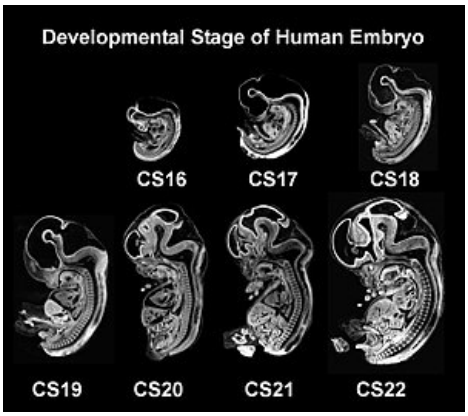
Brain Development

The base of the central nervous system is formed at the beginning of the **3rd week** by the plate of the thickened ectoderm – **neural plate**. It has the shape of a slipper lying in the midline on the dorsal side of the embryo in front of the primitive (Hensen's) node. The lateral edges of the disc rise to form neural crests. Eventually, the neural crests move closer together until they fuse to form the neural tube. The fusion begins in the neck region and continues in the cranial and caudal direction, the neural tube has openings *neuroporus anterior et posterior*. Neuropore closure proceeds cranially and caudally, and at the stage of 18–20 somites, the anterior neuropore is completely closed (day 25), the posterior neuropore closure occurs two days later.

3 **primary brain cysts** are formed at the head end of the neural tube

1. The forebrain or the **prosencephalon**.
2. The midbrain or the **mesencephalon**.
3. The hindbrain or the **rhombencephalon**.



4th week of development

At the same time a **bend** is formed

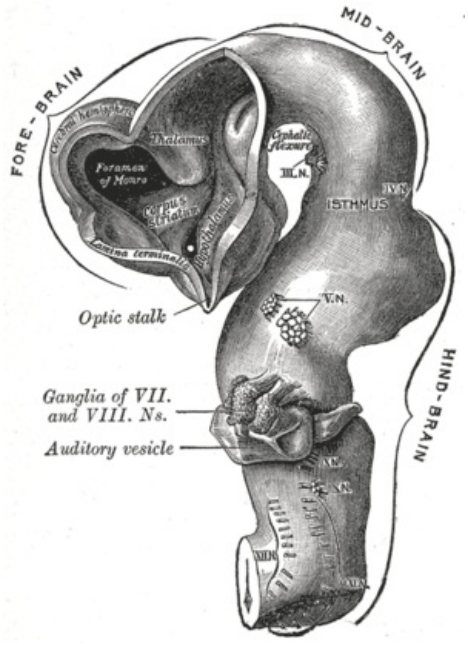
1. Cervical flexure - border of the hindbrain and spinal cord.
2. Cephalic flexure - area of the midbrain.

Changes in week 5

1. Prosencephalon consists of 2 parts:
   - **telencephalon** or terminal brain;
   - **diencephalon** or midbrain.
2. Mesencephalon.
3. Rhombencephalon:
   - **metencephalon**;
   - **myelencephalon**.

In the 5th week, we can distinguish these structures in individual sections of the brain:

- telencephalon – **lamina terminalis'** (middle part) and two lateral arches, **basics of cerebral hemispheres**;
- diencephalon – they grow out of it **eye bags**;
- **rhombencephalic isthmus** – the constriction that separates the mesencephalon and the rhombencephalon;
- **flexure pontis** – border between metencephalon and myelencephalon.



4th week of development

The medulla spinalis, the spinal cord, has a canal inside it, canalis centralis, which continues into the cavity in the brain sacs

- in rhombencephalon – **4th cerebral ventricle**;
- in diencephalon – **3rd cerebral ventricle**;
- in telencephalon, or cerebral hemispheres – the lateral ventricles are connected to the third ventricle by means of the foramen interventricular (Monroi)**;**
- in mesencephalon – **aqueductus mesencephali (Sylvii)**.

Basal and alar plate, or motor and sensitive area, separates the sulcus limitans in the rhombencephala and mesencephala. In the prosencephala this division is obliterated by the great development of the alar plate and the reduction of the basal plate.

Rhombencephalon

Myelencephalon

- **Myelencephalon** is the brain sac that gives rise to the spinal cord medulla oblongata.
- The difference from the spinal cord lies in the opening, in which the alar plates lie more laterally.

Basal Plate

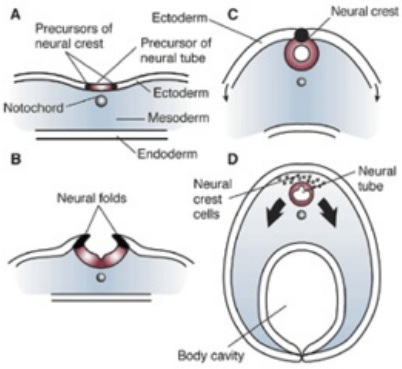
- contains motor neurons grouped in nuclei, which are divided into 3 groups:
  1. Medial somatomotor nuclei.
  2. Lateral somatomotor nuclei.
  3. Visceromotor nuclei.

- Median somatomotor nuclei - '*median row of somatomotor nuclei*.

    - Represents the rostral continuation of the motoneurons of the anterior horns of the spinal cord, continuing to the mesencephalon.
    - The core n. hypoglossus (XII) – tongue muscles.

- Lateral somatomotor nuclei - '*lateral row of somatomotor nuclei*.
    - Cores:
        - n. glossopharyngeus (**IX**),
        - n. vagus (**X**),
        - n. accessorius (**XI**).

- Visceromotor nuclei - '*visceromotor row of nuclei*.
    - They innervate the heart, smooth muscle and glands DS, TS, MPS (urinogenital system).
    - In this row lie preganglionic parasympathetic neurons whose fibers run in:
        1. n. glossopharyngeus (IX),
        2. n. vagus (X).



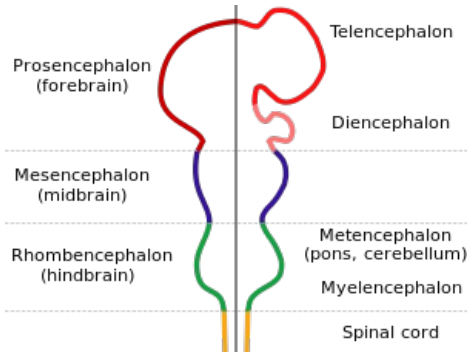
Neural tube development

Alar Plate

- 3 groups of nuclei that provide sensitive (afferent) stimuli:
    1. **Somatic afferent –** *special (sensory)*, to which stimuli from the inner ear arrive via n. vestibulocochlearis (VIII) and ``general - *fibers from the skin of the face, brings mainly n. trigeminus to the long nucleus, which extends into the spinal cord and into the mesencephalon.*
    2. **Special viscerosensitive** - sensory fibers from the taste buds, come n. trigeminus (V), n. facialis (VII), n. glossopharyngeus (IX), n. vagus (X), ends in the nucleus solitarius close to the sulcus limitans.
    3. **General viscerosensitive** – fibers from the mucous membranes of the TS, DS and the heart. It connects to the sensory fibers of the taste buds.

Ceiling Plate Myelencephala, Tela Choroidea

- The ceiling plate of the myelencephala consists of a single layer of ependymal cells covered by a pia mater mesenchyme containing vessels.
- It forms the ceiling of the 4th cerebral ventricle and the choroid plexus emerges into its cavity - it is the place of cerebrospinal fluid production.



Division of cerebral vesicles.

Metencephalon

- The **Metencephalon** is divided into the Varola bridge and the cerebellum.

Varola's Bridge

- **Varola's bridge** is divided in the dorsal part into an alar and a basal plate. The ventral part of the pons contains pathways connecting the cerebral cortex, spinal cord, and cerebellum.
- The basal plate is arranged similarly to the myelencephalon, or is its continuation, and contains 3 rows of cranial nerve nuclei:
    - medial row of somatomotor nuclei: n. abducens (VI), n. trochlearis (IV), n. oculomotorius (III) – innervate oculomotor muscles ;
    - lateral row of somatomotor nuclei: n. facialis (VII), n. trigeminus (V) – innervate the 1st and 2nd pharyngeal arches;
    - a series of visceromotor nuclei containing parasympathetic preganglionic neurons, the axons of which leave the brainstem via the n. facialis (VII) and n. oculomotorius (III) – supply the submandibular and sublingual glands;
    - the basal plate also contains other nuclei that are not continuations of the myelencephalic nuclei and also contains nuclei of the reticular formation;
    - the marginal layer of the basal plate grows by the course of fibers coming from the cerebral cortex to the cerebellum and the spinal cord.
- The nuclei, nuclei pontis, originate from the alar plate, from which part of the fibers are connected from the cortex to the cerebellum. It also contains nuclei that are continuations of the sensitive and sensory nuclei of the alar plate of the myelencephala:
    - somatic afferents – n. trigeminalis (III);
    - special viscerosensitive;
    - general viscerosensitive.

Cerebellum

- The **Cerebellum** is part of the metencephalon.
- The dorsolateral parts of the alar plate bend medially to form ridges that meet in the midline just below the mesencephalon.
- As a result of the deepening of the flexure pontis, the valances are compressed and form the cerebellar plate.
- In the 12th week, a small part of the vermis is visible, and two lateral parts - hemispheres.

    - At the end of the 3rd month, the fissura posterolateralis separates the lobus flocculonodularis, on the vestibular part of the cerebellum, from the front part of the cerebellum.
- At the beginning of the 4th month, the front part of the cerebellum is divided by a deep groove, fissura prima, into the anterior lobe (spinal cerebellum) and the posterior lobe, pontine cerebellum.
- Later, the cerebellum is divided into individual folia.
- The cerebellar plate is made up of 3 layers:
    1. periventricular;
    2. cloak;
    3. marginal.
- Further development of the cerebellum is complicated by the formation of two germinal layers, and only at the end of the 3rd month do the precursors of individual cell types migrate to their definitive layers:
    1. inner germinal layer – periventricular + mantle layer;
    2. external germinal layer – formed on the surface of the cerebellum from the cells of the inner germinal layer.
- Neuroblasts from the inner germinal layer migrate towards the surface of the cerebellum and differentiate into Purkinje and Golgi cells.
- The neurons of the cerebellar nuclei differentiate from the cells that did not migrate.
- Neuroblasts from the outer germinal layer migrate along the radial glia deep into the cerebellum and differentiate from them into granular, stellate and goblet cells.
- Glial cells originate from both germinal layers. The cerebellar nuclei are differentiated before birth, but the cerebellar cortex does not reach its final organization until after birth.

Mesencephalon

- **In the basal plate** there are two groups of motor nuclei:
    - medial row of somatomotor nuclei - axons innervating the oculomotor muscles emerge from them via n. trochlearis (IV);
    - small visceromotor nucleus of the nucleus accessorius n. oculomotorii – whose preganglionic axons, after connecting in the ggl. ciliare, innervate the sphincter pupille and m. ciliaris.

- Under the basal plate, in its marginal zone, the crura cerebri is formed:
    - axons from the cerebral cortex descend from it to centers in the medulla oblongata.

- **In the alar plate:**
    - they are initially visible as two longitudinal bumps separated by a shallow groove in the midline;
    - a transverse groove divides the longitudinal tubercles and creates a quadruple tubercle with paired colliculi superiors and inferiors;
        - '*superior colliculi* and the area in front of them - are the center of visual reflexes;
        - **inferior colliculi** – switched auditory pathway;
    - The quadricorne is formed during several waves of neuroblast migration, which are always directed to the non-superficial layer. The result is the oscillating arrangement seen in the superior colliculi;
    - '*nucleus ruber* and **subtantia nigra** originate from neuroblasts of the alar plate.

Prosencephalon

- The prosencephalon *is a highly specialized part of the CNS, and it is thought that the telencephalon and diencephalon are derivatives of the alar and ceiling plates, and that the basal plate is not formed in the forebrain. Also, segmentation is only indicated in the forebrain and the indicated segments are described as* ***prosomers***.

Diencephalon

- The diencephalon is formed from the middle part of the prosencephalon:
- **the scum and basal plates are not visible** ;
- 'ceiling plate areacorresponds anteriorly in the diencephalu a layer of ependymal cells that covers the vascularized mesenchyme - forms the ceiling of the 3rd cerebral ventricle, ***tela choroidea ventriculi tertii***." In the back part of the ceiling plate, it differentiates:
    - **epithalamus with epifyse, corpus pineal** – the epiphysis is formed as a thickening of the ependyma, which begins to elongate in the 7th week. It eventually develops into a solid organ extending as far as the colliculi superioris. It produces melatonin, which is used in the regulation of hormonal and circadian rhythms as a response to the alternation of light and darkness.
- **areas of the alar disc**;
- form diencephalon structures on the sides of the 3rd ventricle. On their inner side there is a groove, the *hypothalamic sulcus*, which divides this part of the diencephalon:
    - to the dorsal compartment, **thalamus''*.*** The proliferative activity of cells in the area of the thalamus causes it to bulge into the cavity of the 3rd ventricle and often to the fusion of the thalamus of both sides***, adhesio interthalamica***. It is the largest part of the diencephalon. Its nuclei connect impulses from peripheral receptors to the corresponding area of the cortex. The input of visual and auditory stimuli is connected in the nuclei of the metathalamus (corpus geniculatum mediale et laterale);
    - the ventral section, the **hypothalamus**, gradually differentiates into a number of nuclei and areas that are used in the control of visceral functions (digestion, body temperature, emotional behavior, sleep), e.g. one such nucleus is the corpus mamillare, which is evident on the ventral surface of the hypothalamus.
- from the protrusion of the diencephalon in the area of the infundibula, the dorsal part of the pituitary gland

develops. The second part, ventral, arises from the **ectoderm (Rathke's) protrusions'** in the ceiling of the **stomodea*.*** In the 3rd week, Rathke's notch is already visible, it gradually grows in the dorsal direction to the infundibulum, and at the end of the ***2nd month*** it loses its connection with the oral cavity and enters into contact with the infundibulum***.*** During further development, cells in the anterior wall of Rathke's capsule proliferate and differentiate into cells of the anterior lobe of the pituitary gland, adenohypophyses*. Its small projection, the* **pars tuberalis***, surrounds the stalk of the pituitary gland. From the back wall of Rathke's cleft, the pars intermedia and the posterior lobe arise hypofysy, neurohypophysis, differentiates from* ***pituicytes,*** *which are modified neuroglia, contains nerve fibers from hypothalamus.*

Telencephalon

- **Telencephalon** it is the most rostral of the cerebral vesicles.
- It is composed of two lateral protrusions of the hemispheres and a central part, the lamina terminalis.
- Inside the hemispheres are the cavities of the lateral ventricles - ventriculi laterales, which communicate with the 3rd ventricle through the foramen interventricular.
- Hemispheres arise at the beginning of the ***5th week*** of development as the arching of the lateral wall of the prosencephalus. The basal part of the hemispheres begins **in the middle of the 2nd month** to grow and arch into the cavity of the lateral ventricles, which is the basis of the gray matter of the basal ganglia. Their largest central part is called the ``***corpus striatum*** according to its annealed character in transverse sections.
- Neuroblasts do not form on the medial wall of the hemisphere, which is why it is made up only of ependymal cells. They are covered by vascularized mesenchyme and participate in the formation of **plexus choroideus'**and as a result of their uneven growth, it finally arches from the medial side into the lateral chambers as***plexus choroideus ventriculi lateralis***.
- The wall of the hemispheres thickens just above the choroid plexus and forms the hippocampus arched into the lateral ventricle.
- With further growth, the hemisphere presses on the diencephalon from above and comes into close contact with the thalamus. It eventually grows through the mesencephalon and cerebellum. Such overgrowth in the forward and downward direction leads to the formation of ***frontal, parietal, temporal and occipital lobes.***
- The corpus striatum, which is part of the hemisphere, grows dorsally. Bundles of nerve fibers that run from the cerebral cortex to the brainstem divide the striatum into the dorsomedial **nc. caudatus** ***and ventrolateral*** *nc. lentiformis*. The bundle of nerve fibers that divides the striatum into two parts is called the capsula interna
- The area of the cortex that covers the striatum slows its growth and the surrounding parts begin to cover it. This leads to its relative immersion. This area is called the **insula',** it is almost completely covered by the surrounding areas of the hemisphere at the end of prenatal development, forming the ``***fossa lateralis cerebri*.** At this time, the surface of the cerebral hemispheres increases rapidly and numerous gyri are formed, separated by furrows, sulci and deep furrows, fissurae
- On the surface of the hemisphere is the cerebral mantle, **pallium** - the basis of the cerebral cortex, cortex cerebri. It is divided into three parts, which differ in their developmental age:
  - **paleopallium** – just lateral to the striatum;
  - **archipallium** – medial parts of the telencephalon;
  - **neopallium** – between paleopallium and archipallium is differentiated.
- The paleopallium and archipallium differentiate into the three-layered *paleocortex and archicortex*. The largest part of the surface of the hemispheres, the neopallium, differentiates into the neocortex

Description of the Neuroblast Migration Wave

- Neuroblasts that travel to the subpial surface through the previously formed layers differentiate into neurons. The neuroblasts that migrate first are located the deepest in the cortex, and thus the last wave of neuroblasts is located closest to the surface of the brain. At birth, the cerebral cortex is already stratified due to advanced cell differentiation in layers.
- **Motor area of the cortex** contains a large number of pyramidal cells.
- **Sensitive area of the bark** contains granular neurons.
- **White matter of the hemispheres** arises from the growth and myelination of pathways in the space between pallidum and basal ganglia.
- Differentiation of the olfactory placode – differentiation of the *sensory neurons* of the olfactory epithelium and their axons grow into the bulbus olfactorius at the base telencephala. In the bulb, synaptic connections are made with its secondary neurons. By week seven, these connections are well established. As the brain grows, the bulb enlarges and the axons of the secondary neurons in the tractus olfactorius lengthen.
- In the brain, several bundles of nerve fibers are formed that connect the cortical areas of the right and left hemispheres, **commissure cerebri:**
  1. as the first commissure - ***anterior commissure***, which connects the olfactory cortical areas and the cortex of the temporal lobe. It develops in the so-called commissural plate in the 5th week of development as a thickening of the lamina terminalis;
  2. as the second - '***commissura fornicis***, whose fibers connect the right and left gyrus parahippocampalis and hippocampal formations;
  3. The most important of the commissural junctions is the ***corpus callosum*** - it appears in the 10th week and connects large areas of the cerebral cortex of the right and left hemispheres with the exception of the olfactory region and the temporal lobes. It originates in the commissural plate as a small bundle, but as the neopallium expands, it first enlarges anteriorly and later posteriorly;
  4. diencephalic commissures in the epithalamus – **posterior commissure and habenular commissure.**

Links

Related Articles

- Congenital defects of the nervous system
- Development of the spinal cord

References

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