which the posterior nerve roots enter is the *atar lamina.* These parts are important in comparing the morphology of the spinal cord with that of the brain.

In the embryo up to the fifth month there is little difference in the appearance of the grey and white matter of the cord, but at that time the fibres in the columns of Burdach acquire their medullary sheaths or white substance of Schwann, the fatty matter of which is probably abstracted from the blood. Very soon after these the basis bundles myelenate and then, in the sixth month, the columns of Goll. Next follow the direct cerebellar tracts and, in the lacter half of the eighth month the tracts of Gowers, while the fibres of the pyramidal and Lissauer’s tracts do not gain their medullary sheaths until just before or after birth. At first the spinal cord exends as far as the last mesodermal somite, but neuroblasts are only formed as far as the first coccygeal somite, so that behind that the cord is non-nervous and degenerates later into the filum terminale. After the fourth month the nervous portion grows more slowly than the rest of the body and so the long cauda equina and filum terminale are produced. At birth the lower limit of the cord is opposite the third lumbar vertebra, but in post-natal development it recedes still farther to the lower level of the first.

For further details see Quain’s *Anatomy,* vol. i. (London, 1908); J. P. McMurrich, *Development of the Human Body* (1906). Most modern descriptions are founded on the writings of W. His, references to which and to other literature will be found on p. 463 of McMurrich’s book.

*Comparative Anatomy.—*In the Amphioxus there is little difference between the spinal cord and the brain; the former reaches the whole length of the body and is of uniform calibre. It encloses a central canal from which a dorsal fissure extends to the surface of the cord and it is composed of nerve fibres and nerve cells; most of the latter being grouped round the central canal or neurocoele, as they are in the human embryo. Some very large multipolar ganglion cells are present, and there are also large fibres known as *giant fibres,* the function of which is not clear.

When the reptiles are reached the cord shows slight enlargements in the regions of the limbs and these become more marked in birds and mammals.

In the lumbar region of birds the dorsal columns diverge and open up the central canal, converting it into a diamond-shaped space which is only roofed over by the membranes of the cord, and is known as the *sinus rhomboidalis.*

In all these lower vertebrates except the Anura (frogs and toads), the cord fills the whole length of the spinal canal, but in the higher mammals (Primates, Chiroptera and Insectivora) it grows less rapidly, and so the posterior part of the canal contains the cauda equina within its sheath of dura mater. In mammals below the anthropoid apes there are no direct pyramidal tracts in the cord, since the decussation of the pyramids in the medulla is complete. Moreover, the crossed tracts vary very much in their proportional size to the rest of the cord in different animals. In man, for example, they form 11∙87% of the total cross area of the cord, in the cat 7∙76%, in the rabbit 5-3%, in the guinea-pig 3%, and in the mouse 1·14 %. In the frog no pyramidal tract is found. It is obvious, thcre- fore, that in the lower vertebrates the motor fibres of the cord are not so completely gathered into definite tracts as they are in man.

A good deal of interest has lately been taken in a nerve bundle which in the lower vertebrates runs through the centre of the central canal of the cord, and takes its origin in the optic reflex cells in close relation to the posterior commissure of the brain. More posteriorly (caudad) it probably acquires a connexion with the motor cells of the cord and is looked upon as a means by which the muscles can be made to actively respond to the stimulus of light. It is known as *Reissner's fibre,* and its morphology and physiology have been studied most carefully in cyclostomes and fishes. It is said to be present in the mouse, but hitherto no trace of it has been found in man. It was discovered in 1860, but for forty years has been looked upon as an artifact.

See P. E. Sargent, “ Optic Reflex Apparatus of Vertebrates,” *Bull. Mus. Comp. Zool. Harvard,* vol. xlv. No. 3 (July, 1904); also for general details R. Wiedersheim, *Comparative Anatomy of Vertebrates* (London, 1907) ; Lenhossek, *Bau des Nervensystems* (1895). (F. G. P.)

Surgery of the Spine and Spinal Cord

*Fracture of the spine* may occur from indirect violence, as when a man falls from a height upon his head, or in a sitting position; or it may result from direct violence, as when he is hanged, or as when he is run over by a loaded van, or in a fall from a height across a beam. The vertebrae above the fracture being displaced from those below it, the spinal cord is generally torn across, and the parts of the trunk, or the limbs, which are supplied by the spinal nerves passing out from the cord below the seat of injury are of necessity cut off from their connexion with the brain, and at once deprived of sensation and of the power of voluntary movement. In some cases of fracture of the spine there is at the time marvellously little constitutional disturbance. The higher up the column that the fracture occurs the more quickly does death ensue. If the fracture is in the middle of the back the patient may linger for several weeks, but even if he is lying upon a water-bed, and even if every care is taken of him, inflammation of the bladder and intractable bed-sores are apt to make their appearance, and his existence becomes truly miserable. Operative surgery is unable to effect much in these cases on account of the spinal cord being generally torn across or hopelessly crushed.

*Curvature of the spine* may be due to deformity of the bodies of the vertebrae caused by irregular pressure, or to the disintegration of their anterior parts by tuberculous ulceration, known as Pott’s disease or spinal caries. Thus the causes of spinal curvature are very different, and it is necessary that the actual condition be clearly recognized or treatment may prove harmful. Briefly, the curvature which is due to tuberculous disease requires absolute and continuous rest; the other calls for well-regulated exercises.

*Lateral or rotatory curvature of the spine* is a deformity which comes on during the developing period of life, before the bodies of the vertebrae are solidly formed. In young people who are