Medical Neuroscience | Tutorial Notes

Embryological Subdivisions of the Human CNS

Map to Neuroscience Core Concepts[1]

NCC1. The brain is the body's most complex organ.

Learning Objectives

After study of the assigned learning materials, the student will:

1. Identify each of the major subdivisions of the adult nervous system, and relate them to their embryological precursors and associated ventricular spaces.

Narrative

by Leonard E. WHITE and Nell B. CANT
Duke Institute for Brain Sciences
Department of Neurobiology
Duke University School of Medicine

Introduction

The fundamental divisions of the brain and spinal cord are easier to appreciate if you understand their embryological derivations. This is just one helpful means of organizing your knowledge about the central nervous system (CNS). Thus, the human CNS—as in all other vertebrate species—is derived from four basic embryological formations: the prosencephalon (**forebrain**), the mesencephalon (**midbrain**), the rhombencephalon (**hindbrain**), and the elongated **spinal cord**. The embryonic divisions of the central nervous system give rise to adult structures as summarized in the chart below (next page). This chart depicts the conserved relationships among the parts of the developing brain and their adult brain derivatives, although the relatively greater growth of the cerebral hemispheres makes some of these relations somewhat difficult to appreciate.

This tutorial a refresher on the basic parts of the human central nervous system (CNS); it is designed to help you learn how to recognize major adult derivations of each embryological formation. Hopefully, you are now well on your way toward learning how to locate the components of important sensory, motor, and associational pathways in each subdivision of the central nervous system. As we begin our studies of the **Changing Brain** in Unit 5 of the course, let's recount the basic events of neuroembryology and give you opportunity to appreciate the relation between the embryological and mature forms of the basic parts of the human CNS.

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

Basic subdivisions of the mammalian brain

By the end of the first month of gestation, the neural tube closes and three swellings appear at its cephalic end (see **Figure 22.3** in Purves et al., *Neuroscience, 5th Ed.* [2]). These will form the brain, while the rest of the neural tube gives rise to the spinal cord. The most rostral of the three, the **prosencephalon**, soon divides into two parts: the **telencephalon**, which gives rise to the cerebral hemispheres, and the **diencephalon**, which becomes the thalamus and hypothalamus. These structures together make up the adult forebrain.

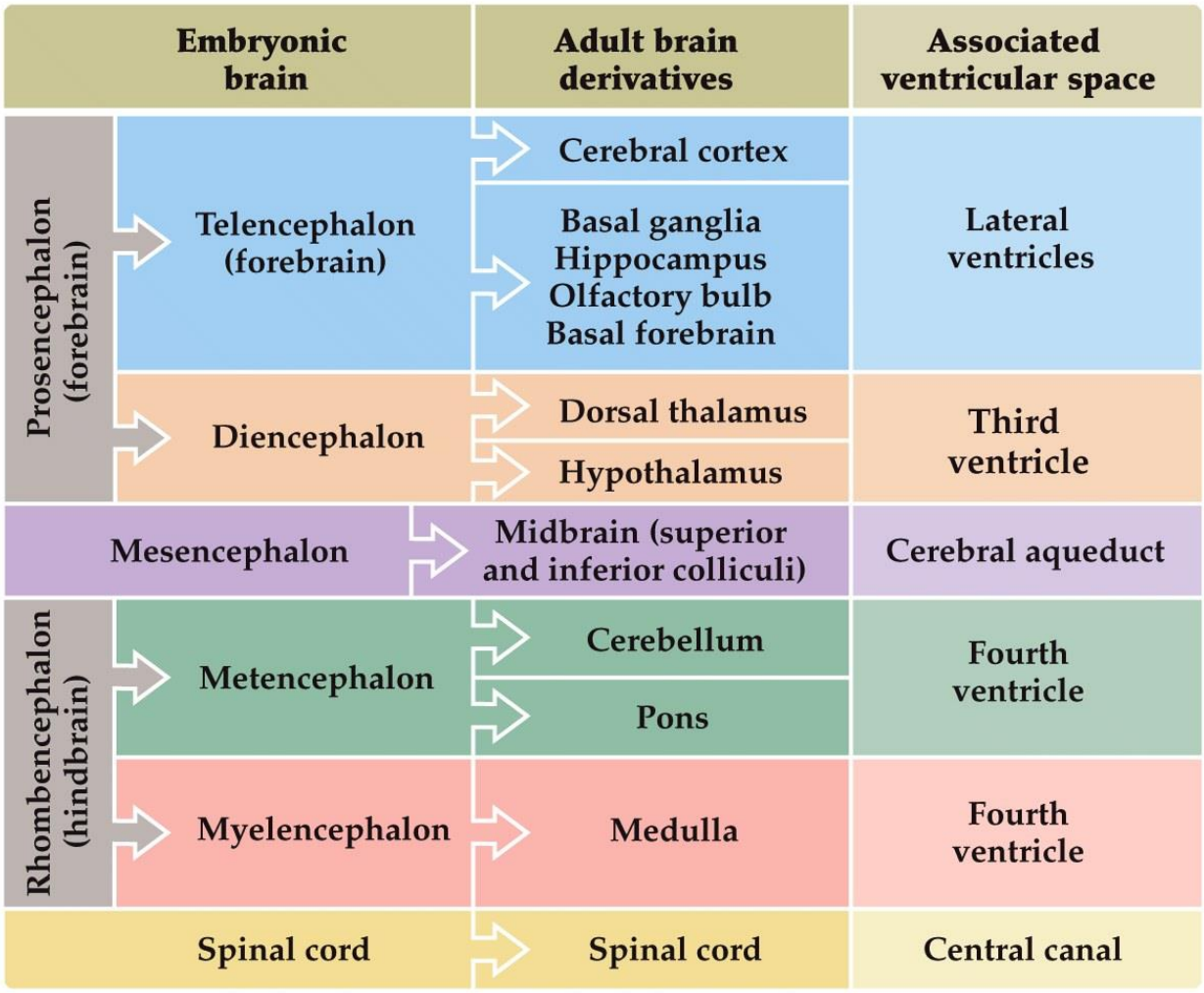
Since the nervous system starts out as a simple tube, the lumen of the tube remains in the adult brain as a fluid-filled space. (Consider for a moment the fact that the entire brain is formed in the walls of a hollow tube!) This fluid-filled space, known as the **ventricular system**, is filled with cerebrospinal fluid (CSF) and provides an important landmark on images of the nervous system. As the brain grows, the shape of the central space also changes from that of a simple tube to its complex adult form. The space, although continuous, takes different names in each of the subdivisions. Thus, the spaces inside the hemispheres are known as the **lateral ventricles**, and the space inside the diencephalon is the **third ventricle**. The **mesencephalon**, which is the middle swelling in the 4-week embryo, does not divide further and becomes the midbrain of the adult. The space inside the midbrain is called the **cerebral aqueduct**.

The **rhombencephalon** further divides into the **metencephalon**, which becomes the pons and cerebellum, and the **myelencephalon**, which becomes the medulla. The neural tube caudal to these three cephalic swellings becomes the spinal cord. The space inside the developing rhombencephalon is called the **fourth ventricle**. In early postnatal life, the development of the cerebellum gives rise to three apertures in the fourth ventricle that allow cerebrospinal fluid to exit the ventricular system and bathe the CNS in the subarachnoid space (see below). In the embryo and young children, the opening in the spinal cord is patent and is known as the **central canal**. However, it is very narrow and usually reduced to a "potential" space with very little CSF in the adult and no continuous ventricular channel connecting the central canal to the fourth ventricle.

Not all of the brain structures just mentioned (terms in **bold**) are easily seen in the accompanying video tutorial. But you have seen them all if you viewed the full set of video tutorials in Unit 1 of the course when we explored the major parts of the adult brain. Nevertheless, at this point, focus on learning the relationships depicted in the chart below and their embryological origins. This will help to make relationships among brain structures and ventricular spaces in the adult much more obvious.

To test yourself (in place of a Study Question), use the ventral view of the brain in **Figure 1** and label as many of the structures in the chart below that you can find in this brain.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]



***NEUROSCIENCE 5e*, Figure A24**

STUDY QUESTION

It is sometimes said that the hippocampus is a subcortical structure. What do you think? Agree or Disagree: the hippocampus is subcortical.

A. Agree

B. Disagree

Of course, after you respond, you should think about why you choose the answer you did and whether or not you agree with Prof. White's opinion of this question.

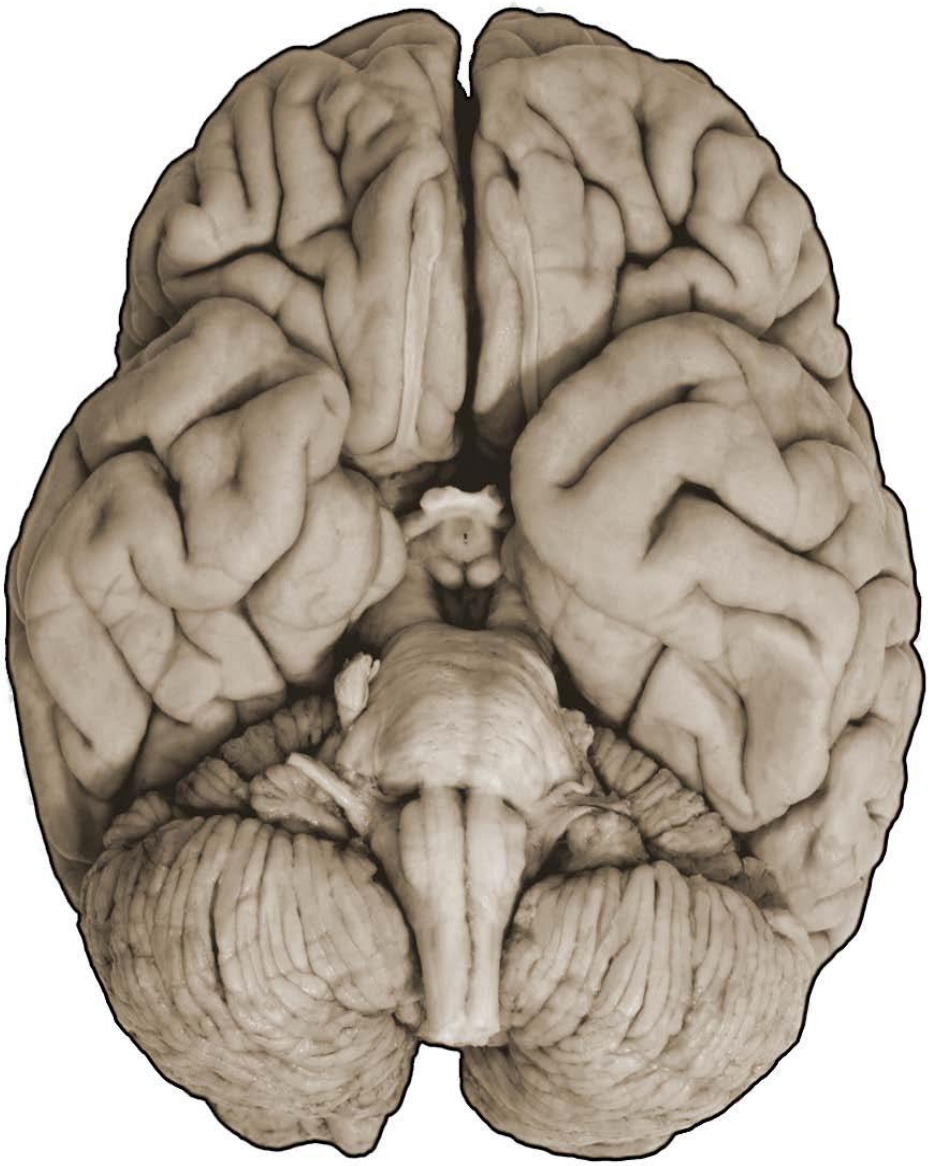


Fig. 1. The ventral surface of the brain. (Image from ***Sylvius4***)