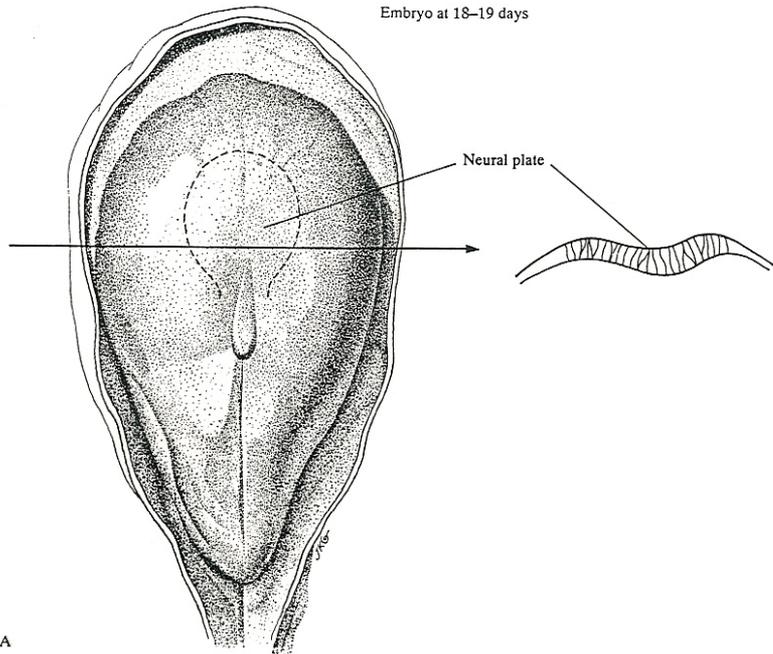
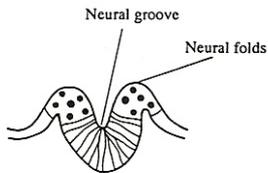
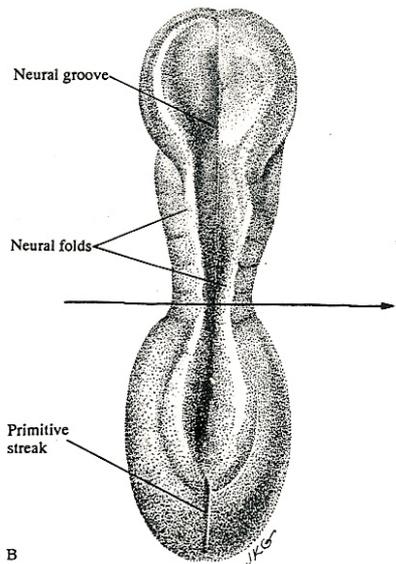


—A schematic drawing of a longitudinal section of a 7-somite human embryo. It shows the early development of the head and tail folds and the formation of the fore- and hind-gut.

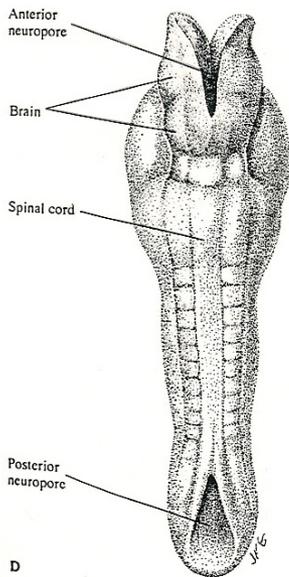
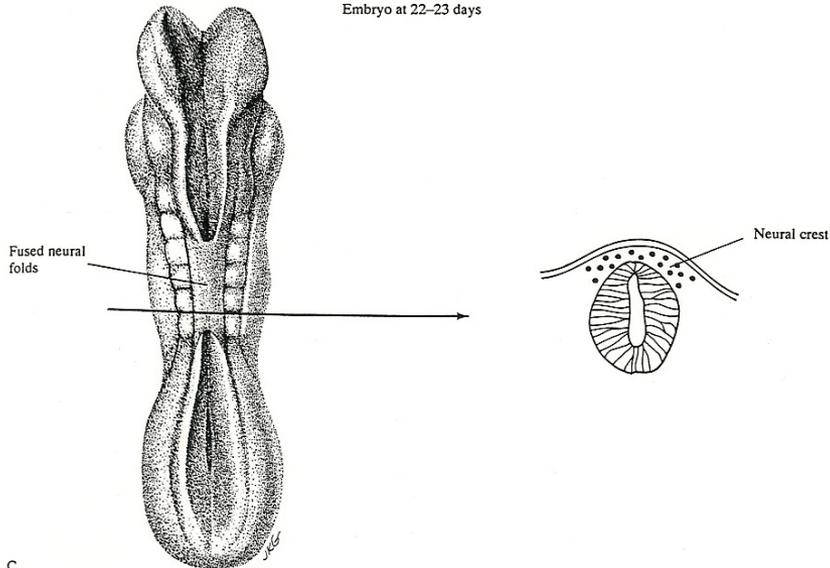
Embryo at 18-19 days



Embryo at 20-21 days

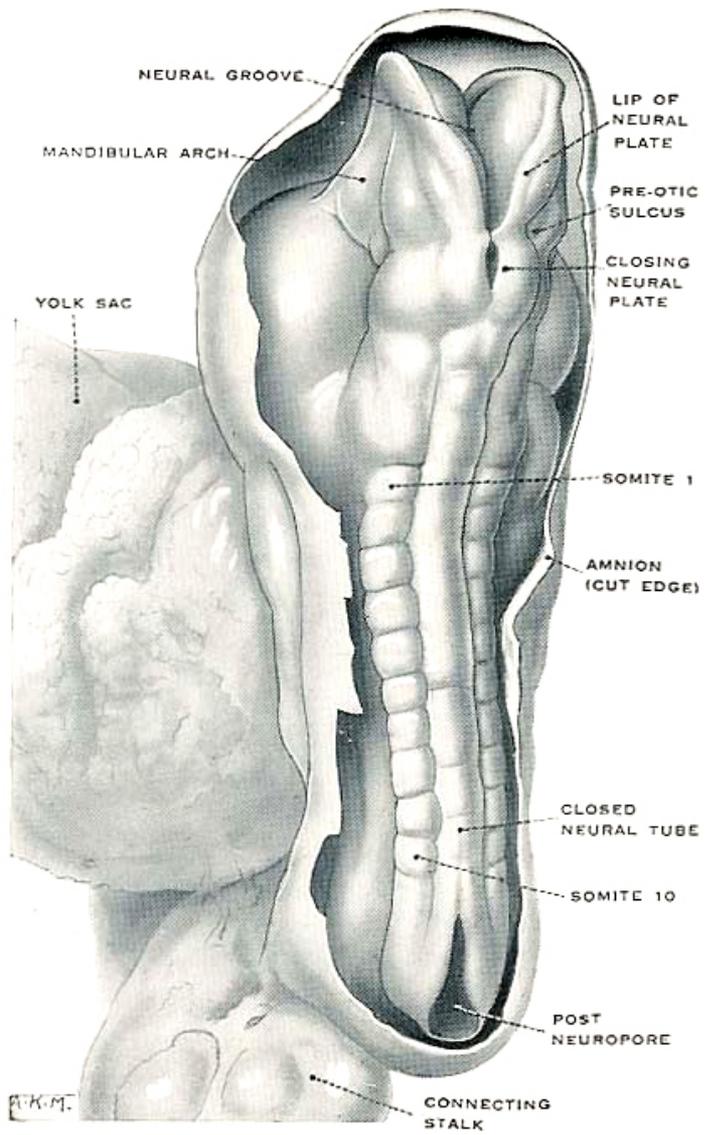
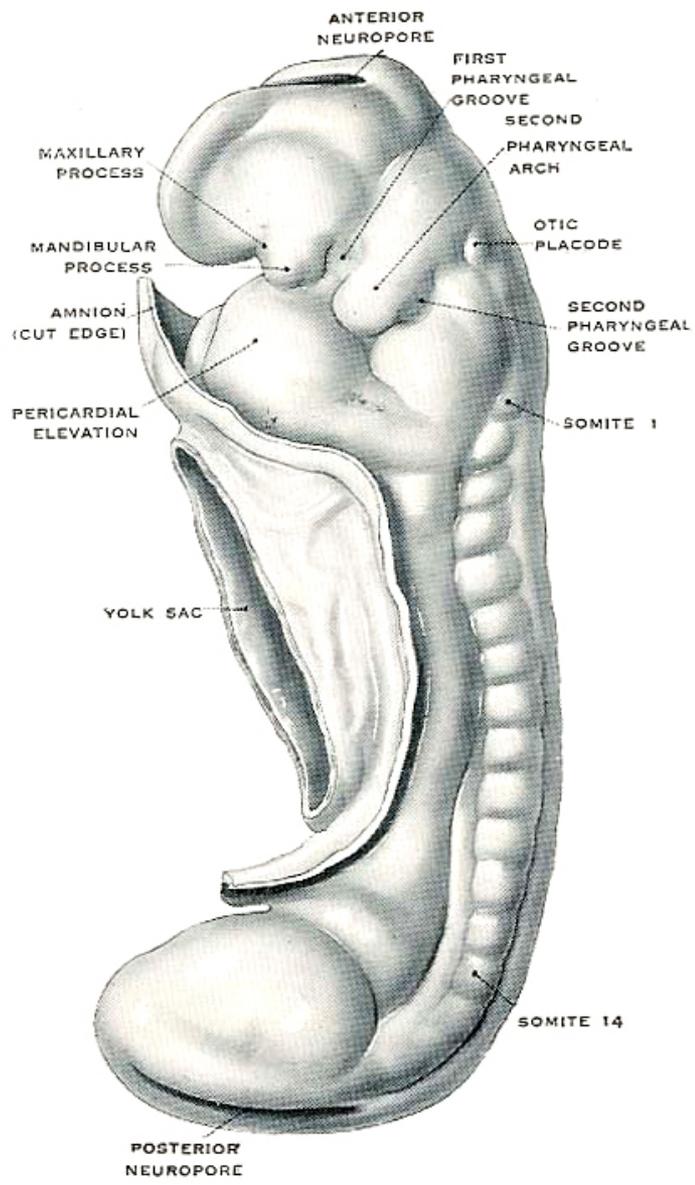


Embryo at 22-23 days



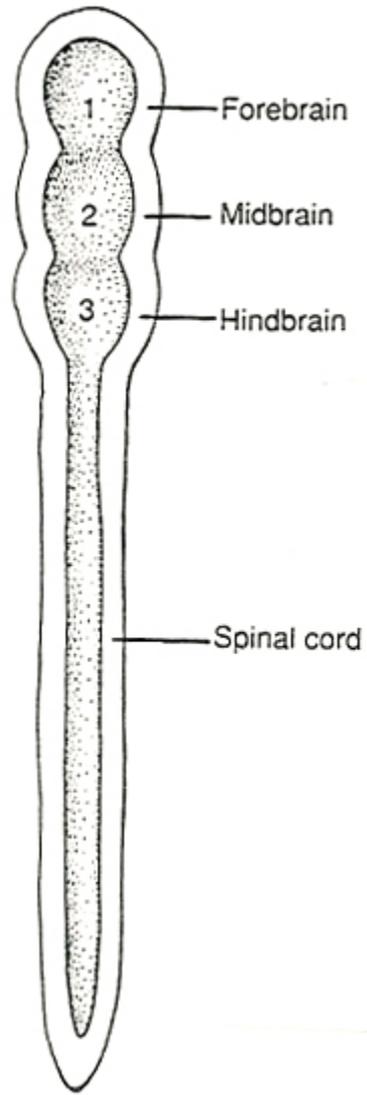
Embryo at 24-25 days

From neural plate to neural tube. A: The neural plate on the dorsal side of the embryo. B,C,D. The plate folds to form a groove that is transformed into the neural tube. The neural crest cells are pinched off from the tube and develop into sensory ganglion cells, postganglionic autonomic neurons and peripheral glial (Schwann) cells (From Heimer, 1995).

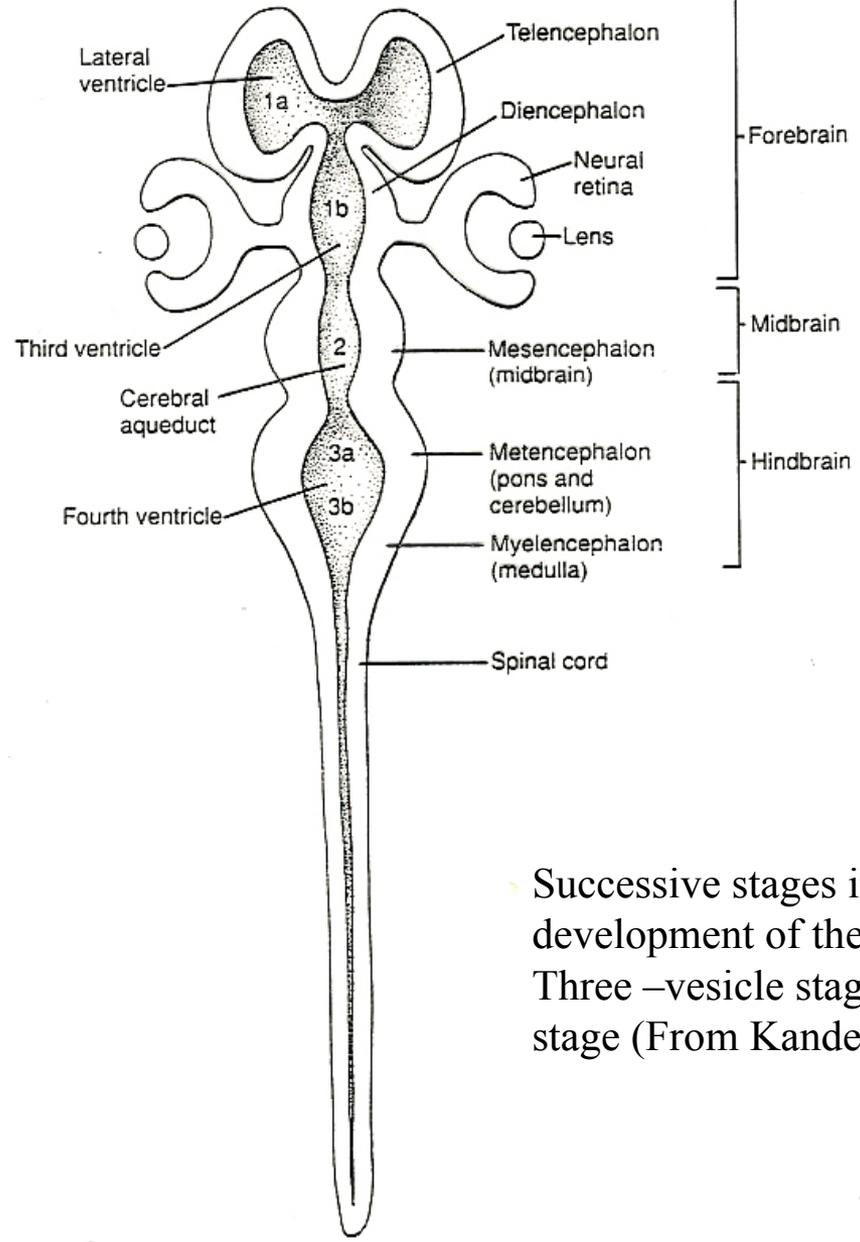
A**B**

A: Dorsal aspect of a reconstruction of a 10-somite human embryo (23 day). **B:** Left lateral aspect of a 14-somite human embryo (25 day). (From Hamilton and Mossman, 1972)

A



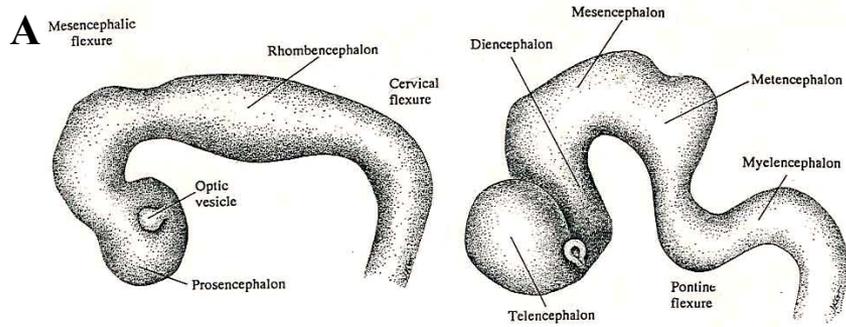
B



Successive stages in the development of the neural tube. A: Three-vesicle stage. B: Five vesicle stage (From Kandell and Schwartz)

Three-vesicle stage	Five-vesicle stage	Major mature derivatives
1. Forebrain (prosencephalon)	1a. Telencephalon (endbrain)	1. Cerebral cortex, basal ganglia, hippocampal formation, amygdala, olfactory bulb
	1b. Diencephalon	2. Thalamus, hypothalamus, subthalamus, epithalamus, retinae optic nerves and tracts
2. Midbrain (mesencephalon)	2. Mesencephalon (midbrain)	3. Midbrain
3. Hindbrain (rhombencephalon)	3a. Metencephalon (afterbrain)	4. Pons and cerebellum
	3b. Myelencephalon (medullary brain)	5. Medulla oblongata
4. Caudal part of neural tube	4. Caudal part of neural tube	6. Spinal cord

The main subdivisions of the embryonic central nervous system and mature adult forms (Kandel-Schwartz)



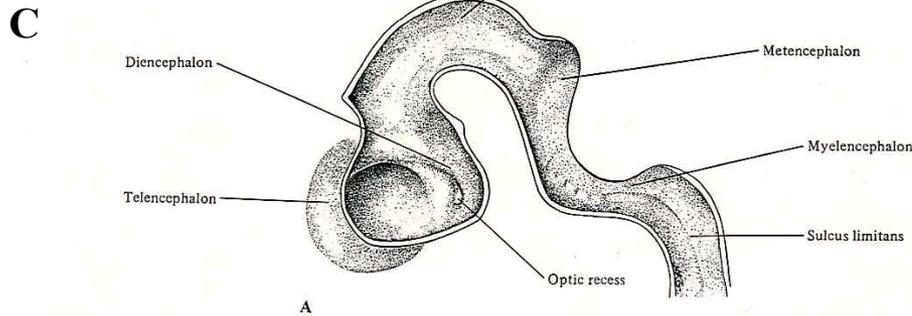
B

A-B: Early development of the brain.

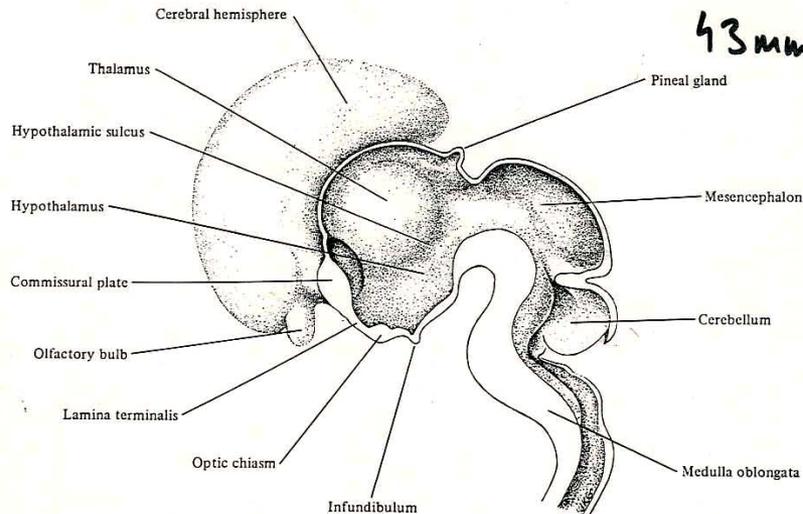
A midbrain flexure develops in the region of the mesencephalon and a slight bend, the cervical flexure, can be recognized at the junction of the rhombencephalon and the spinal cord.

B: A third flexure, the pontine flexure, develops between the metencephalon and myelencephalon and the brain now contains five parts. **C:** Same as (B) showing the medial surface of the right half of the brain in an 11-mm embryo.

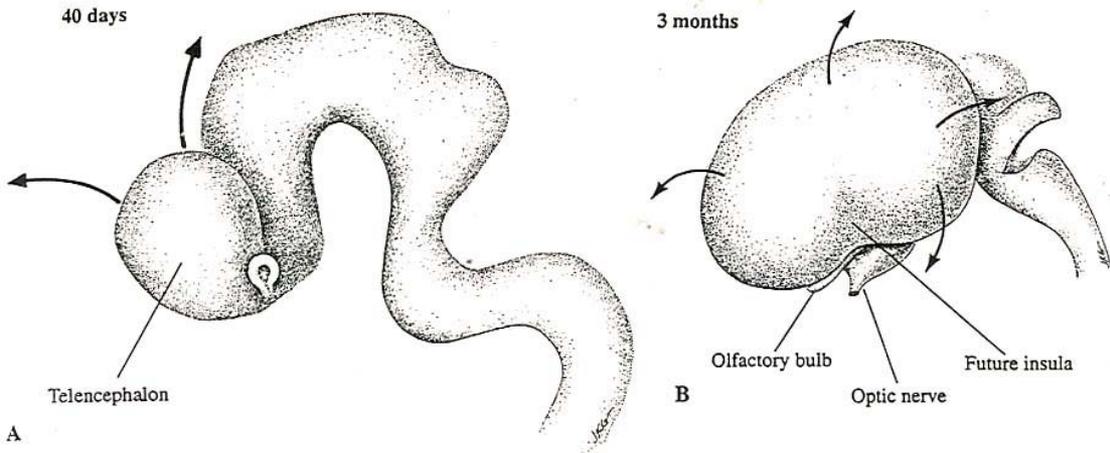
22 DEVELOPMENT OF THE NERVOUS SYSTEM



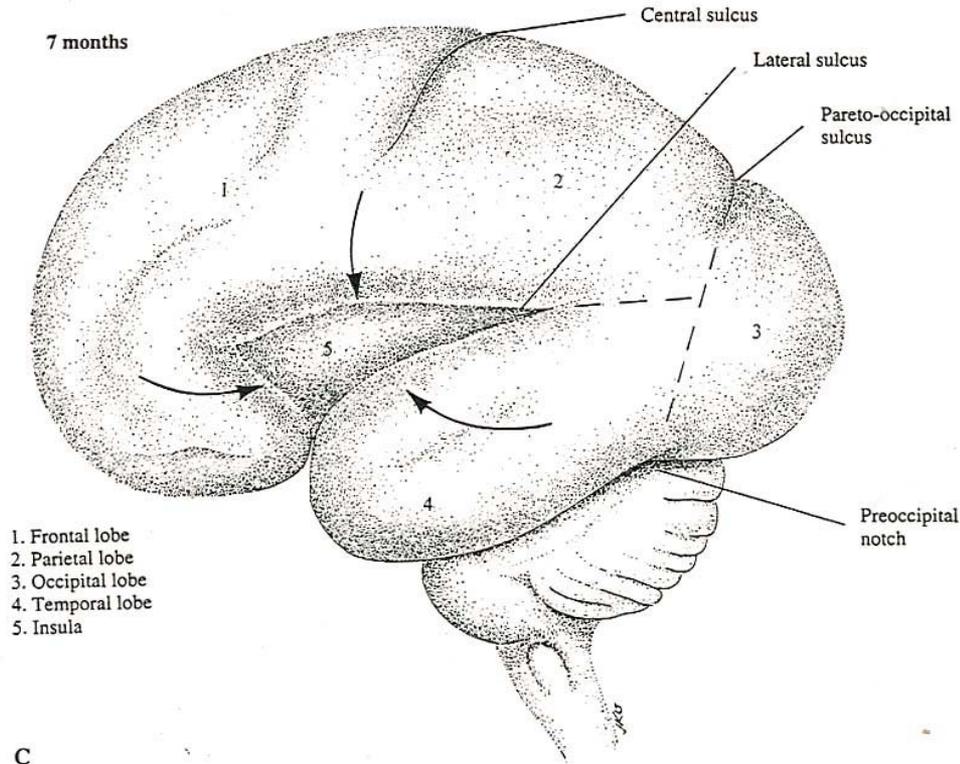
D

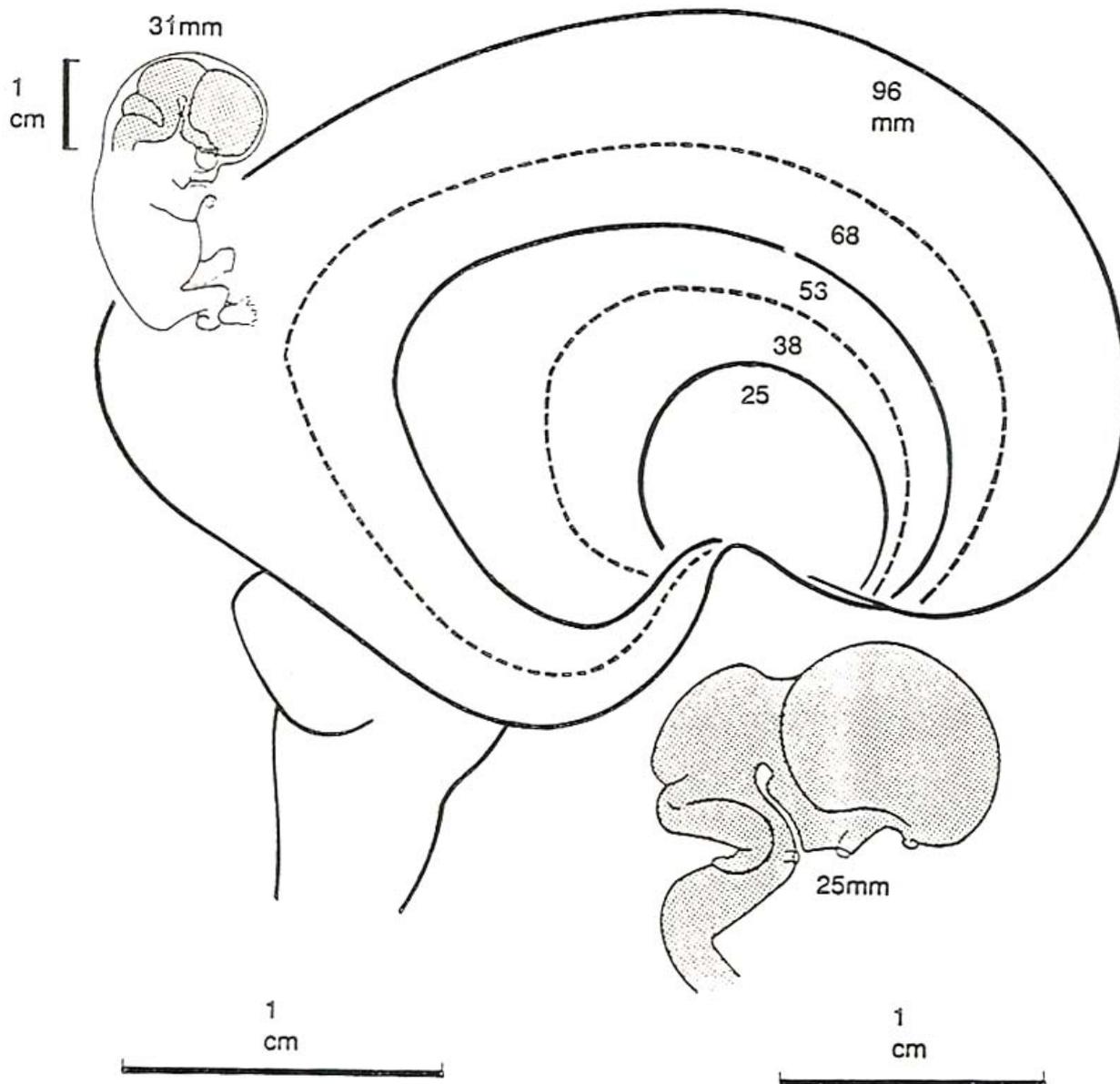


D: The medial surface of the brain in a 43-mm human embryo. The diencephalon can be subdivided into the thalamus and hypothalamus. (From Heimer, 1995)

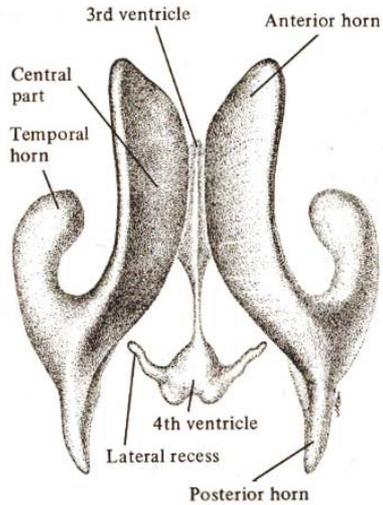


Development of the Cerebral Hemispheres. A and B: The telencephalic vesicle expands rapidly to cover the crest of the brain, and the posteroventral part of the vesicle curves down and forward to form the temporal lobe. **C:** The lateral surface of the brain of a 7-month-old foetus. The insular region is bounded by the frontal, frontoiparietal, and temporal opercula. Some of the more pronounced grooves have appeared and the hemisphere can be divided into four lobes: the frontal, parietal, occipital, and temporal lobes and the insula (From Heimer, 1995)



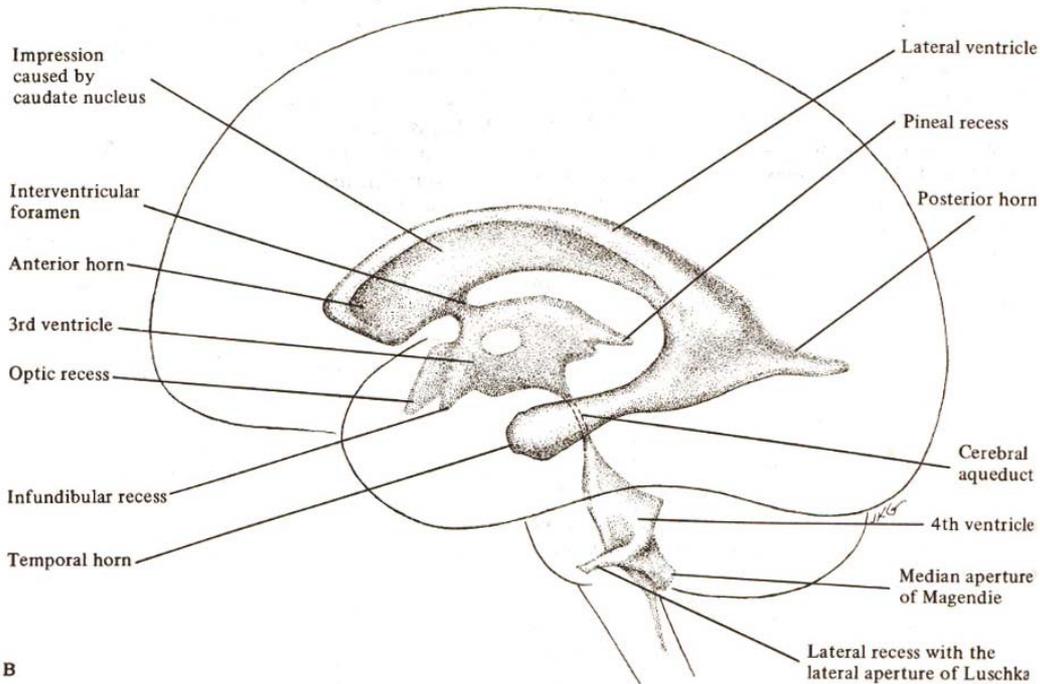


Outlines of the cerebral hemisphere at 25, 38, 53, 68 and 96 mm, drawn to the same scale, showing the considerable enlargement from the end of the embryonic period proper (8 postovulatory weeks). The lowermost drawing presents the entire brain at 25 mm. The uppermost drawing shows the brain in situ at 31 mm in almost natural size. (From O'Rahilly and Muller, 1994)

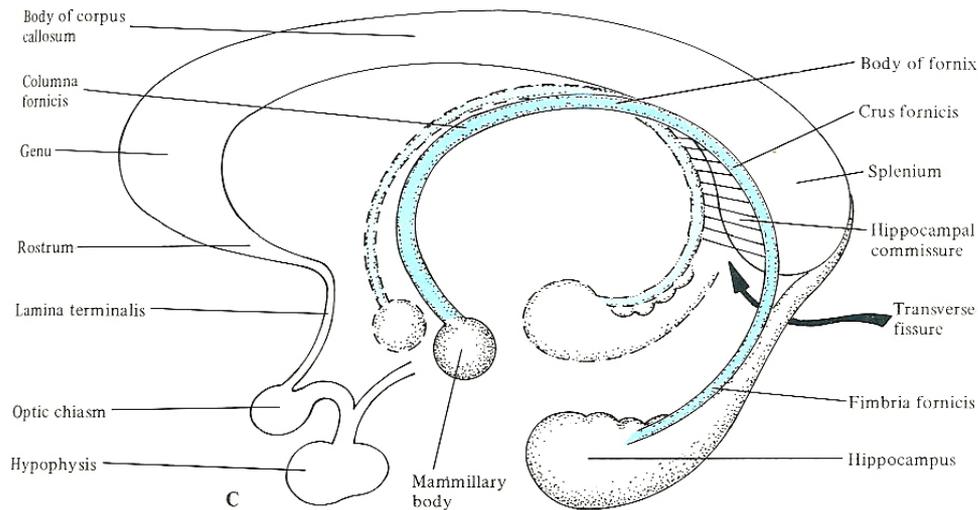
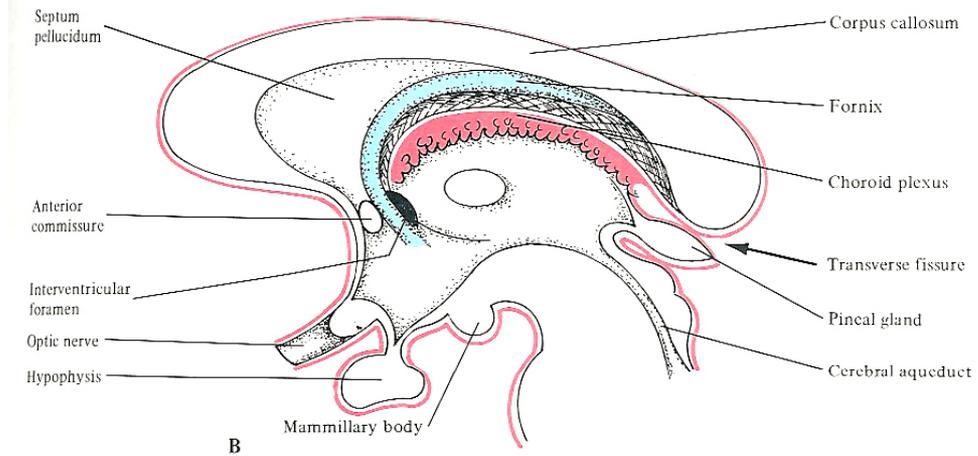
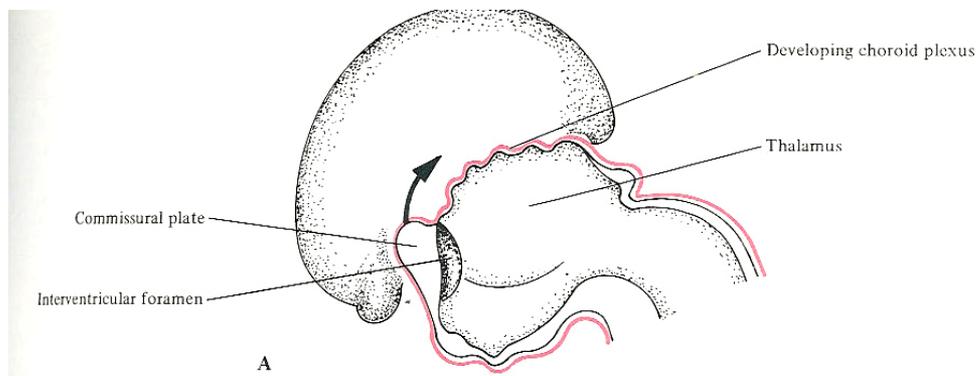


Development of the ventricle system. With the appearance of the temporal lobe, the lateral ventricle develops into a long curved cavity. A: superior, B: lateral views of the ventricle system (From Heimer, 1995)

A

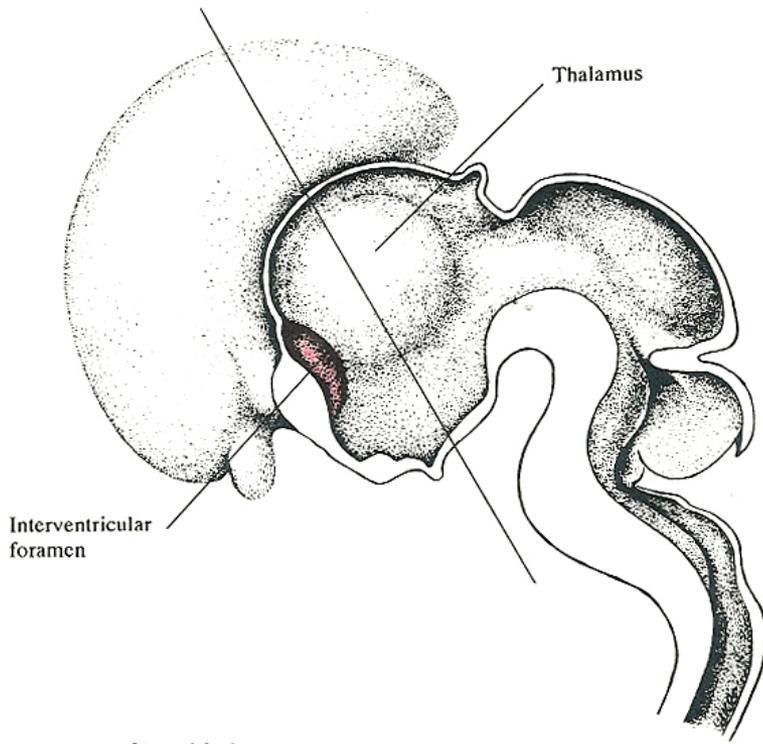


B



Development of Corpus callosum

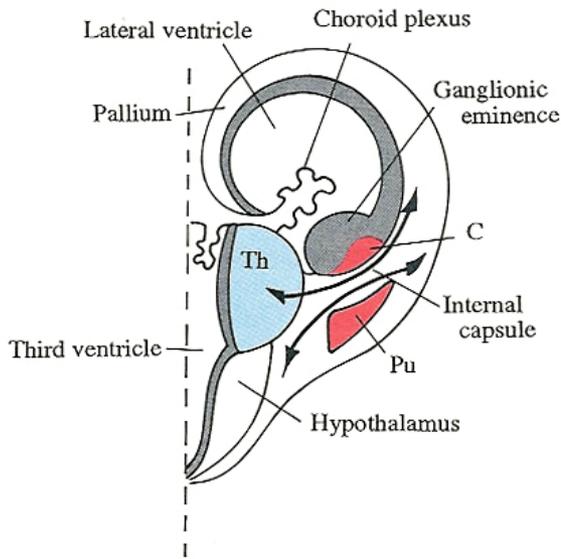
and fornix. **A:** Median sagittal section in a 10-week embryo showing the commissural plate and its development into corpus callosum. **B:** Median section through the corpus callosum and diencephalon in adult human brain. **C:** 3-D drawing illustrating the relationship between corpus callosum, fornix and hippocampus. (From Heimer, 1995)



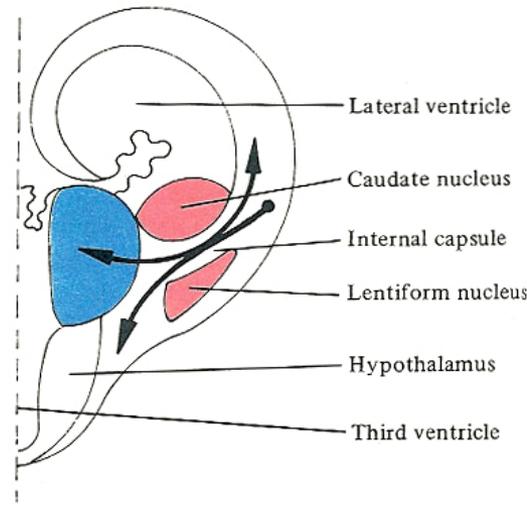
A

Development of corpus striatum and internal capsule

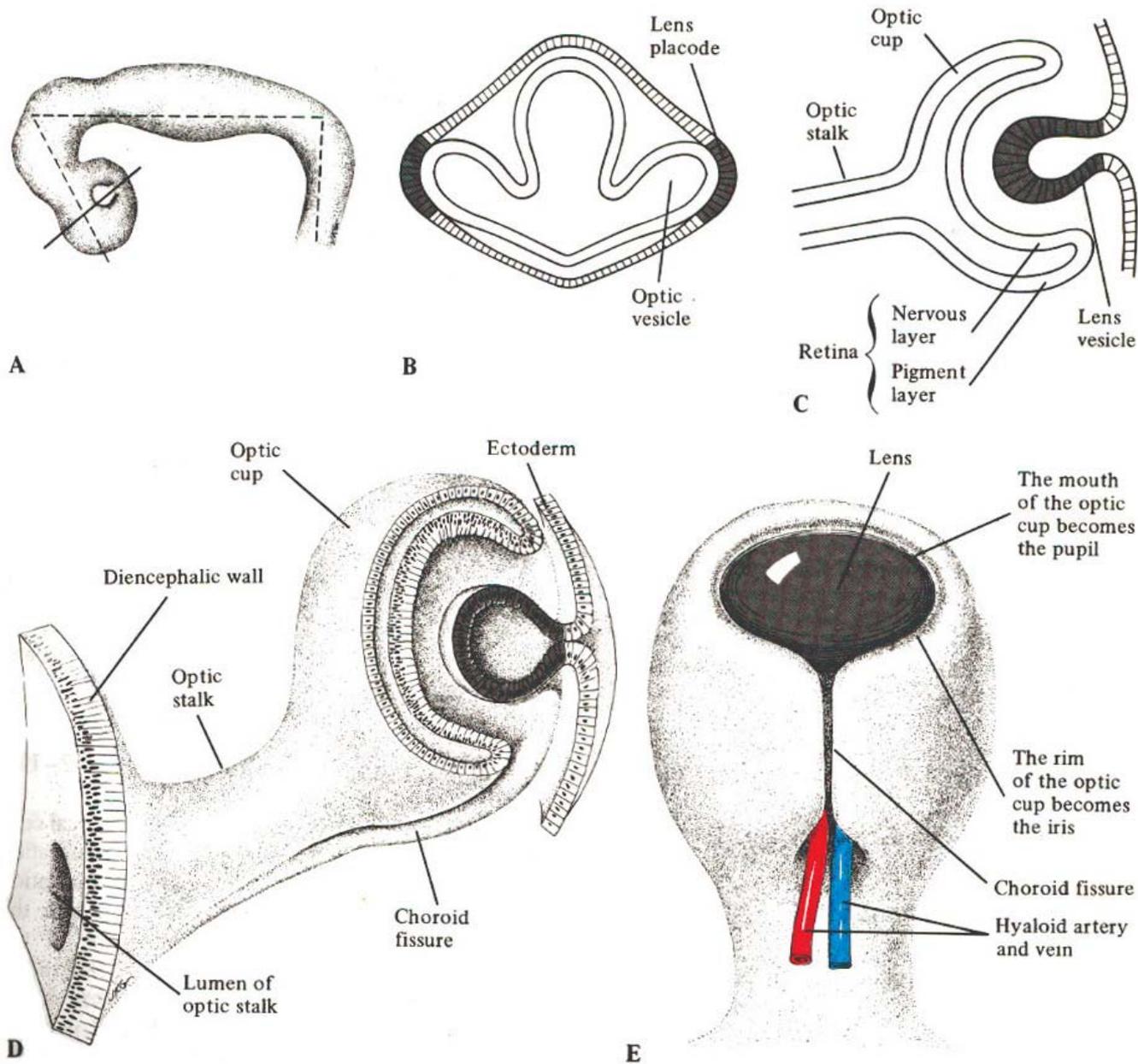
A: the medial surface of the brain in a 43 mm embryo. The thalamus is developing in the diencephalon, and corpus striatum in the basal part of the telencephalon. Part of the ganglionic eminence can be seen through the interventricular foramen. **B, C:** transverse sections through the developing brain.



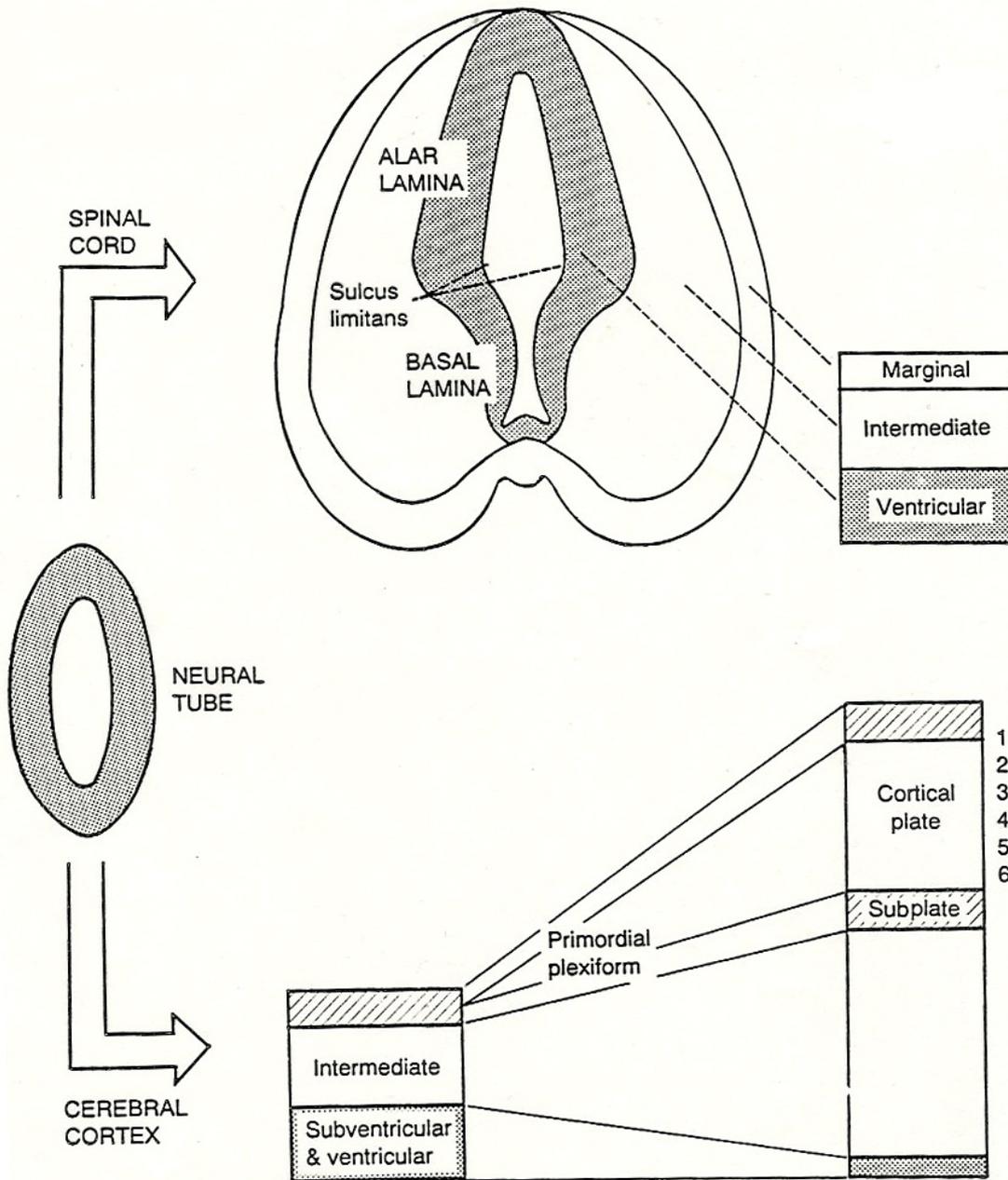
B



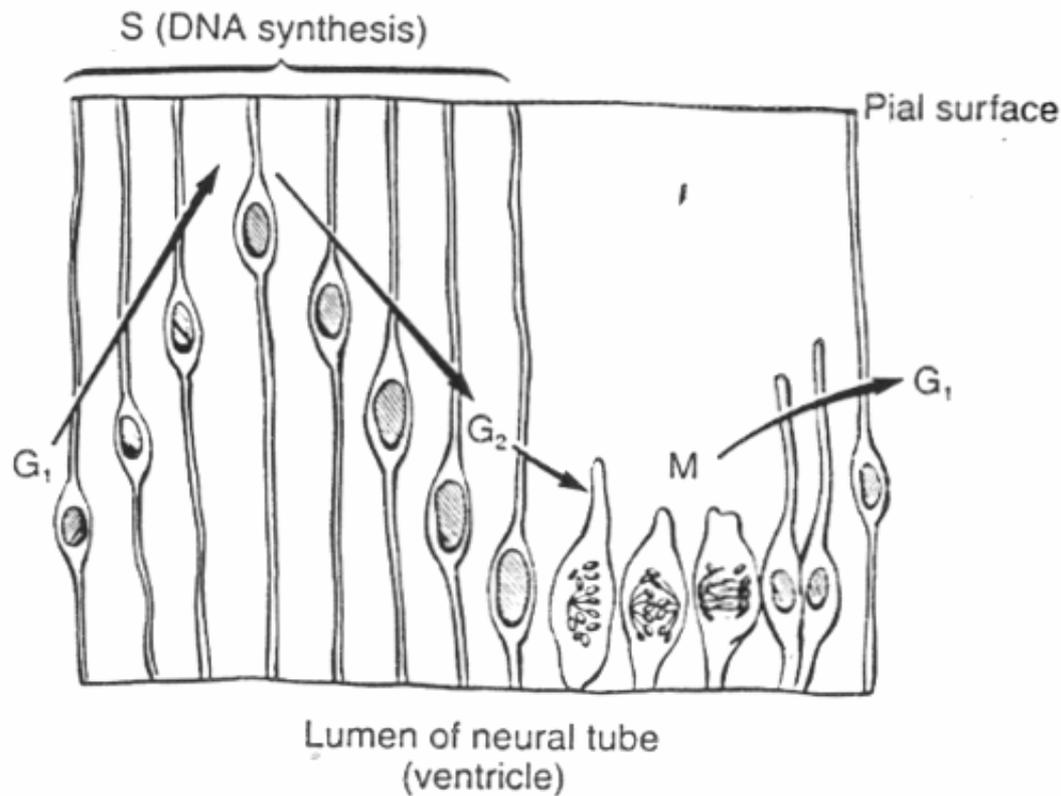
C



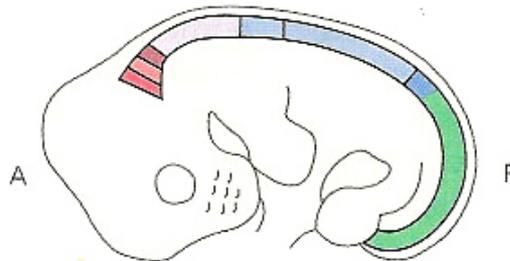
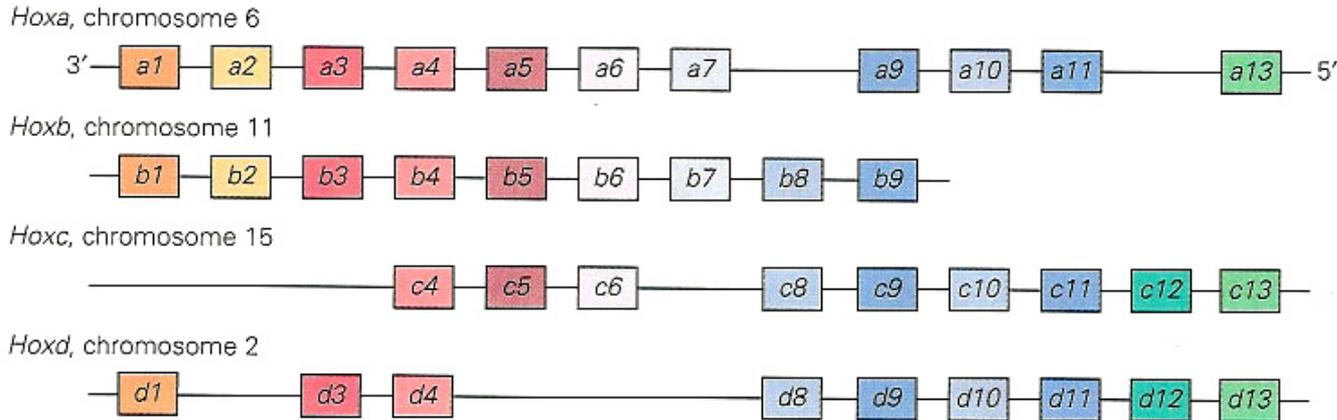
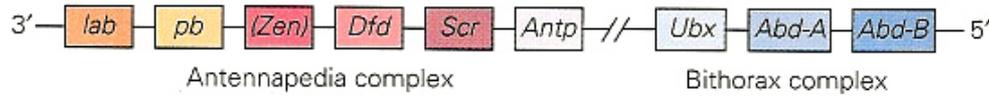
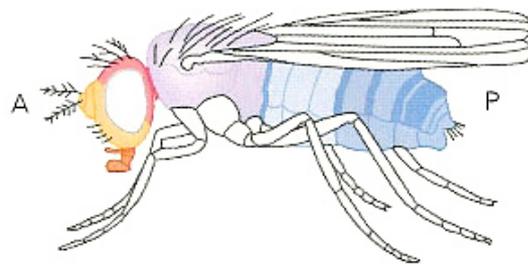
Development of the eye. The optic vesicles invaginate to form the retina, whereas the lens develops from the ectoderm (From Heimer, 1995)



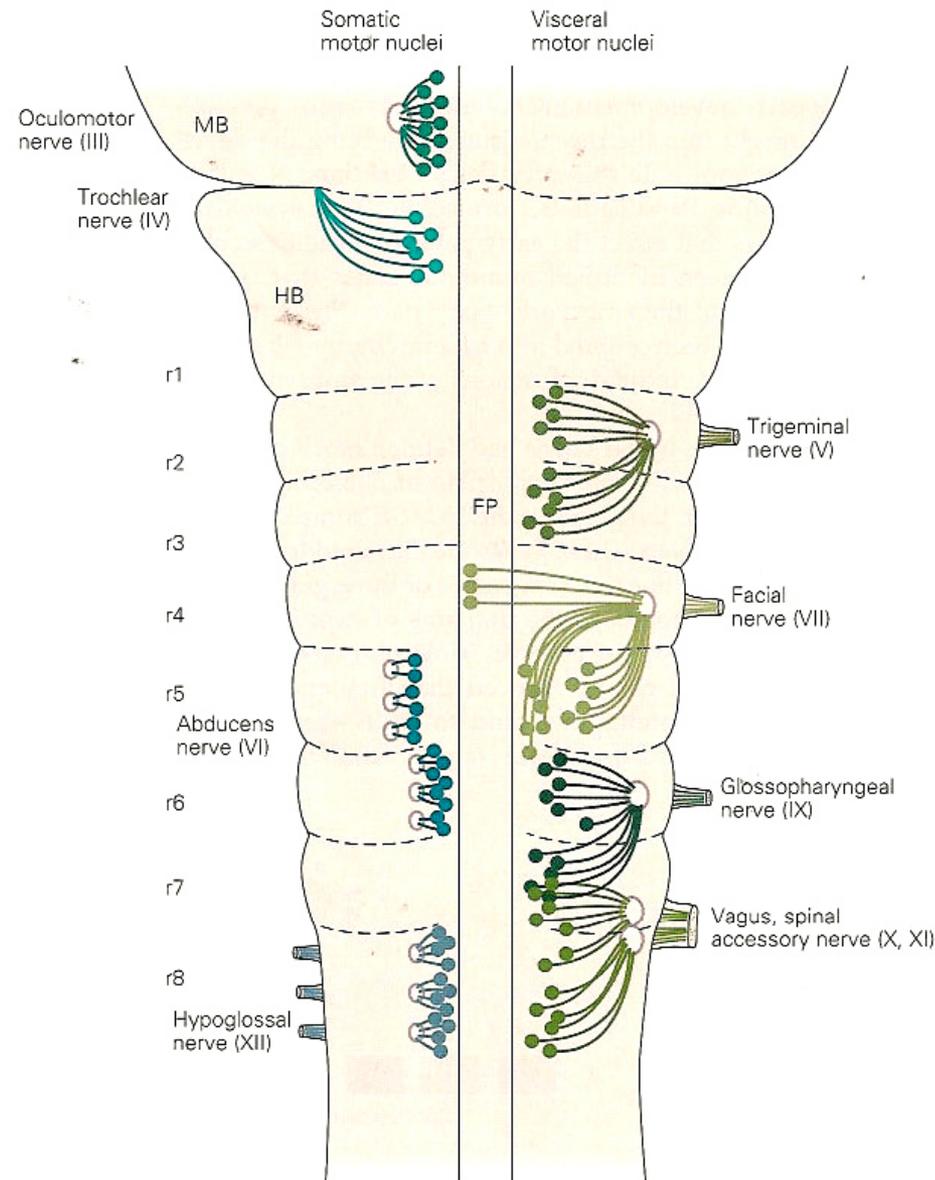
Developmental comparison between the spinal cord and the brain wall as derivatives of the neural tube. The cortical plate develops within the primordial plexiform layer, so that it comes to lie between superficial and deep laminae (namely layer I and the subplate of the neocortex). (From O’Rahily and Muller, 1991). See figure 18 for further development of the cortical plate.



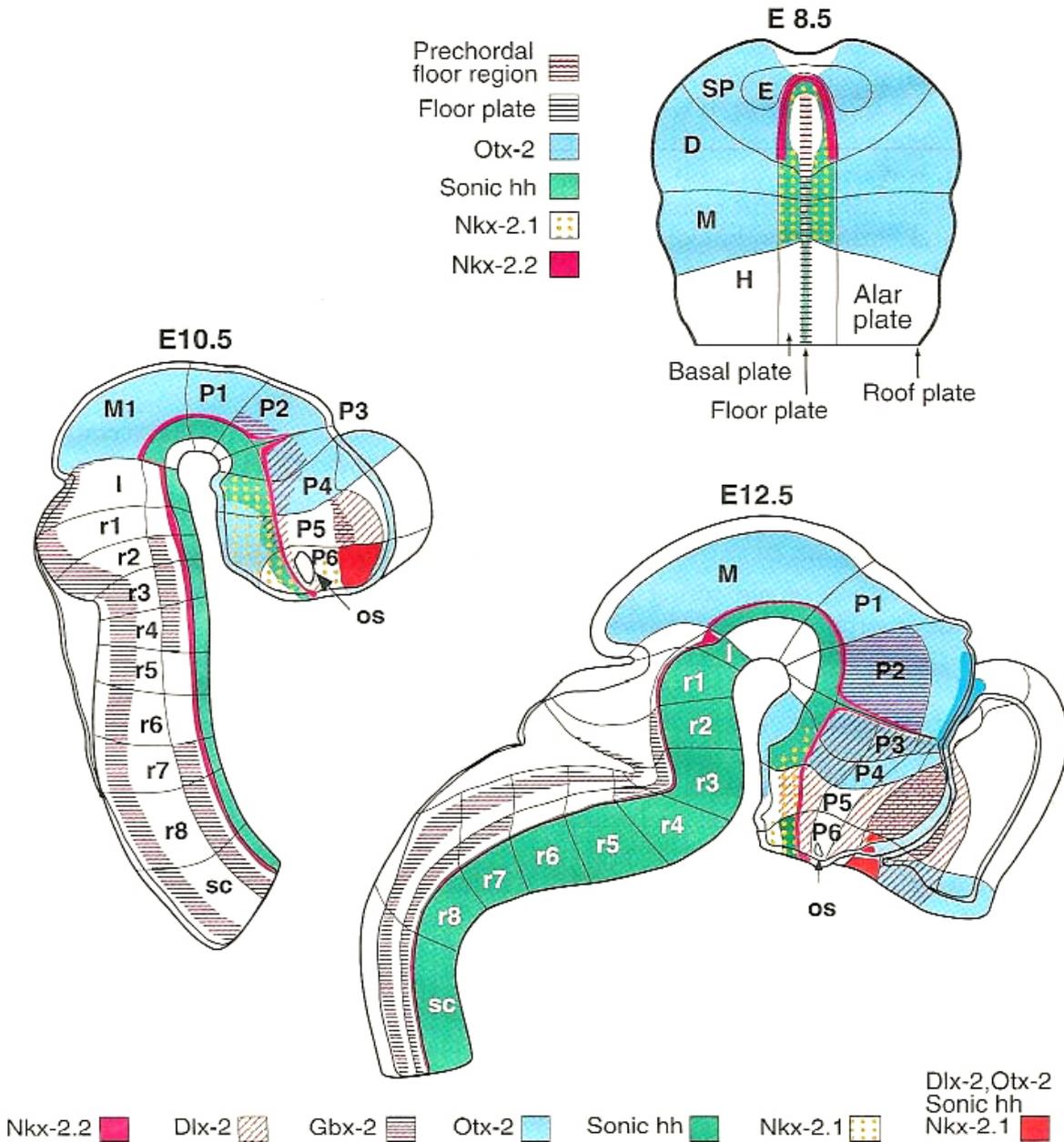
Cell proliferation in the neuroepithelium of the recently closed neural tube. The wall of the neural tube is composed entirely of proliferating neuroepithelial cells at this stage and appears as a pseudostratified epithelium in histologic sections. This effect is created by interkinetic nuclear migrations occurring during G₁ to S (DNA synthesis), and G₂ phases of the cell cycle. During mitosis (M), the cells retract their distal processes, become rounded, and divide next to the lumen of the ventricle. (From Cohen)



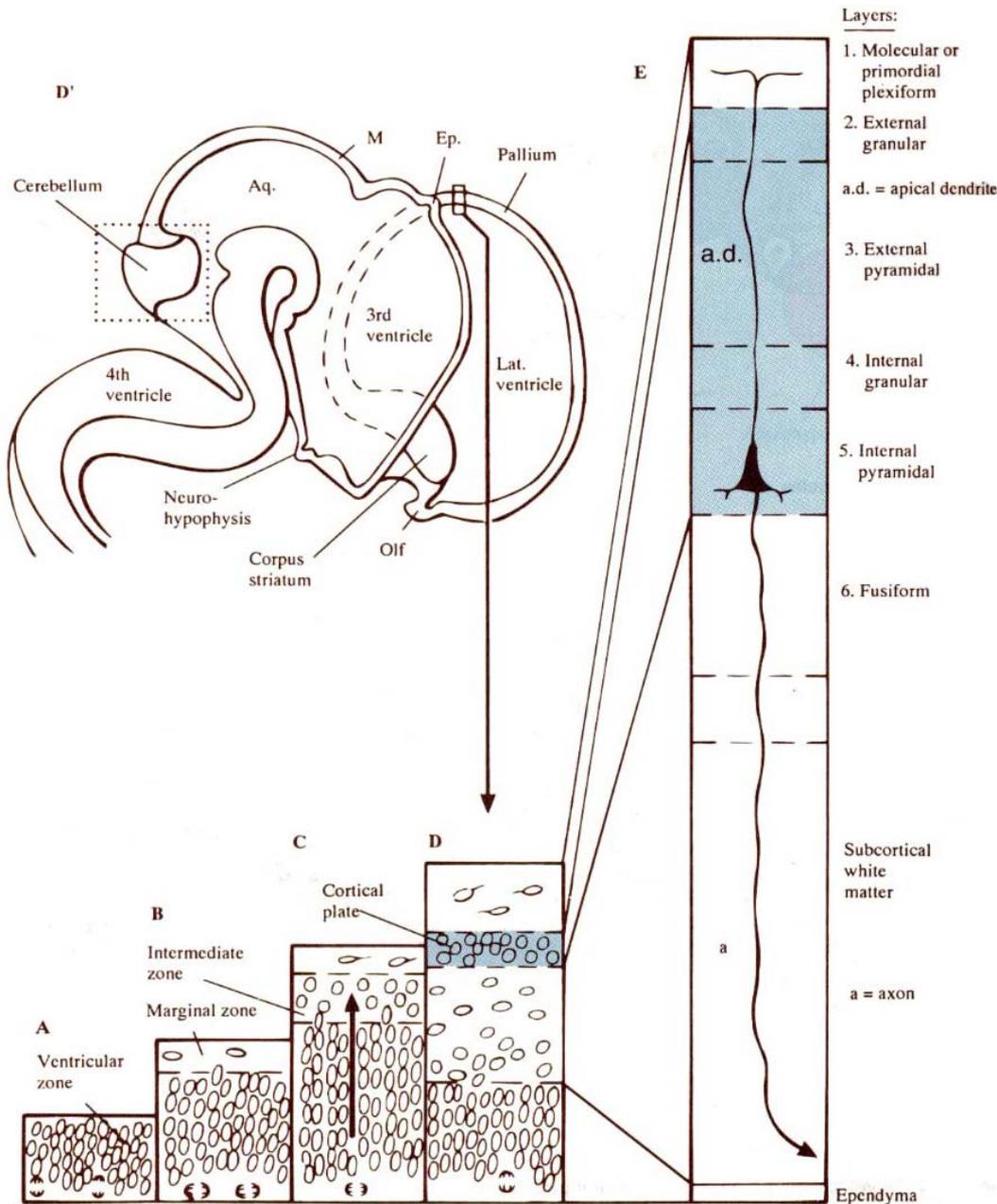
The clustered organization of Hox genes is conserved in flies and mammals. The diagram shows the chromosomal arrangement of Hox genes in the mouse and in *Drosophila*. The mouse has four Hox gene clusters, as do humans. The Hox (homeobox) genes are ordered in hierarchy, by which specific genes organize individual regions of the embryo in progressively finer detail. The Hox genes encode transcription factors – proteins that bind to DNA and activate the transcription of other regulatory factors. (From Kandell and Schwartz)



Segmentation pattern in the hindbrain. Chick embryohindbrain and caudal midbrain, viewed from ventral side, shows the rhombomeres (r1-r8) and the cranial motor nuclei (Keynes and Lumsden, 1990).



Rhombomers (r1-r8) and prosomers (p) defined by gene expression. The expression of the various genes are shown in the neural plate (E 8.5) and the neural tube (E 10.5 and E 12.5) of the embryonic mouse brain. D: diencephalon; E: eyes; H: rhombencephalon-hindbrain; I: isthmus; M: mesencephalon-midbrain; os: optic stalk; sc: spinal cord; SC: secondary prosencephalon (From Rubinstein)



Development of the cerebral cortex. From the earliest stage of rapidly multiplying cells in the ventricular zone (A) to the definitive cortex (E). Layers 2-5 develop according to an 'inside-out' sequence, as they derive from the cortical plate (blue in D), which begins to form inside the primordial plexiform layer. (From Heimer, 1995)

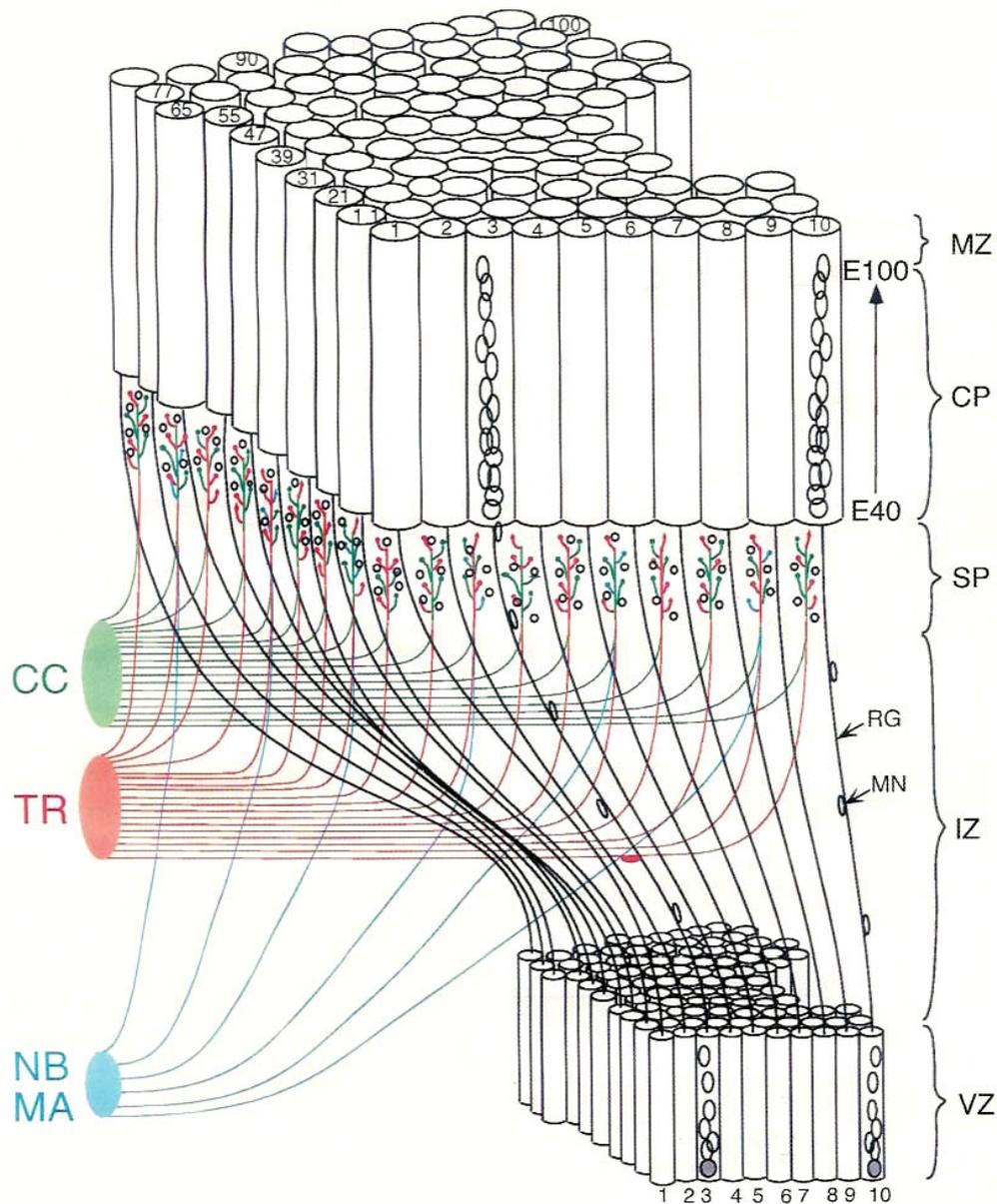
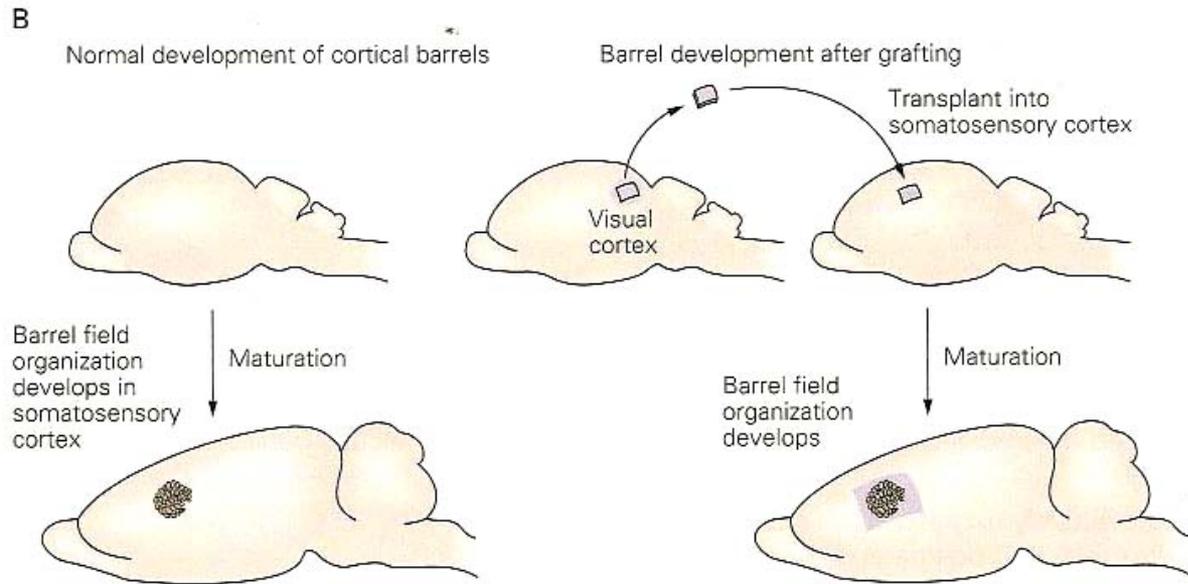
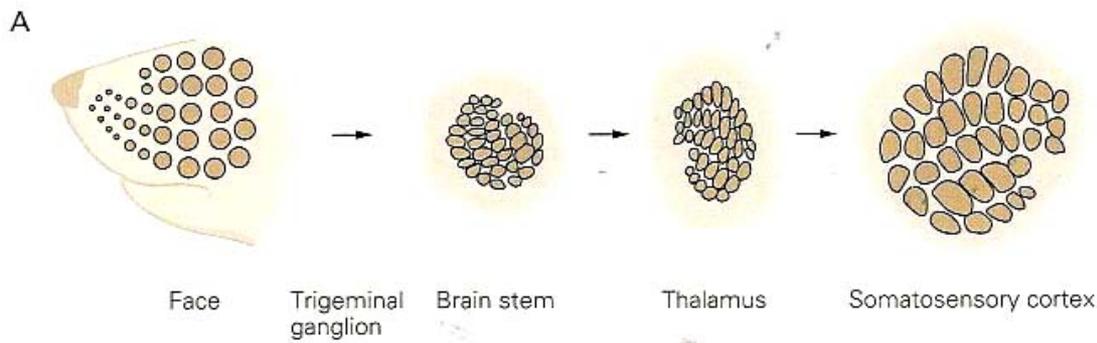


Diagram of the radial unit hypothesis. Radial glial cells (RG) in the ventricular zone (VZ) project their processes in an orderly map through the various cortical layers, thus maintaining the organizational structure specified in the ventricular layer. After their last division, cohort of migrating neurons (MN) first traverse the intermediate zone (IZ) and then the subplate zone (SP) where they have an opportunity to interact with 'waiting' afferents that arrive sequentially from the nucleus basalis (NB), monoaminergic axons (MA), from the thalamic radiation (TR) and the contralateral cortex (CC). After newly generated neurons bypass the earlier generated ones that are situated in the deep cortical layers, they settle at the interface between the developing cortical plate (CP) and the marginal zone (MZ), and eventually, form a radial stack of cells that share a common site of origin but are generated at different times. (Rakic, 1995)



Regional differentiation in the cortex. **A:** barrels in the somatosensory cortex are a somatotopic representations of the whiskers on the animal's face. Similar barrel representations of the whisker field are present in the brainstem and the thalamic nuclei that relay somatosensory inputs from the face to the cortex. **B:** A barrel field organization is induced when a region of the developing visual cortex is grafted into the site normally occupied by somatosensory cortex. The grafted region of visual cortex now acquires a barrel-like organization. (Schlagger and O'Leary, 1991)