

BASICS OF NEUROBIOLOGY

DEVELOPMENT OF THE NERVOUS SYSTEM

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Basics of Neurobiology: Development of the nervous system

FEATURES OF HUMAN DEVELOPMENT

FROM THE GAMETES TO THE NEWBORN INDIVIDUAL: THROUGH EMBRYONIC AND FETAL LIFE

THE DEVELOPMENTAL SCHEDULE OF THE HUMAN BEING

FORMATION OF THE GERM DISCS: THE BILAMINAR AND TRILAMINAR STAGES

THE MAIN GERM LAYERS PROVIDING THE BASIC TISSUES AND ORGANS OF THE BODY: THE ECTODERM, THE MESODERM AND THE ENDODERM

THE DERIVATIVES OF THE THREE GERM LAYERS OF THE EMBRYO

THE SIMULTANEOUS DEVELOPMENT OF ORGAN SYSTEMS

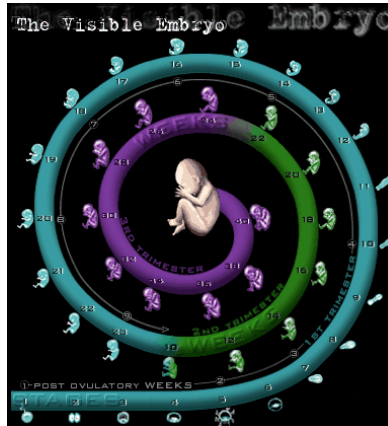
VULNERABLE STAGES OF THE DEVELOPMENT

GENETIC REASONS OF MALFORMATIONS

ENVIRONMENTAL REASONS OF DEVELOPMENTAL DEFECTS, EPIGENETICS

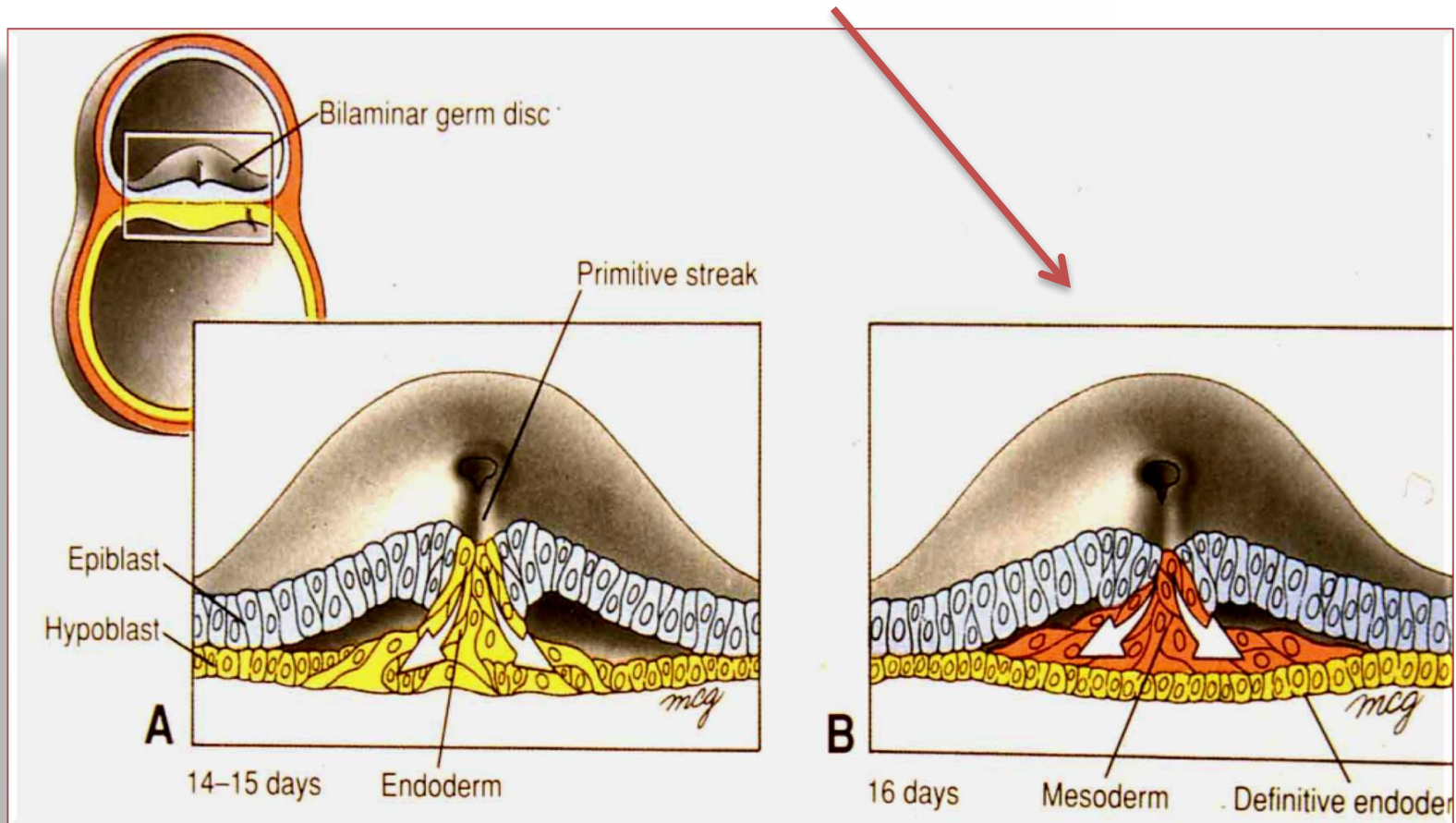
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Development of the human being: embryonic and fetal life

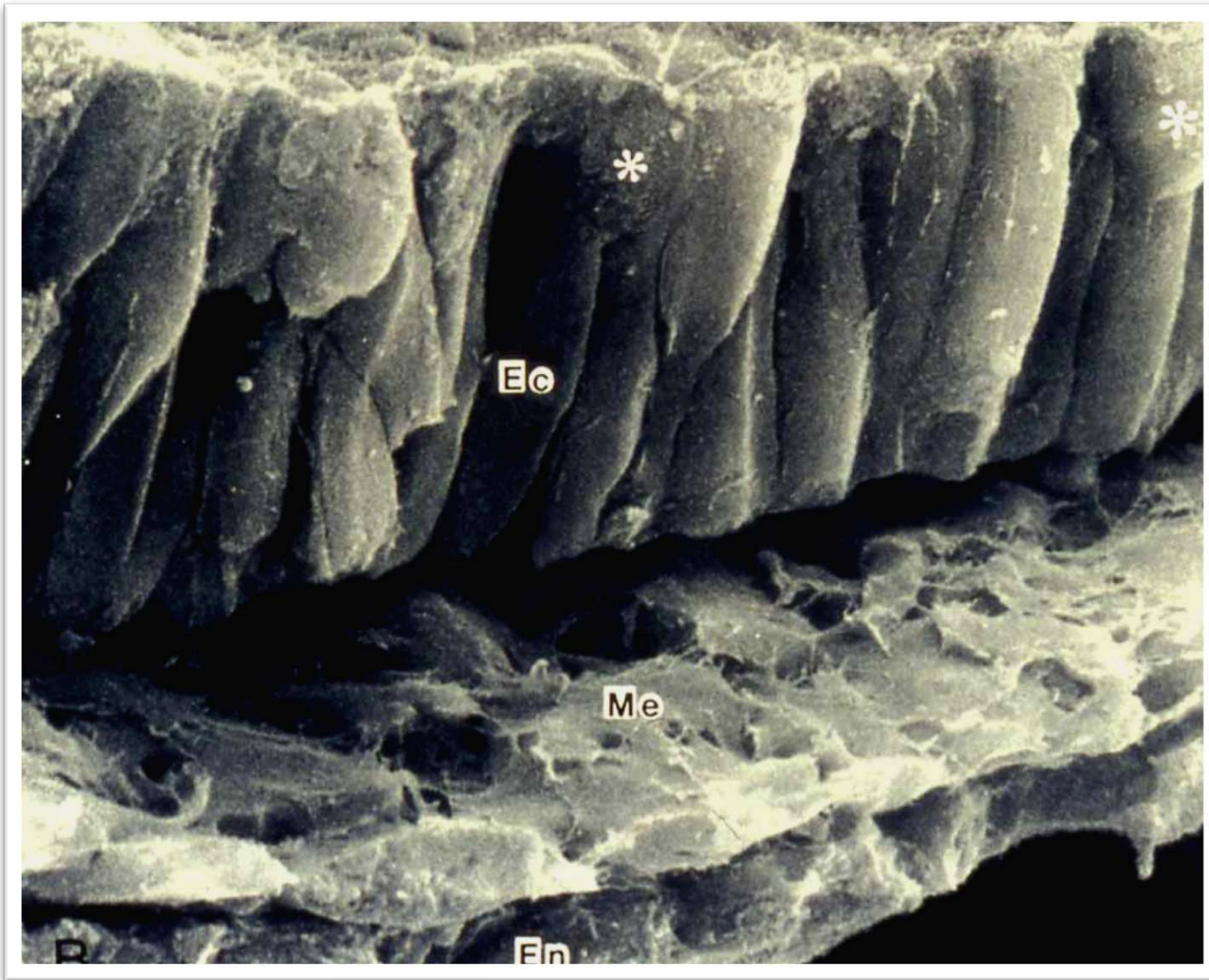


<http://www.visembryo.com/baby/index.html>

Formation of trilaminar germ disc



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ECTODERM

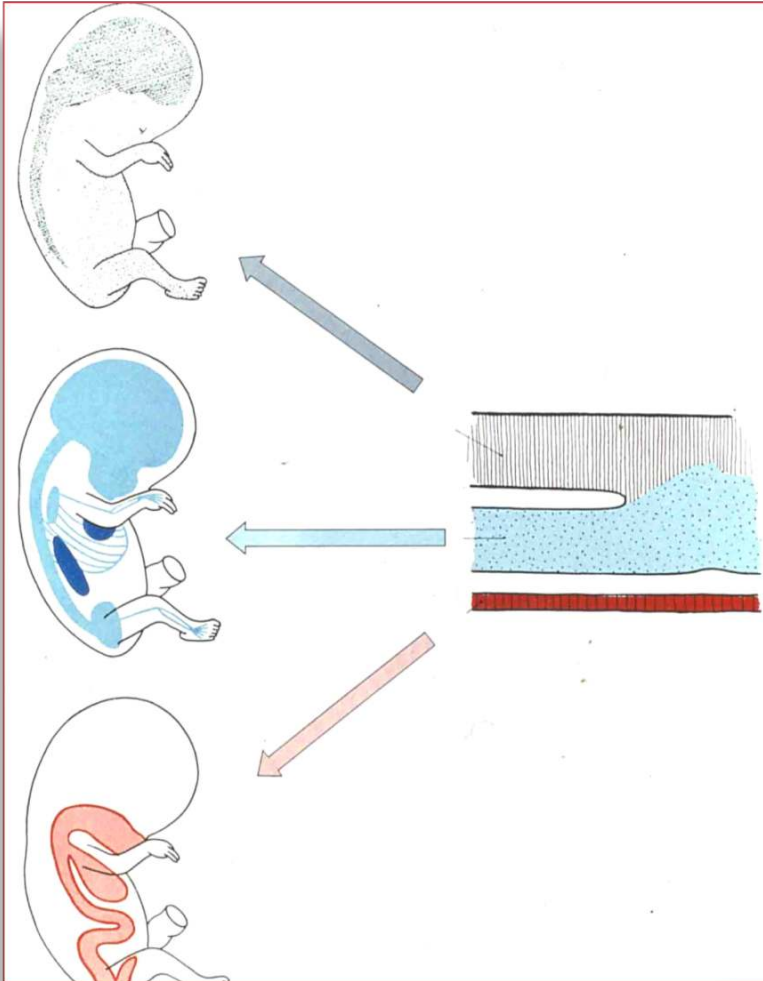
MESODERM

ENDODERM

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DERIVATIVES OF GERM LAYERS

ECTODERM
MESODERM
ENDODERM



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THE EARLY EVENTS OF NEURAL DEVELOPMENT

FORMATION OF THE NEURAL TUBE FROM THE ECTODERM. THE INDUCTIVE ROLE OF THE NOTOCHORD

THE SONIC HEDGEHOG MORPHOGEN SIGNALING

ANTERIOR AND POSTERIOR NEUROPORES AND THEIR CLOSURE. MALFORMATIONS

DEVELOPMENT OF THE NEURAL CREST AND ITS DERIVATIVES

FORMATION OF SENSORY AND AUTONOMIC GANGLIA. CONNECTIONS WITH THE CENTRAL NERVOUS SYSTEM AND TARGET STRUCTURES.

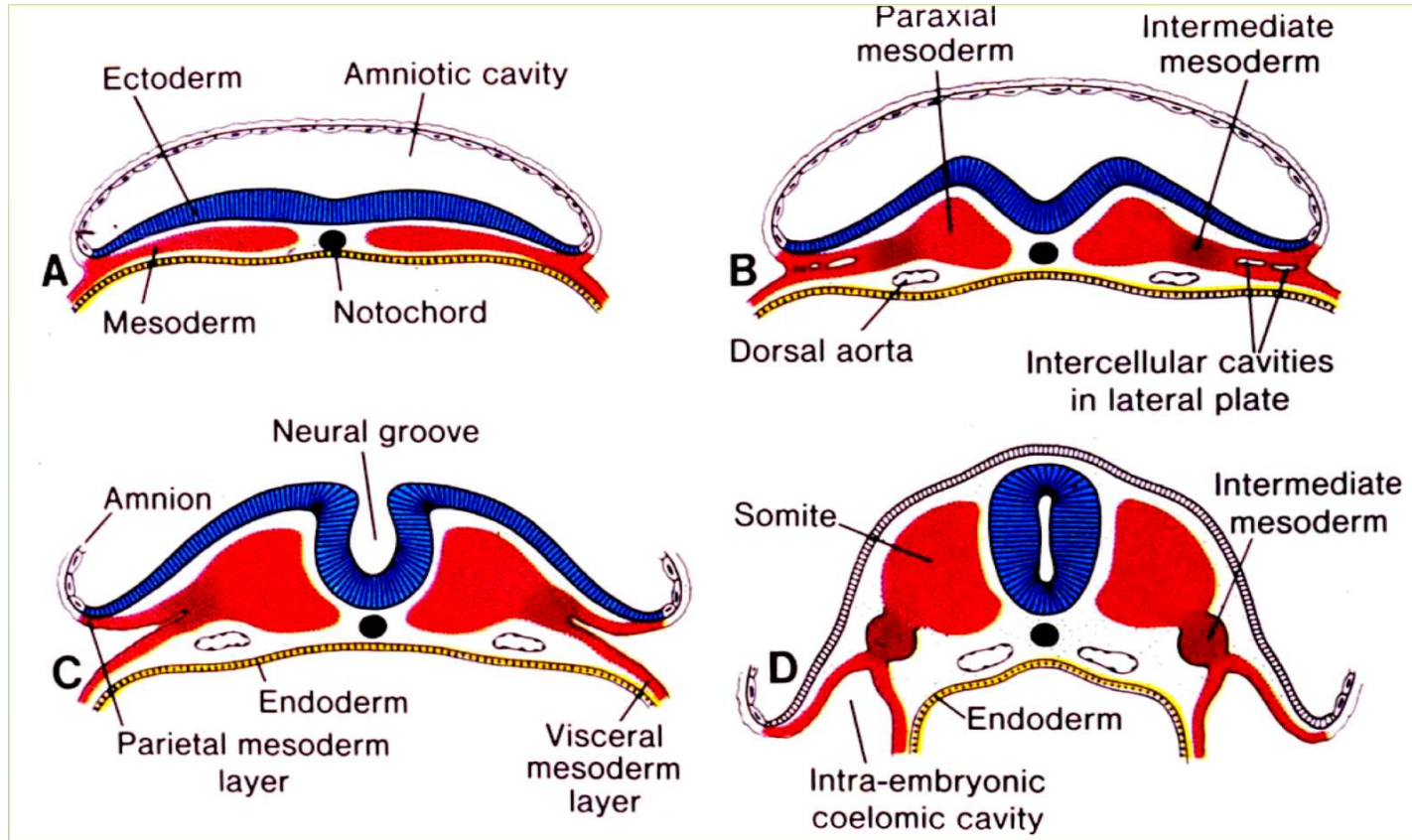
THE PLACODE PLATE AND ITS DERIVATIVES

THE NON- PROPORTIONAL DEVELOPMENT OF THE NEURAL TUBE

THE EARLY FORMATION OF THE SPINAL CORD

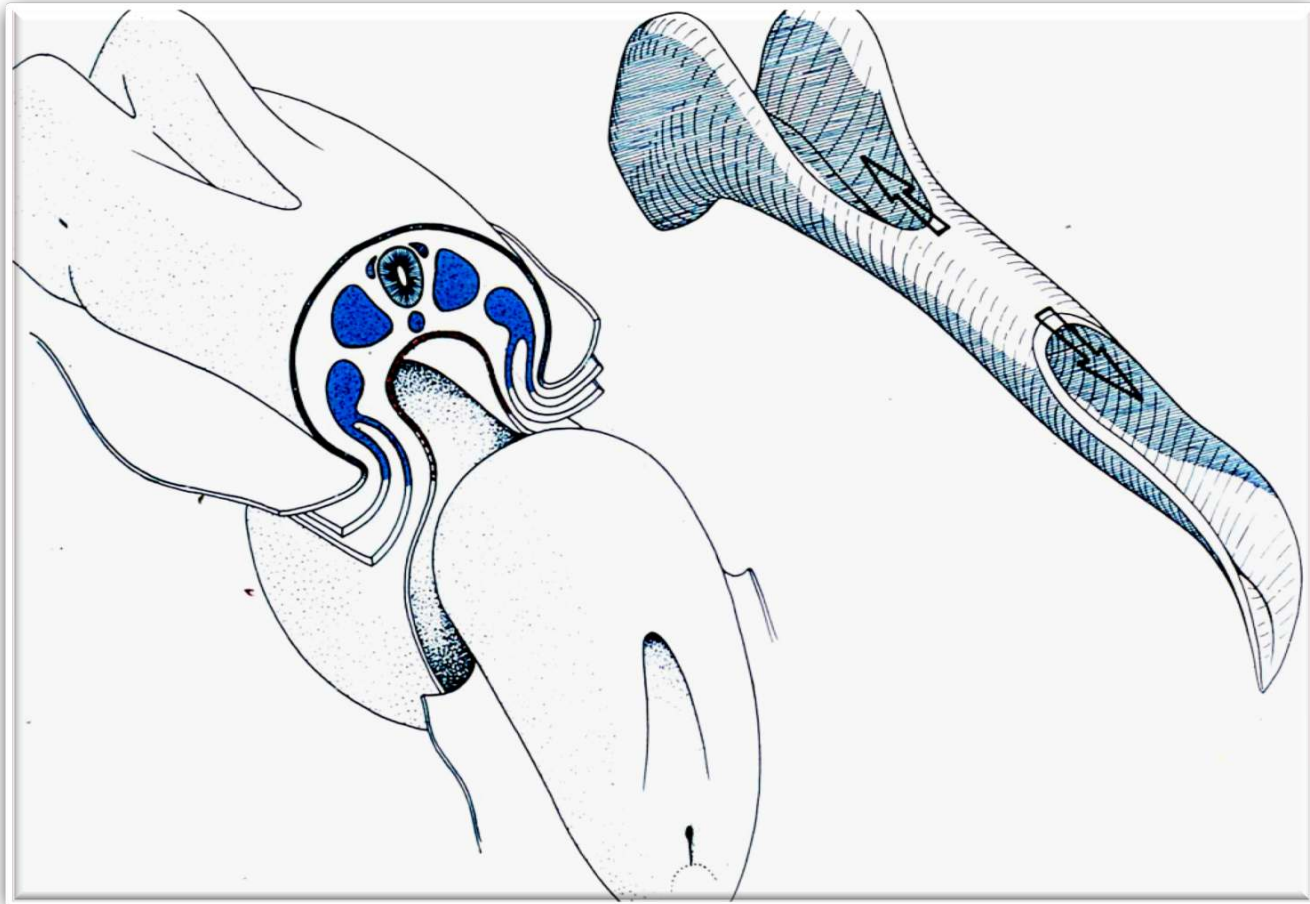
THE EARLY APPEARANCE OF THE BRAIN PRIMORDIUM

NEURULATION



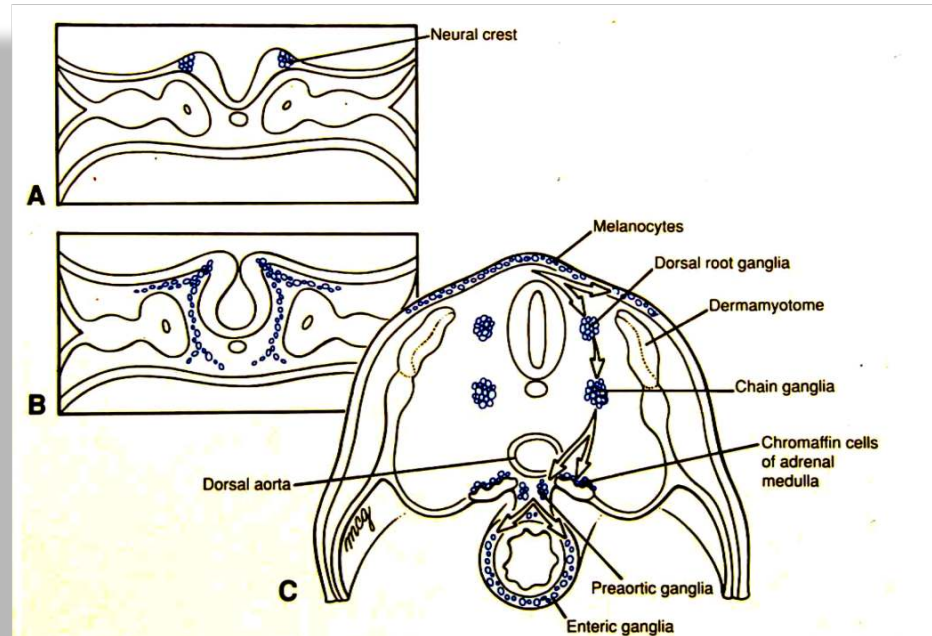
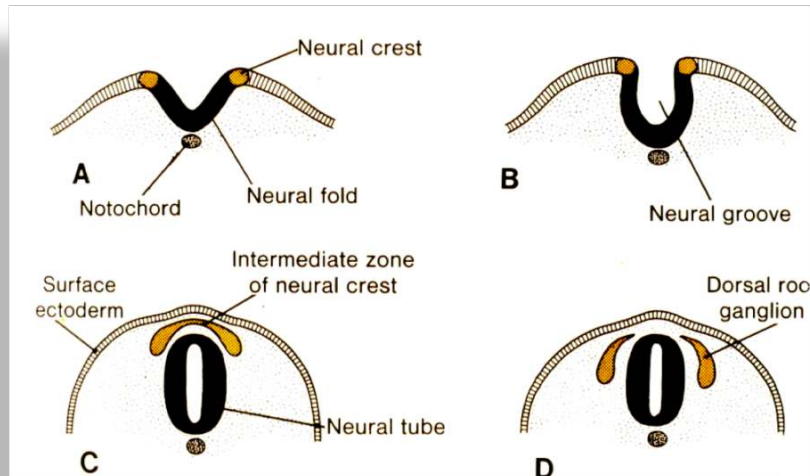
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Formation of the neural tube



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Derivatives of neural crest



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CELLULAR DIFFERENTIATION OF THE NEURAL TUBE

PARALLEL TO THE GROWTH OF THE EMBRYO THE NEURAL TUBE GETS THICKER AND ELONGATES

^{kopfe-ende}
THE CRANIAL END OF THE NEURAL TUBE DEVELOPS MORE INTENSELY RESULTING IN THE PRIMARY BRAIN VESICLES - a system

^{hinteres ende}
FROM THE LESS INTENSELY PROLIFERATING CAUDAL PART OF THE NEURAL TUBE THE SPINAL CORD DERIVES

^{epithelium}
THE EPITHELIAL CELLS LINING THE NEURAL TUBE DIVIDE HEAVILY AND GIVE RISE TO THE CELLULAR CONSTITUENTS OF THE BRAIN AND SPINAL CORD

AT FIRST GLIOBLAST AND NEUROBLAST CELLS DEVELOP

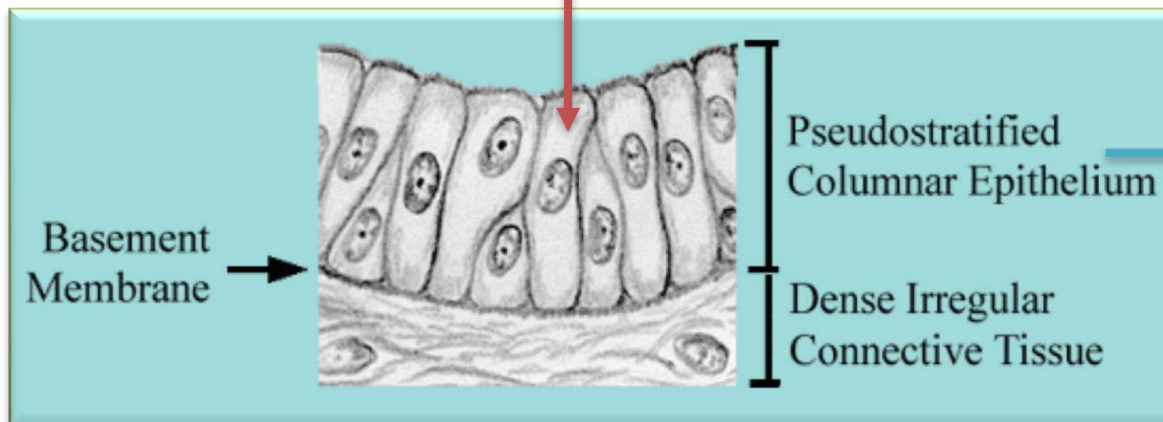
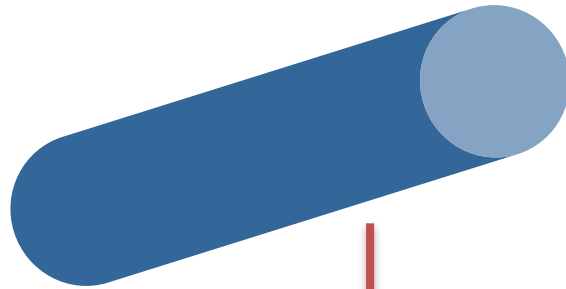
GLIOBLASTS DIFFERENTIATE INTO GLIAL CELLS THAT MAINTAIN THE SELF-RENEWAL CAPABILITY AND ACCORDINGLY DIVIDE FREQUENTLY

IN ADDITION TO PROVIDING ASTROCYTES, OLIGODENDROGLIA AND EPENDYMAL CELLS, GLIOBLAST ALSO FORM RADIAL GLIA CELLS

[↓]
senior cells cerebri cerebralis - 1
+ agglomerat. beili

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DIFFERENTIATION OF NEUROPITHEL CELLS



Ependymal layer
Mantle layer
+
Marginal layer

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CELLULAR DIFFERENTIATION OF THE NEURAL TUBE

számos gliásjtípus különböző mélységekig jutnak a belső hértől a vékony vastagságig ^{a vékonyabb rész homályos}
THE PROCESSES OF RADIAL GLIA CELLS STRETCH THROUGH THE ENTIRE THICKNESS OF THE DEVELOPING NEURAL TUBE IN A PERPENDICULAR ^{→ függőleges} ORIENTATION RELATIVE TO THE EPENDYMAL LINING OF THE NEURAL TUBE ^{mélységek}

RADIAL GLIA CELL PROCESSES PROVIDE PATHWAYS AND GUIDANCE FOR NEURONS MIGRATING FROM THE EPENDYMAL TO THE MANTLE LAYER

THE MIGRATING NEURONS ARE POSTMITOTIC CELLS INCAPABLE OF DIVIDING

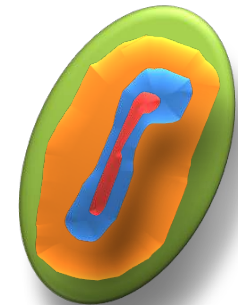
THIS MIGRATORY PROCESS IS CALLED: RADIAL MIGRATION

LAYERS GROWING AROUND THE **NEURAL CANAL** INCLUDE:

1. EPENDYMAL LAYER

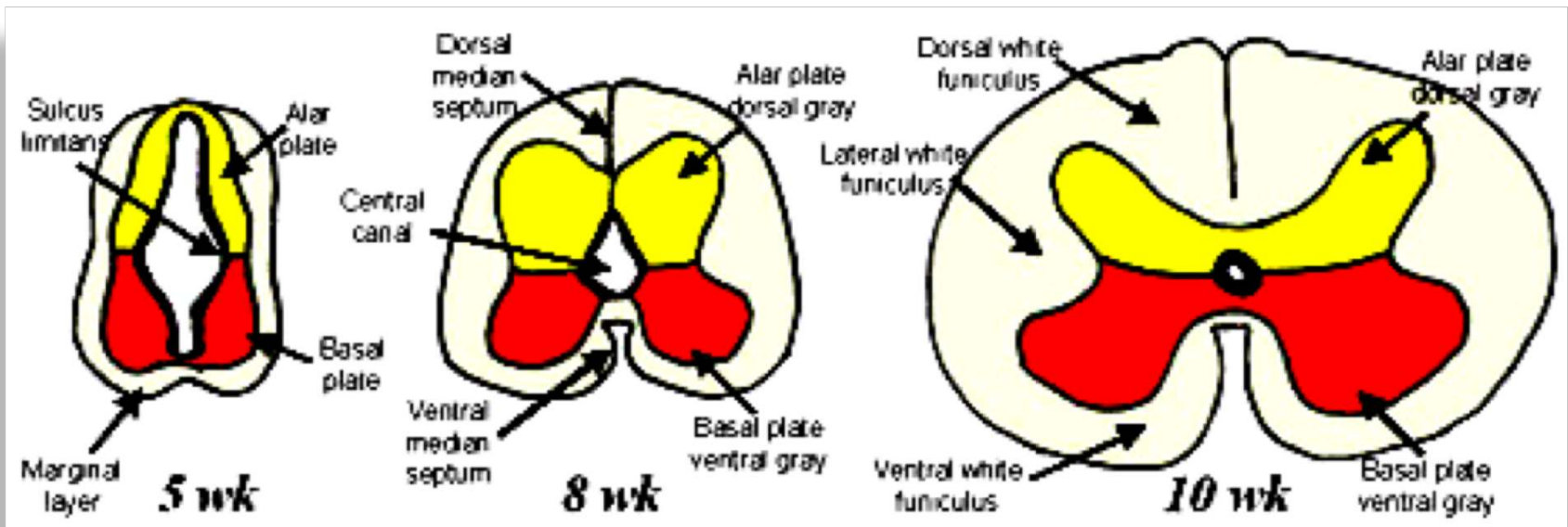
2. MANTLE LAYER FORMS THE GREY MATTER

3. MARGINAL LAYER FORMS THE WHITE MATTER

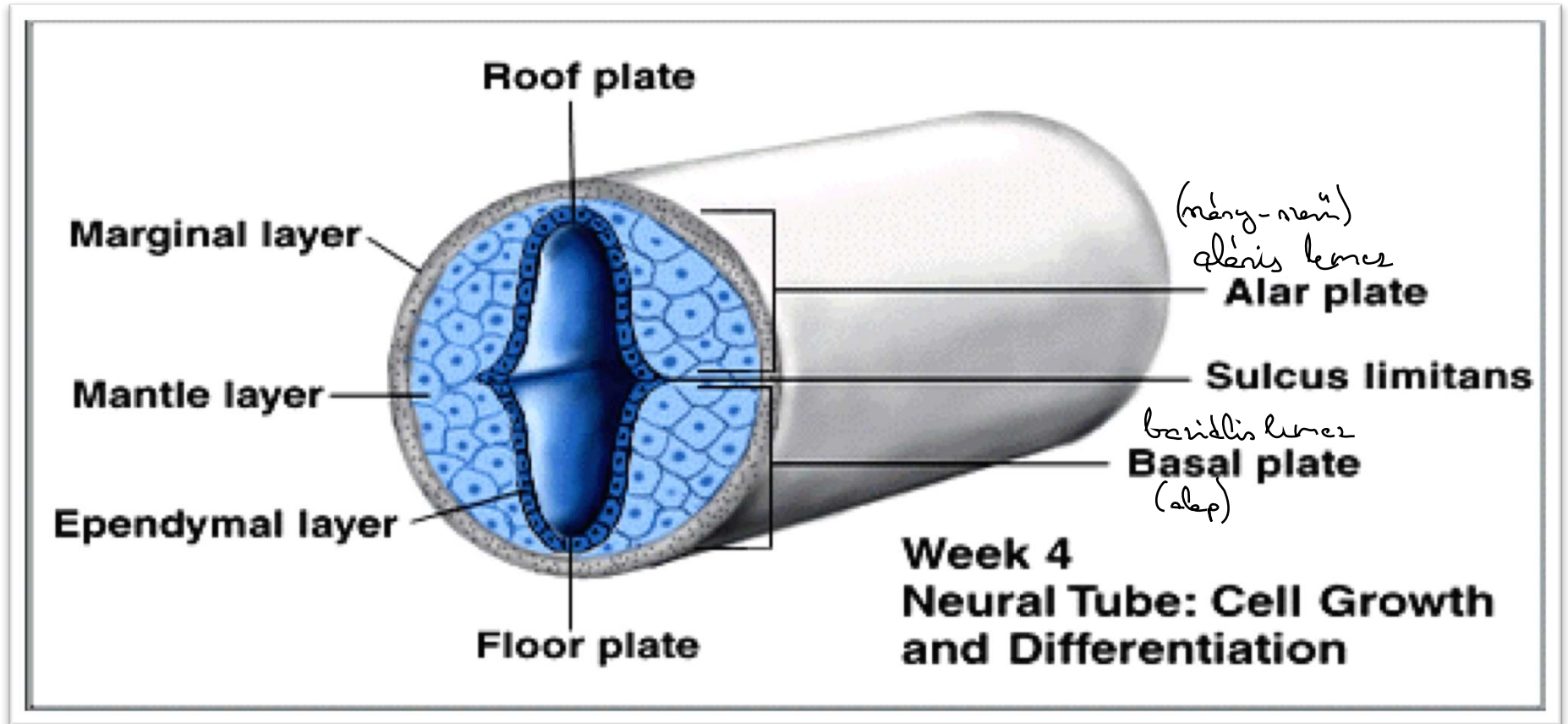


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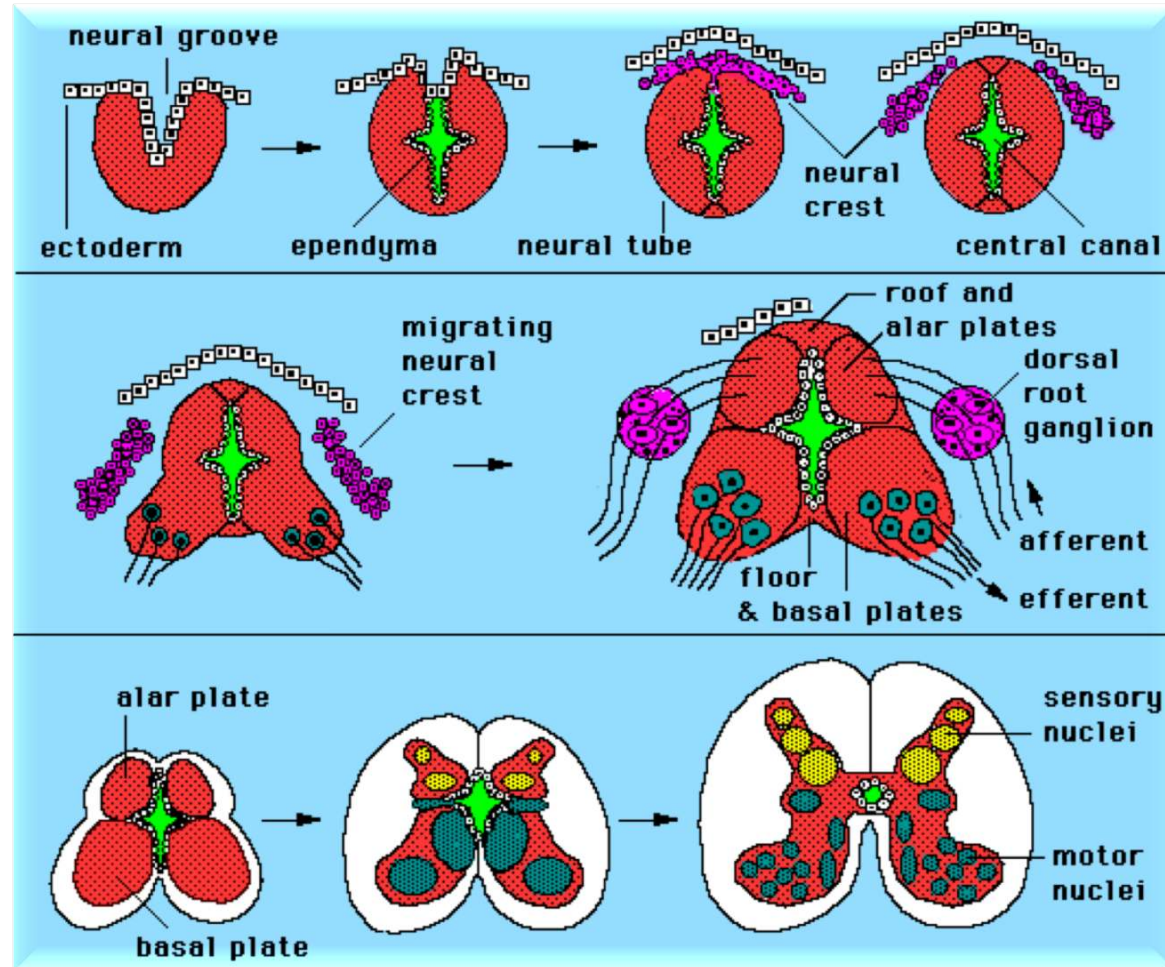
FORMATION OF ALAR AND BASAL PLATES



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DEVELOPMENT OF THE SPINAL CORD

WITHIN THE FOURTH EMBRYONIC WEEK, THE MANTLE LAYER DIFFERENTIATES INTO VENTRALLY LOCATED BASAL AND DORSALLY POSITIONED ALAR PLATES ON BOTH SIDES

IN THE MEDIAN SAGITTAL PLANE, THE MANTLE LAYER REMAINS THIN FORMING THE FLOOR PLATE VENTRALLY AND THE ROOF PLATE DORSALLY

FROM THE BASAL PLATE THE VENTRAL HORN OF SPINAL CORD DEVELOPS

THE DORSAL, SENSORY HORN DERIVES FROM THE ALAR PLATE

SOMATO-MOTOR NEURONS DEVELOPING IN THE BASAL PLATE GROW AXONS THAT LEAVE THE SPINAL PRIMORDIUM AND ESTABLISH CONNECTIONS WITH STRIATED MUSCLES DEVELOPING IN THE SAME SEGMENT. THIS IS THE EARLY FORMATION OF THE NEUROMUSCULAR JUNCTIONS

VEGETATIVE MOTOR NEURONS DEVELOPING AT THE LEVEL OF THE SULCUS LIMITANS PROVIDE AXONS THAT COMMUNICATE WITH AUTONOMIC GANGLION CELLS OUTSIDE THE SPINAL PRIMORDIUM

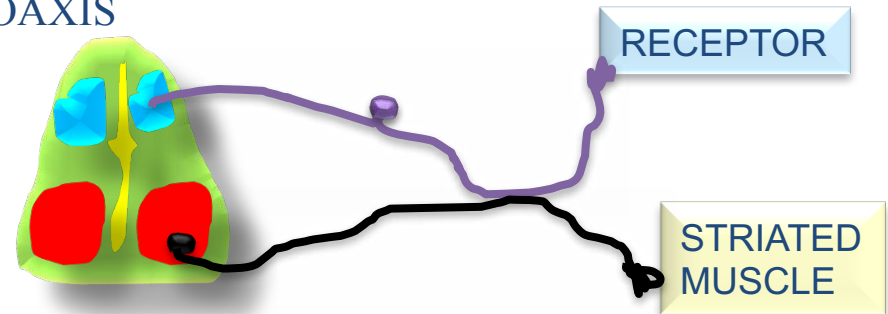
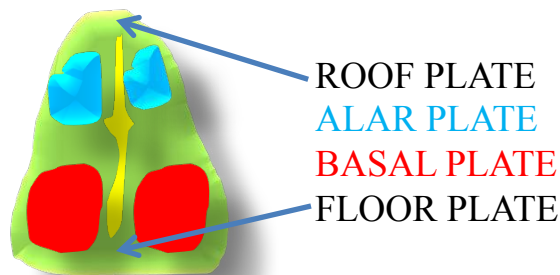
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DEVELOPMENT OF THE SPINAL CORD

NEURONS OF THE ALAR PLATE DIFFERENTIATE FURTHER AND ESTABLISH COMPLEX NUCLEI THAT ARE FUNCTIONALLY COUPLED TO THE PROCESSING OF SENSORY INFORMATION

THE SENSORY STIMULI ARE CARRIED TO THE ALAR PLATE BY THE CENTRAL PROCESSES OF EXTERNAL PSEUDO-UNIPOLAR NEURONS. THESE CELLS *hat's gonna die* DIFFERENTIATE FROM THE NEURAL CREST AND ESTABLISH THE SENSORY DORSAL ROOT GANGLIA IN THE SEGMENTS OF THE BODY. THE PERIPHERAL PROCESSES OF THESE SENSORY NEURONS ARE LINKED WITH RECEPTORS

IN THE MARGINAL LAYER *testes* AXON BUNDLES *testes* CAN BE FOUND. THEY EITHER BELONG TO SHORT INTERSEGMENTAL CONNECTIONS OR TO MAJOR ASCENDING AND DESCENDING FIBER TRACTS *→ fahrer is lenk'g poly'k* INTERCONNECTING THE SPINAL SEGMENTS WITH OTHER REGULATORY PARTS OF THE NEUROAXIS



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THE SPINAL SEGMENT



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DEVELOPMENT OF THE BRAIN. FORMATION OF PRIMARY AND SECONDARY BRAIN VESICLES

FROM THE ROSTRAL PART OF THE NEURAL TUBE THREE BRAIN VESICLES DERIVE: THE PROSENCEPHALIC, THE MESENCEPHALIC AND THE RHOMBENCEPHALIC VESICLES

FURTHER DIFFERENTIATION DIVIDES THE PROSENCEPHALON IN TWO SECONDARY BRAIN VESICLES: THE TELENCEPHALIC AND THE DIENCEPHALIC ONES

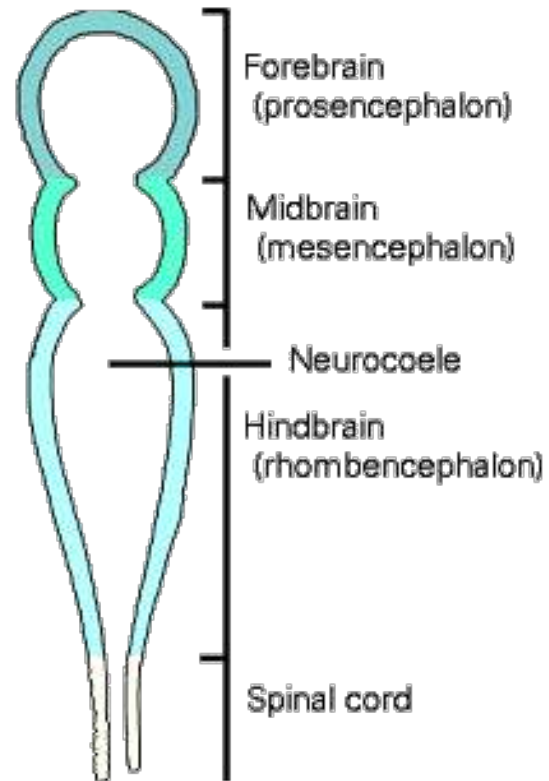
THE MESENCEPHALIC VESICLE MAINTAINS ITS ORIGINAL INTEGRITY WITHOUT SPLITTING INTO PARTS

THE DEVELOPMENT OF THE RHOMBENCEPHALIC VESICLE RESULTS IN THE FORMATION OF THE SECONDARY METENCEPHALIC AND MYELENCEPHALIC VESICLES

FROM THE ORIGINAL CAVITY OF THE PROSENCEPHALON THE LATERAL AND THIRD VENTRICLES, FROM THE CAVITY OF THE MESENCEPHALON THE CEREBRAL AQUEDUCT AND FROM THAT OF THE RHOMBENCEPHALON THE FOURTH CEREBRAL VENTRICLE DEVELOP

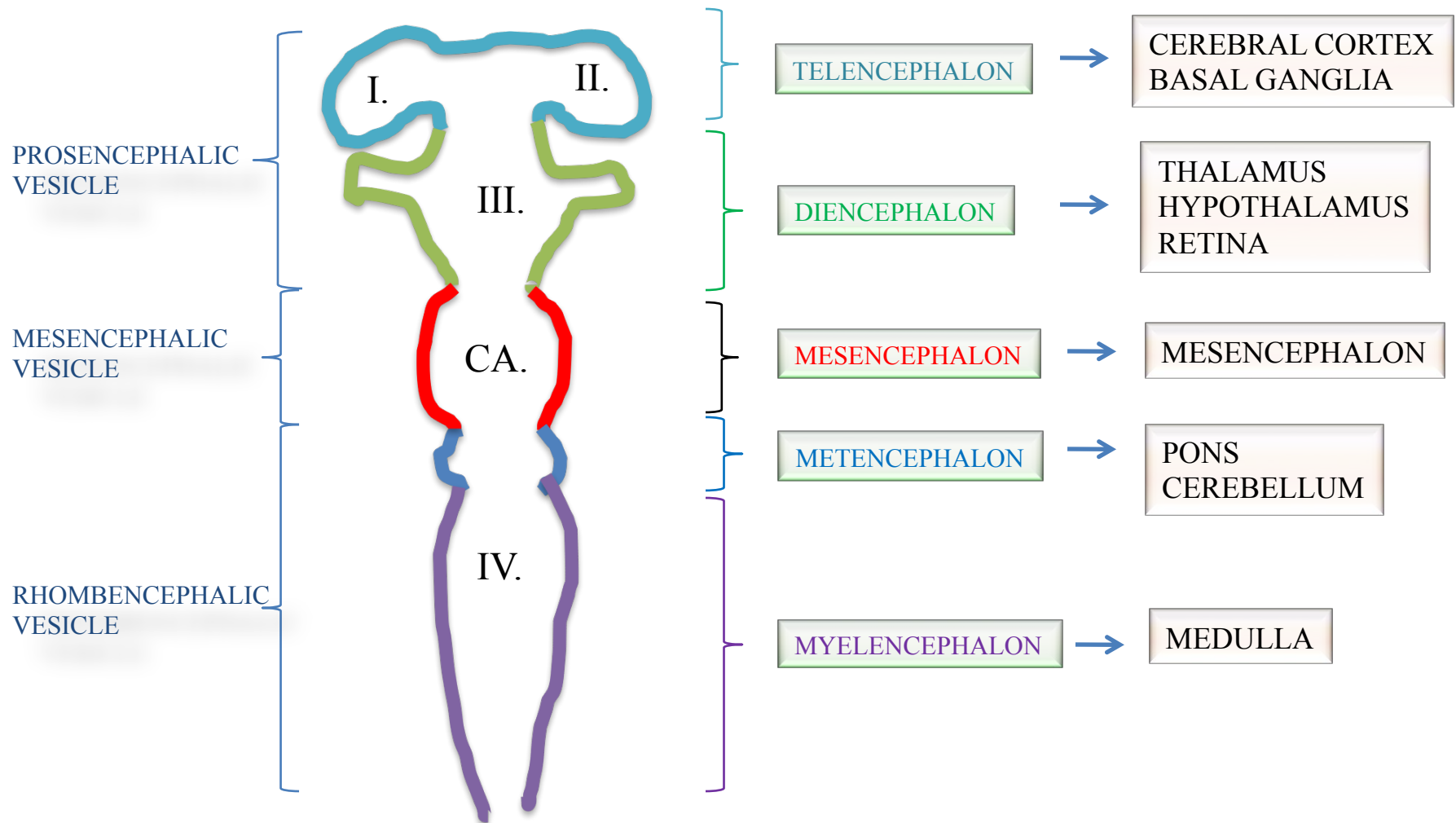
AT THE LEVEL OF THE 4TH VENTRICLE, THREE APERTURES DEVELOP THAT ALLOW THE OUTFLOW OF THE CEREBROSPINAL FLUID INTO THE SUBARACHNOID SPACE

Development of brain vesicles

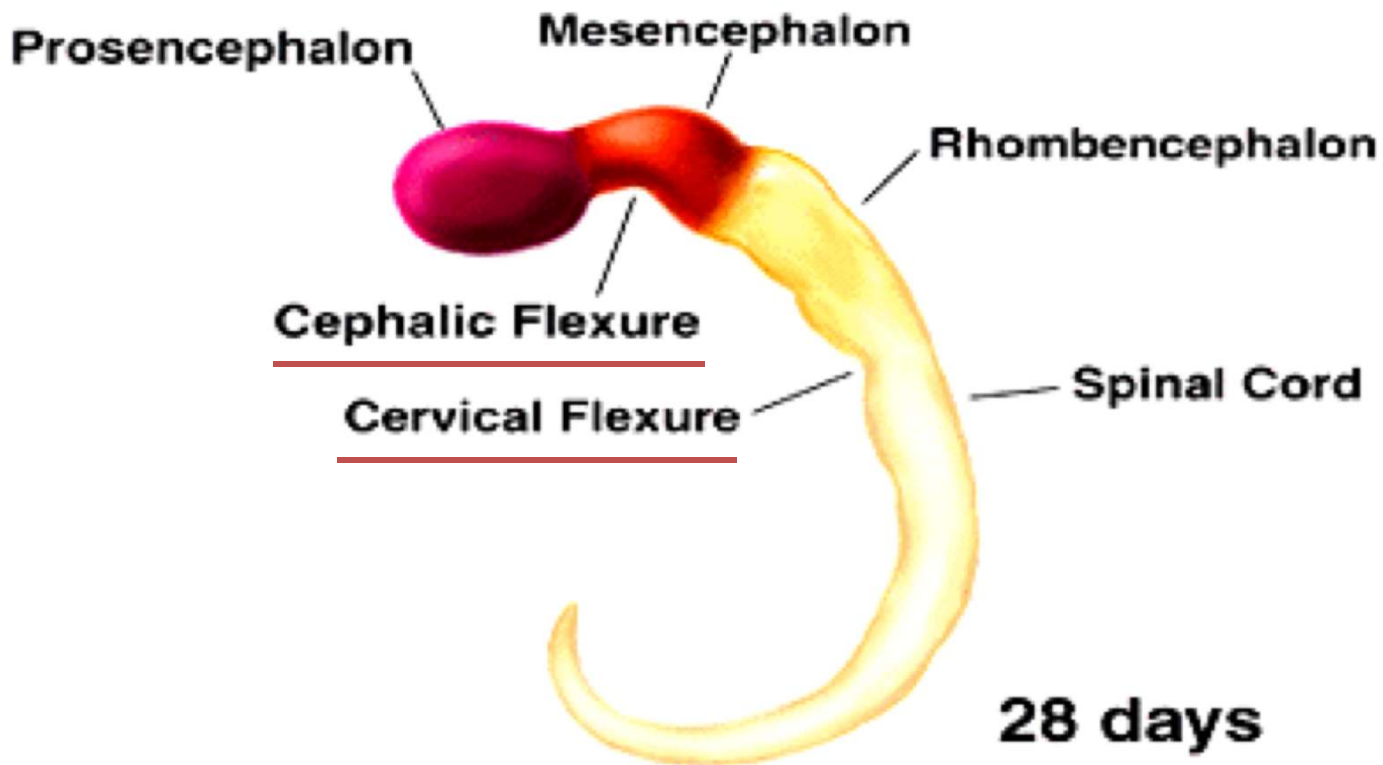


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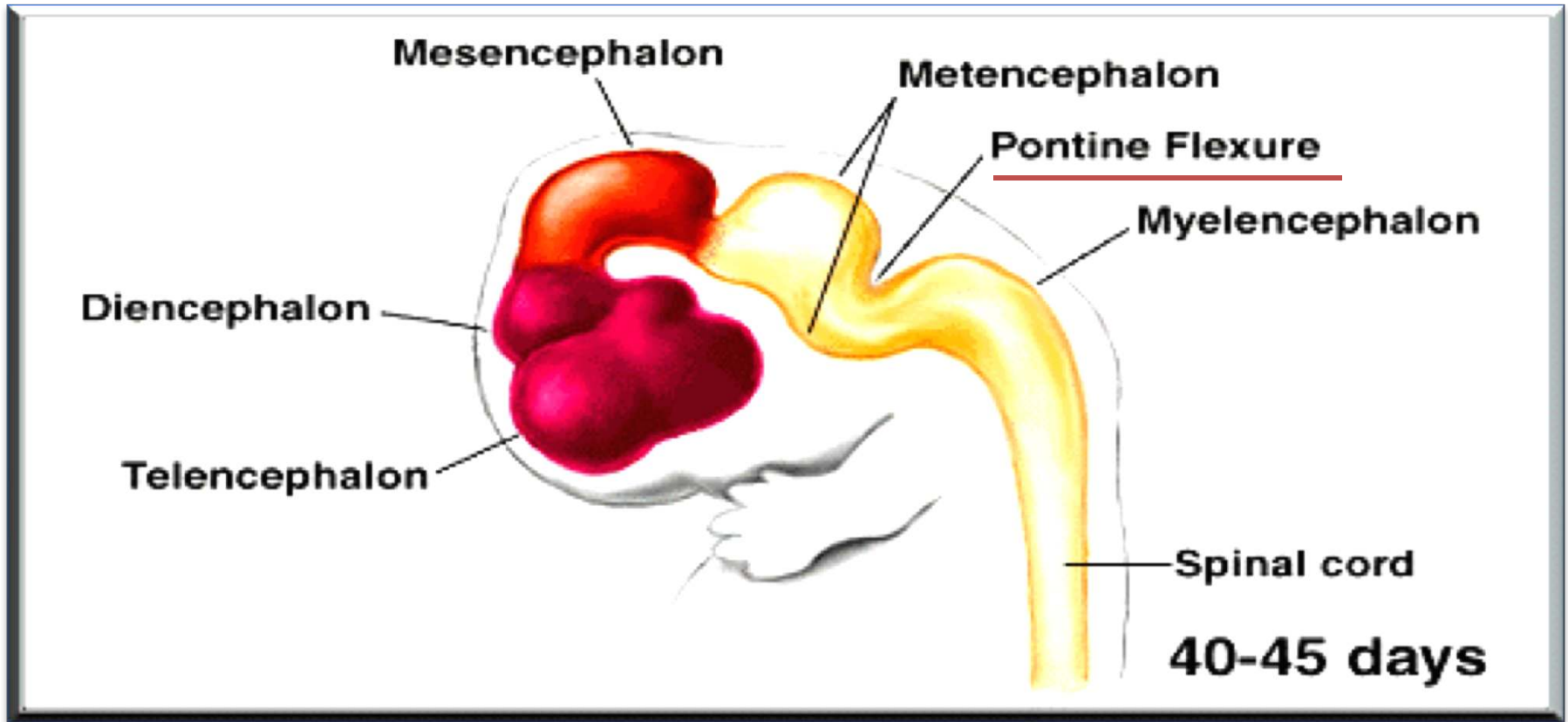
SCHEMATIC ILLUSTRATION OF BRAIN VESICLES AND THEIR DERIVATIVES



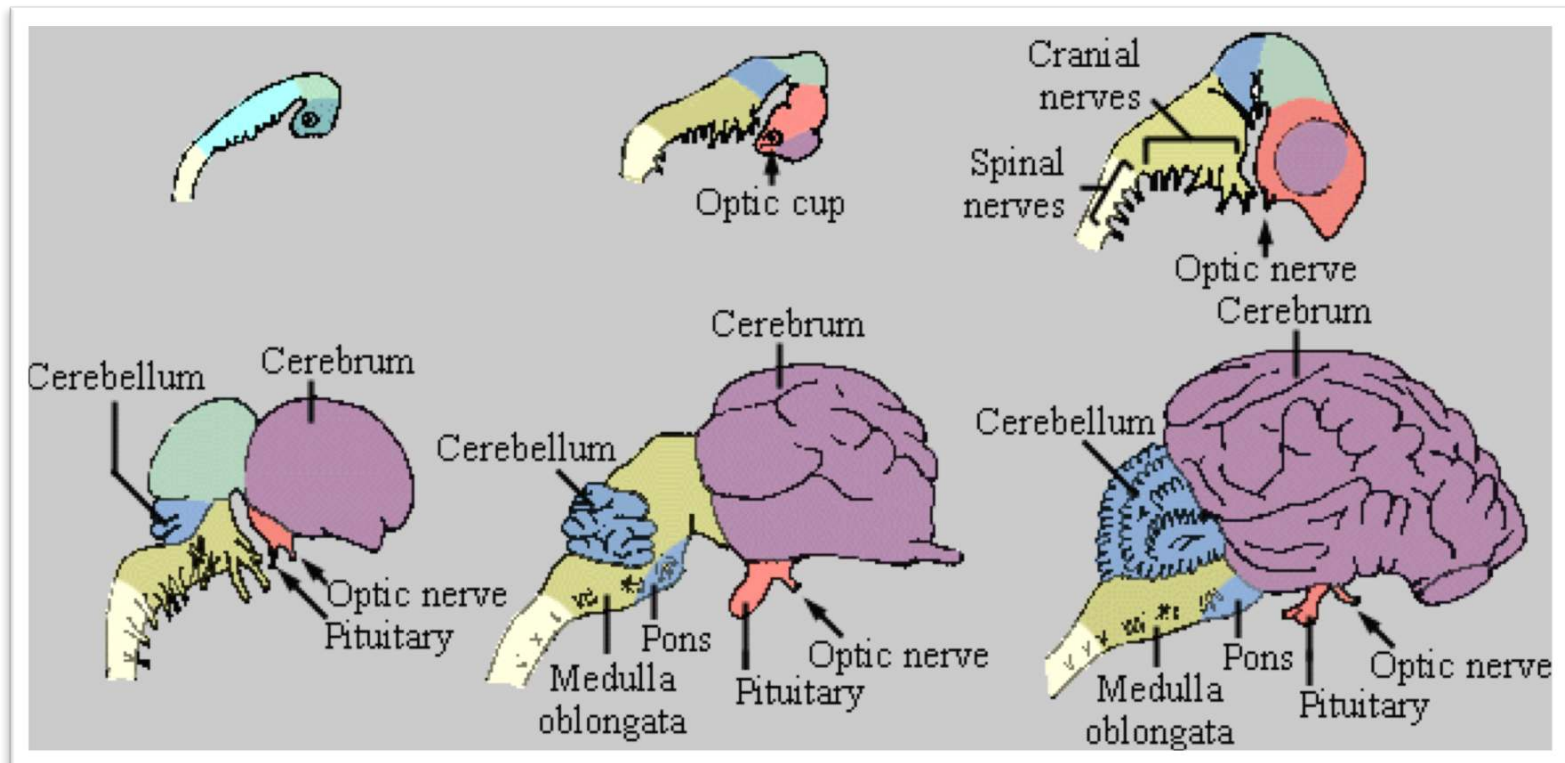
Cervical and cephalic flexures



Pontine flexure



Main stages of brain development



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FOLDING OF THE BRAIN, COMPARTMENTALIZATION OF THE BRAIN STEM

THE EMBRYO DISPLAYS A CHARACTERISTIC ROSTRO-CAUDAL, C-SHAPED FLEXURE AT THE END OF THE FIRST MONTH, TWO FLEXURES OF THE BRAIN ARE OBVIOUS. THE CERVICAL FLEXURE OCCURS BETWEEN THE SPINAL CORD AND THE MEDULLA. THE MESENCEPHALIC FLEXURE DEVELOPS AT THE LEVEL OF THE MIDBRAIN. THE CONCAVITY OF BOTH FLEXURES POINTS TOWARD THE VENTRAL PART OF THE BODY

LATER, A THIRD FLEXURE DEVELOPS AT THE LEVEL OF THE RHOMBENCEPHALON, CALLED THE PONTINE FLEXURE. IT FOLDS THE METENCEPHALON BACK TO THE MYELENCEPHALON THE RHOMBIC LIPS

THE LATERAL OUT-POCKETINGS OF THE TELENCEPHALIC VESICLES ARE ALSO CHARACTERISTIC FEATURES, TOGETHER WITH THE DEVELOPMENT OF THE OPTIC CUP WHICH PROVIDES THE PRIMORDIUM OF THE RETINA ^{neuroglia}

THE BRAIN STEM SHOWS AN ORGANIZATION RESEMBLING THE PATTERN OF THE SPINAL CORD. FROM THE BASAL AND ALAR PLATES CENTERS OF CERTAIN CRANIAL NERVES DEVELOP

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DEVELOPMENT OF THE TELENCEPHALON

THE TELENCEPHALIC VESICLES GROW LATERALLY AS ^{bubbles in the} BUBBLES ON BOTH SIDES, IN A SPIRAL MANNER SIMILAR TO THE SHAPE OF THE RAM'S HORN. THE DEVELOPING VESICLE PROVIDES THE FRONTAL, PARIETAL, TEMPORAL AND OCCIPITAL LOBES, AS WELL AS, THE INSULA. THESE PARTS GRADUALLY COVER AND HIDE THE DIENCEPHALON. THE CAVITY OF THE TELENCEPHALIC VESICLE IS THE LATERAL VENTRICLE

FROM THE DORSAL PART OF THE WALL OF THE GROWING TELENCEPHALIC VESICLE THE CEREBRAL CORTEX DEVELOPS

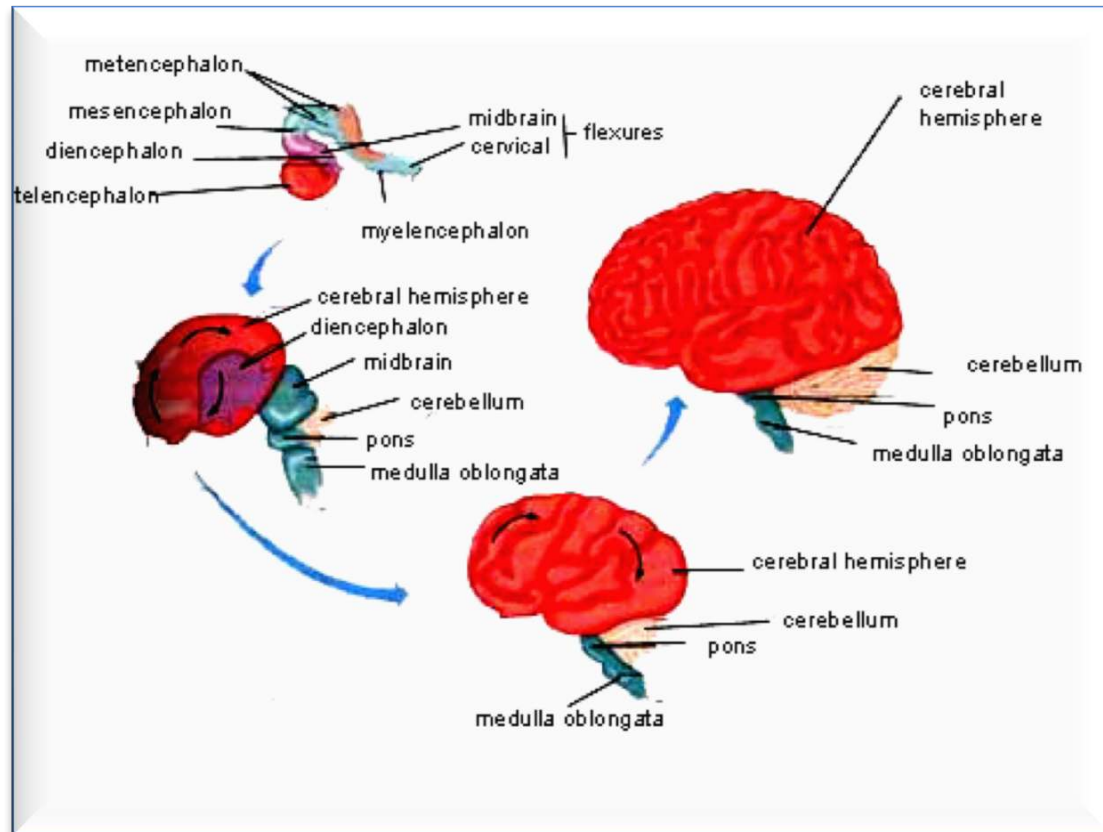
FROM THE THICKER, VENTRAL PART OF THE VESICLE THE CORPUS STRIATUM DEVELOPS

THE VENTRAL SURFACE OF THE TELENCEPHALIC VESICLE GETS JUXTAPOSED TO THE DIENCEPHALIC STRUCTURE, THE THALAMUS.

THIS BORDER ZONE IS CROSSED BY AN EXTREMELY MASSIVE AND FUNCTIONALLY CRUCIAL FIBER BUNDLE SYSTEM, THE INTERNAL CAPSULE. IT CONTAINS FIBERS ESTABLISHING COMMUNICATION BETWEEN THE THALAMUS AND THE CEREBRAL CORTEX, AND ALSO MULTIPLE CONNECTIONS AMONG THE CORTEX, THE BRAIN STEM AND THE SPINAL CORD. BOTH ASCENDING AND DESCENDING FIBER TRACTS ARE REPRESENTED IN IT

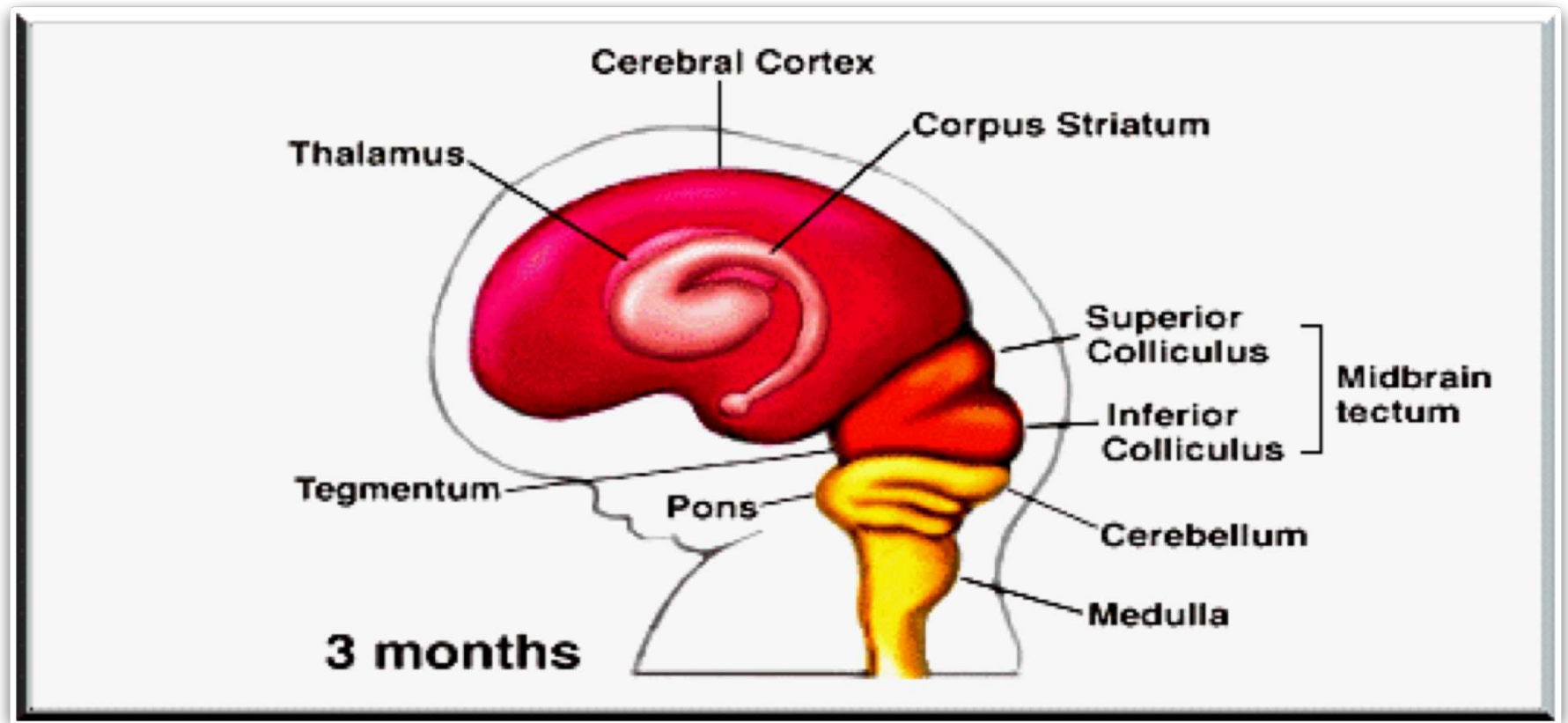
DIFFERENTIATION OF THE PROSENCEPHALON

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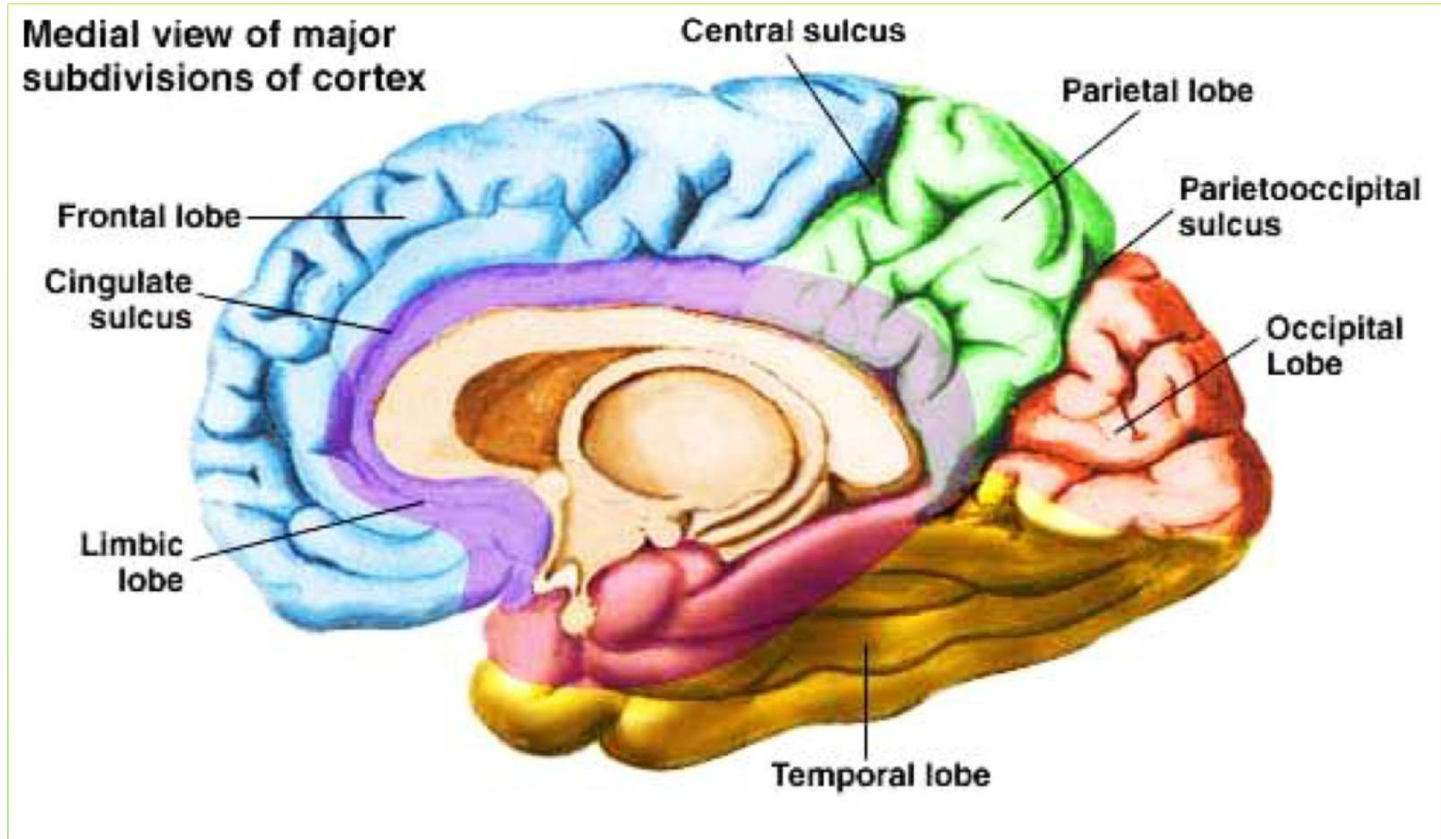
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Development of telencephalon



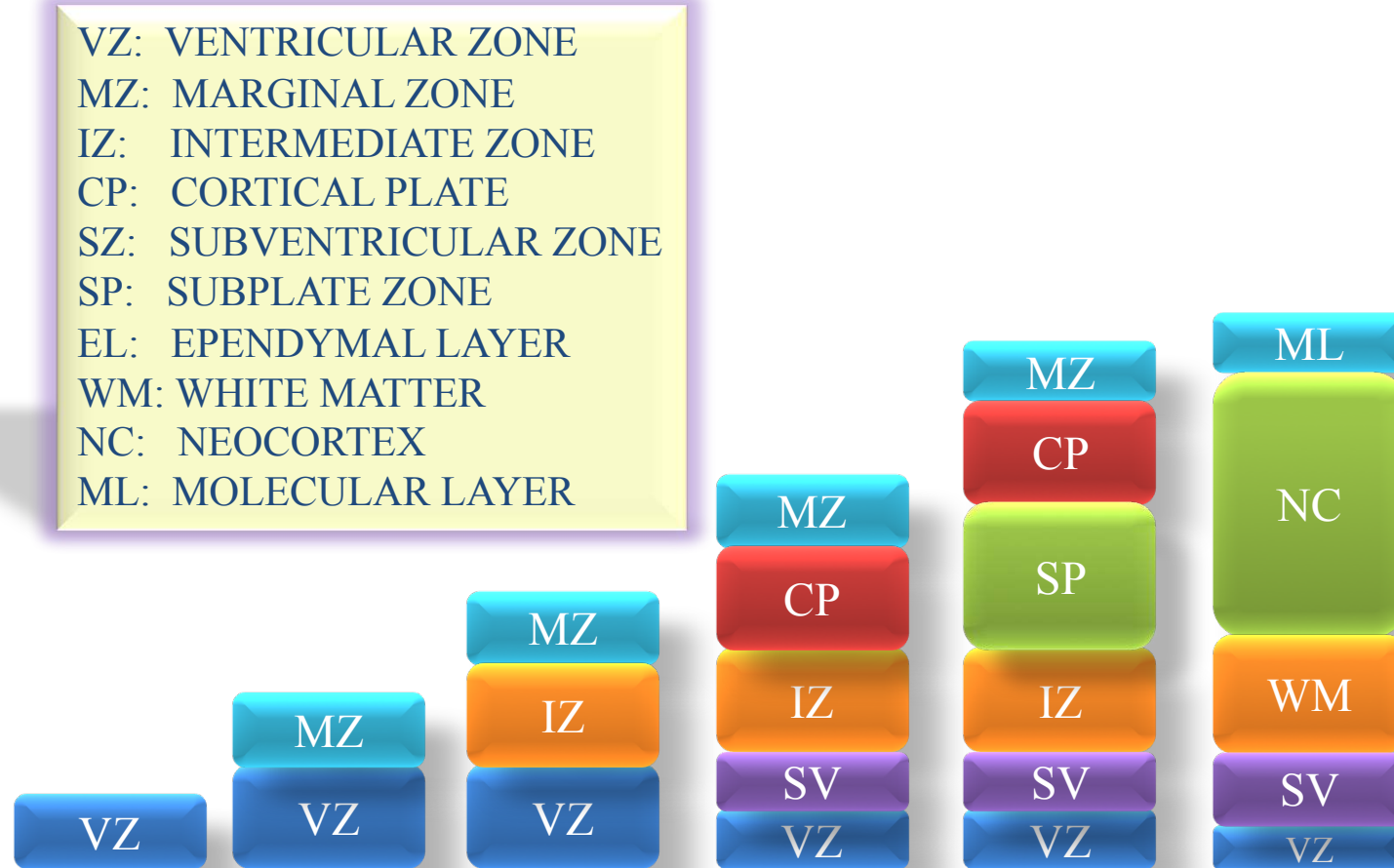
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Derivatives of prosencephalon



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THE CYTO-DIFFERENTIATION OF THE CEREBRAL CORTEX



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SLIDE SHOW



http://www.med.unc.edu/embryo_images/unit-nervous/nerv_htms/nervtoc.htm