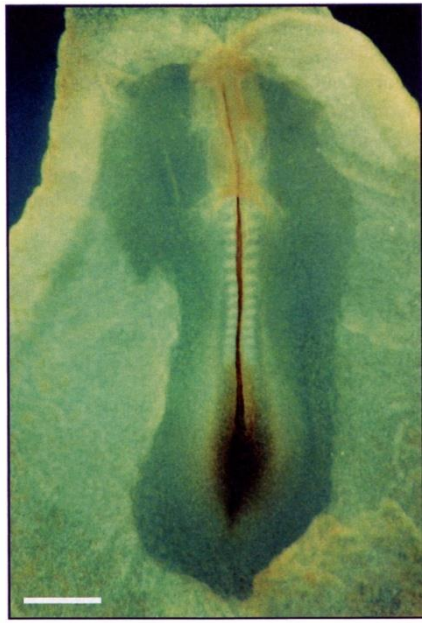
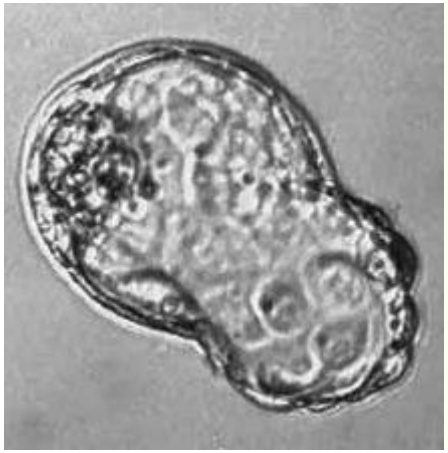
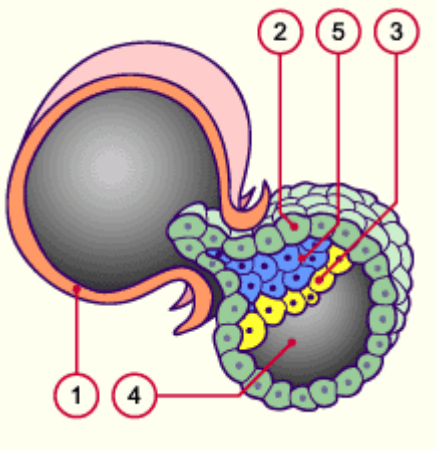
Neurulação

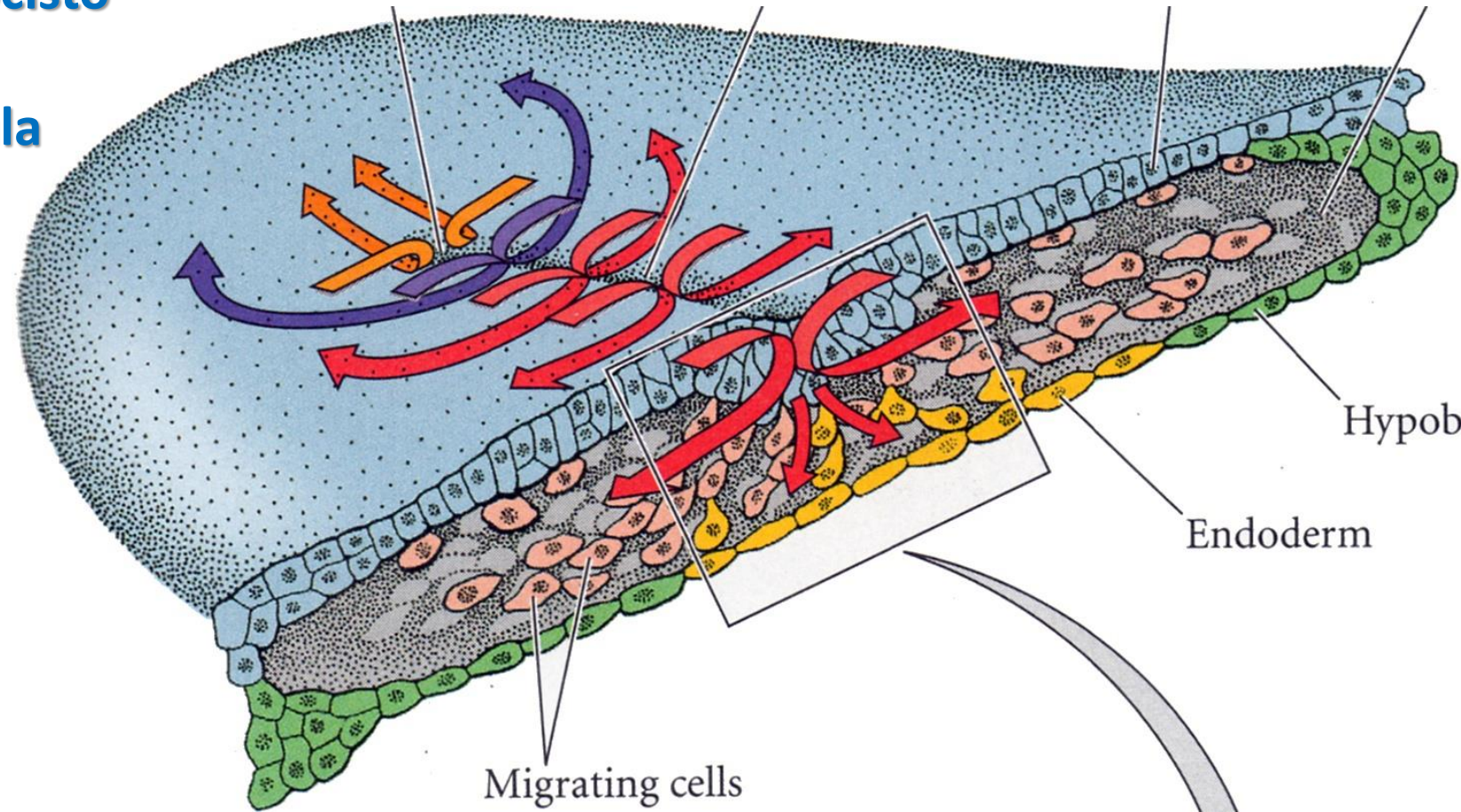


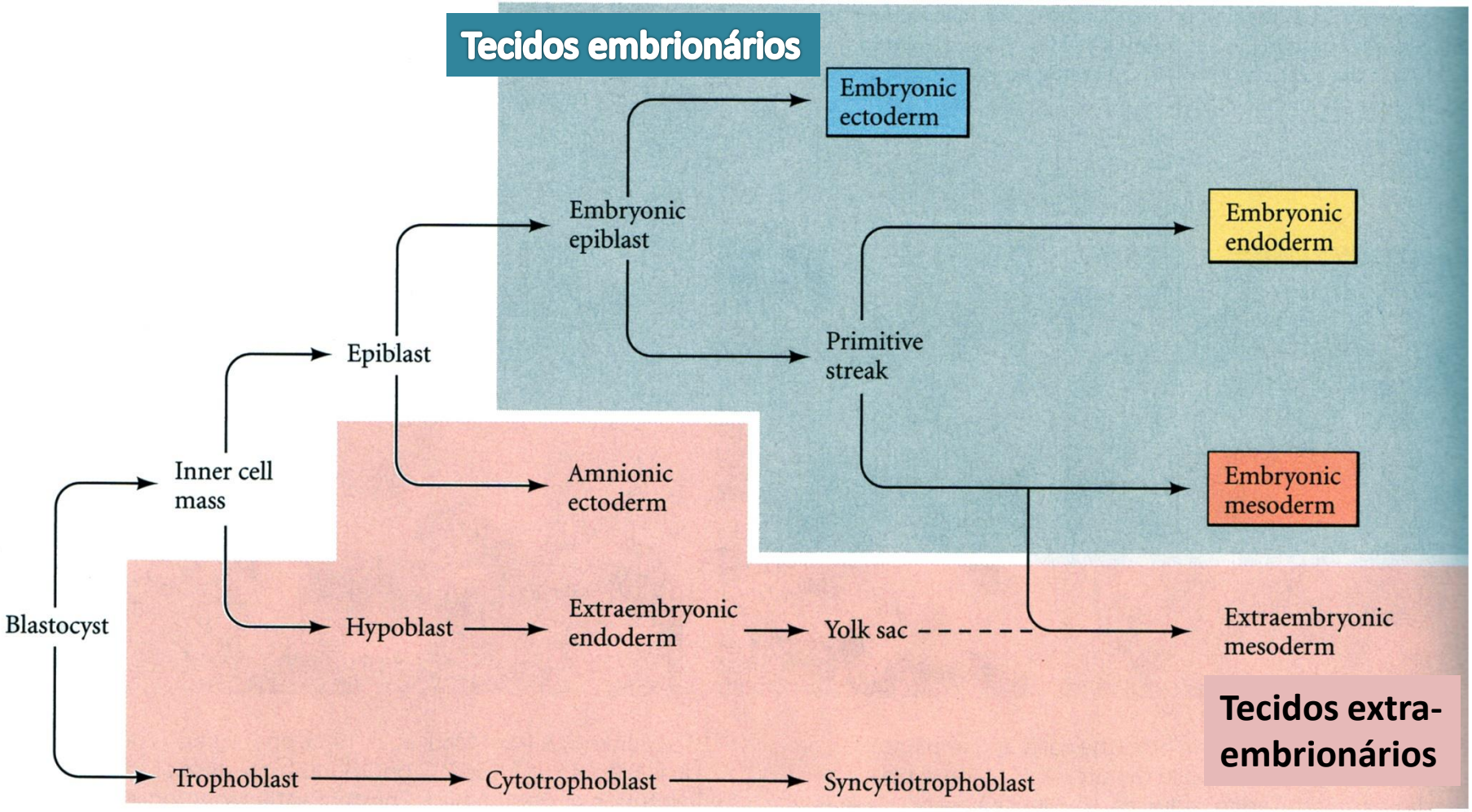
Anteriormente em LOST…

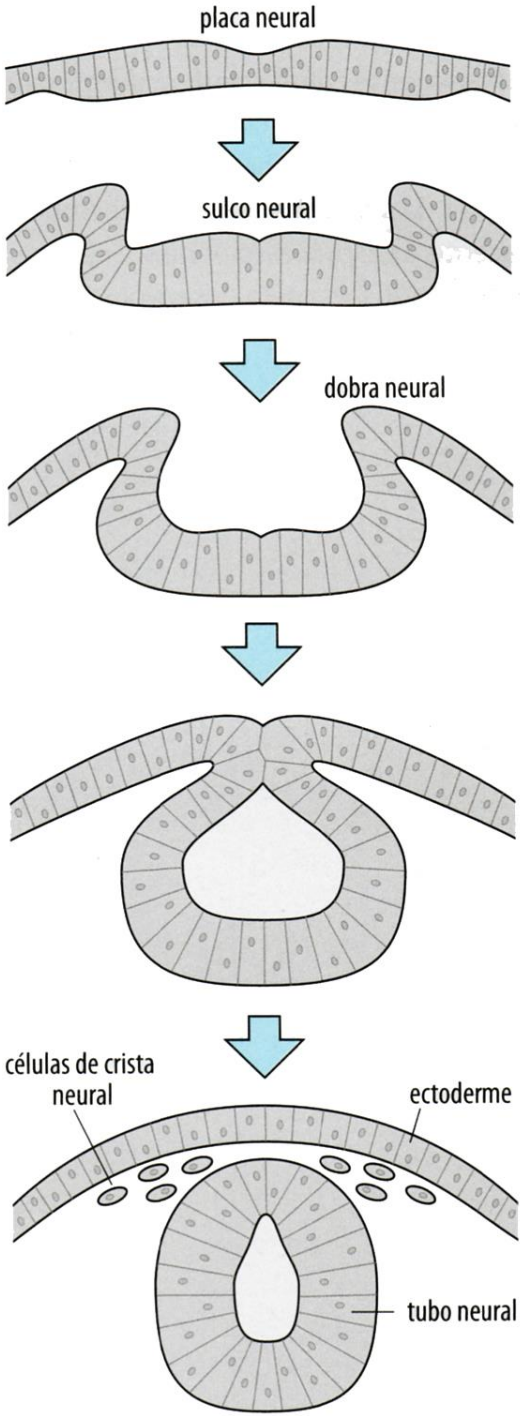




Do Blastocisto à Gástrula




Tecidos embrionários
Embryonic ectoderm
Embryonic epiblast
Embryonic endoderm
Primitive streak
Epiblast
Inner cell mass
Amnionic ectoderm
Embryonic mesoderm
Blastocyst
Hypoblast
Extraembryonic endoderm
Yolk sac
Extraembryonic mesoderm
Trophoblast
Cytotrophoblast
Syncytiotrophoblast
Tecidos extra-embrionários

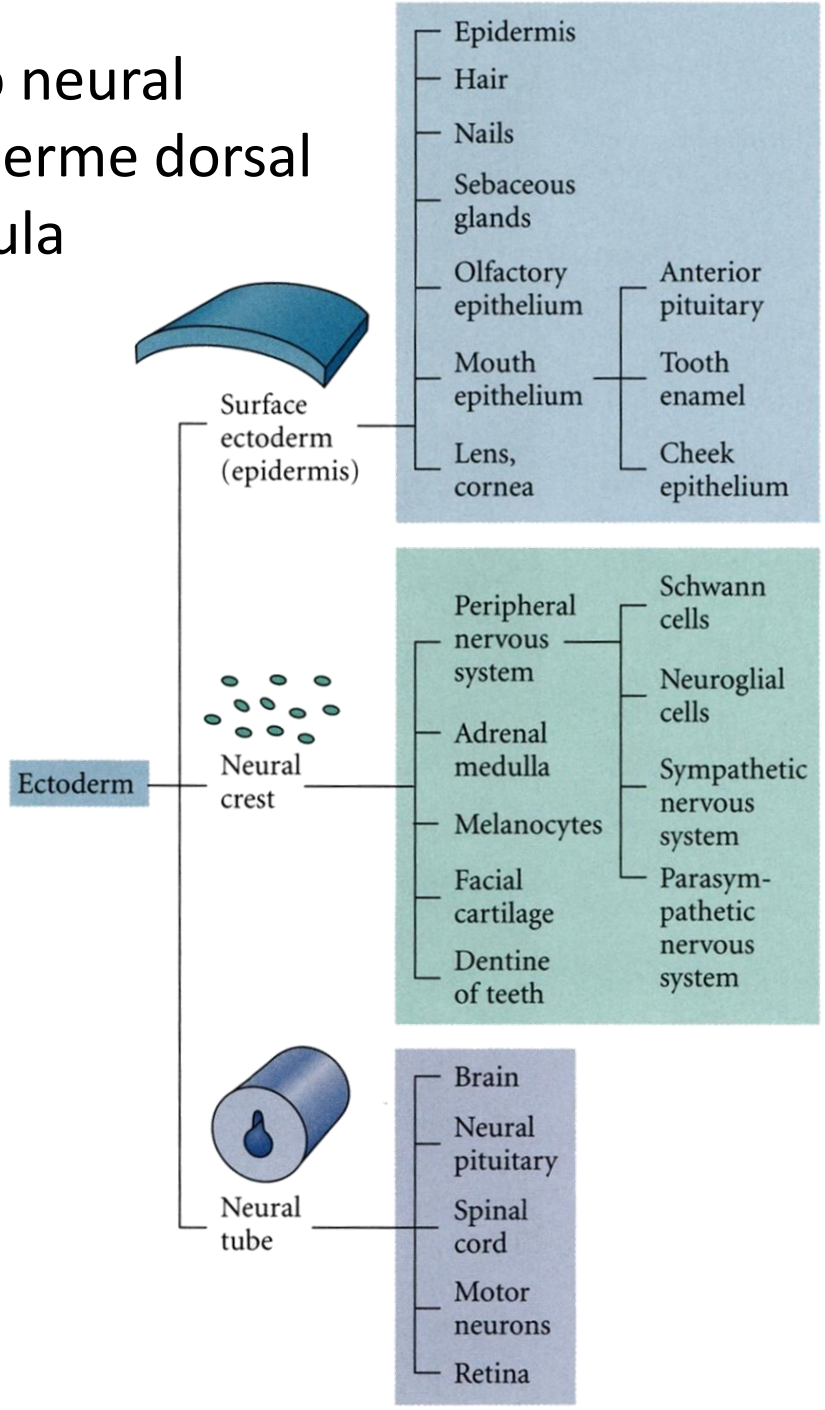


Formação do Tubo neural

Derivado do ectoderme dorsal

→ Cérebro + medula

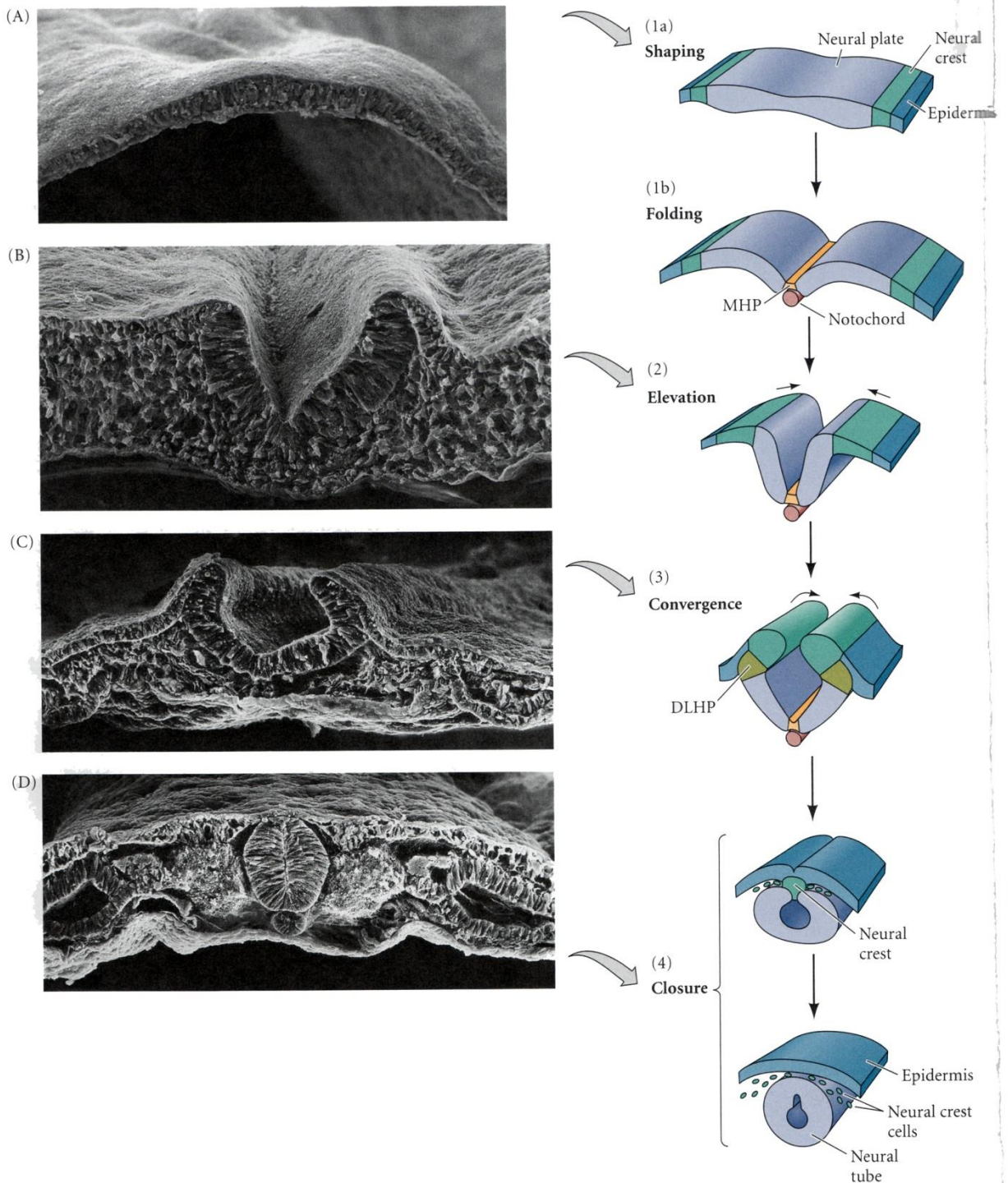
Indução

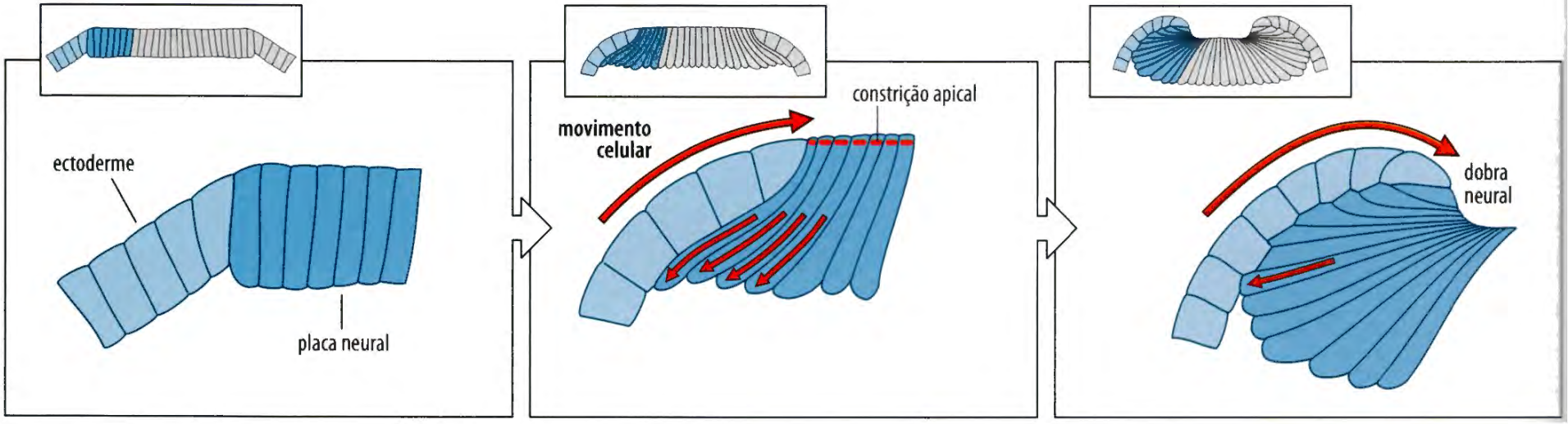


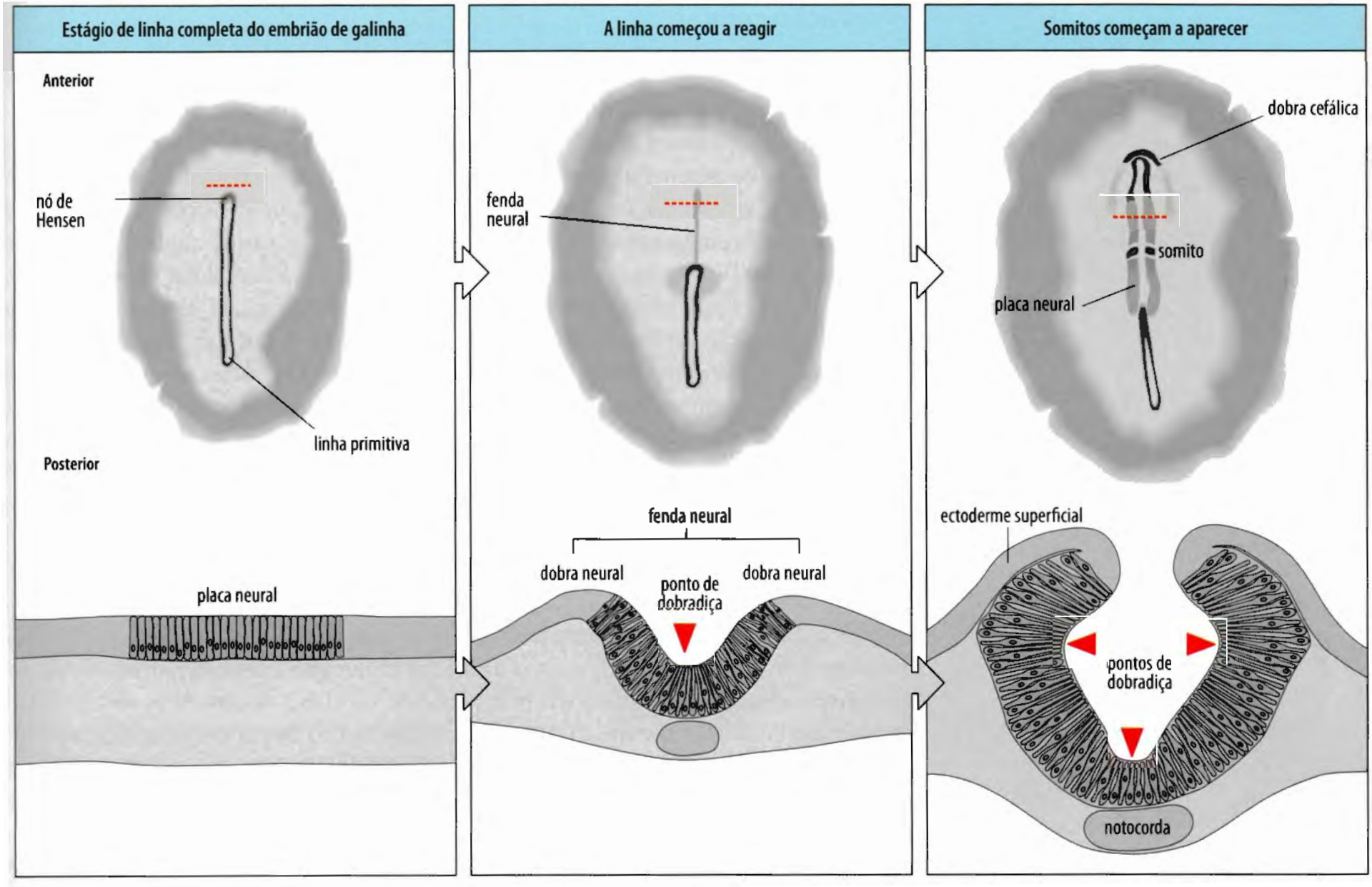
Indução mesodérmica: células ectodérmicas tornam-se colunares. ~50%

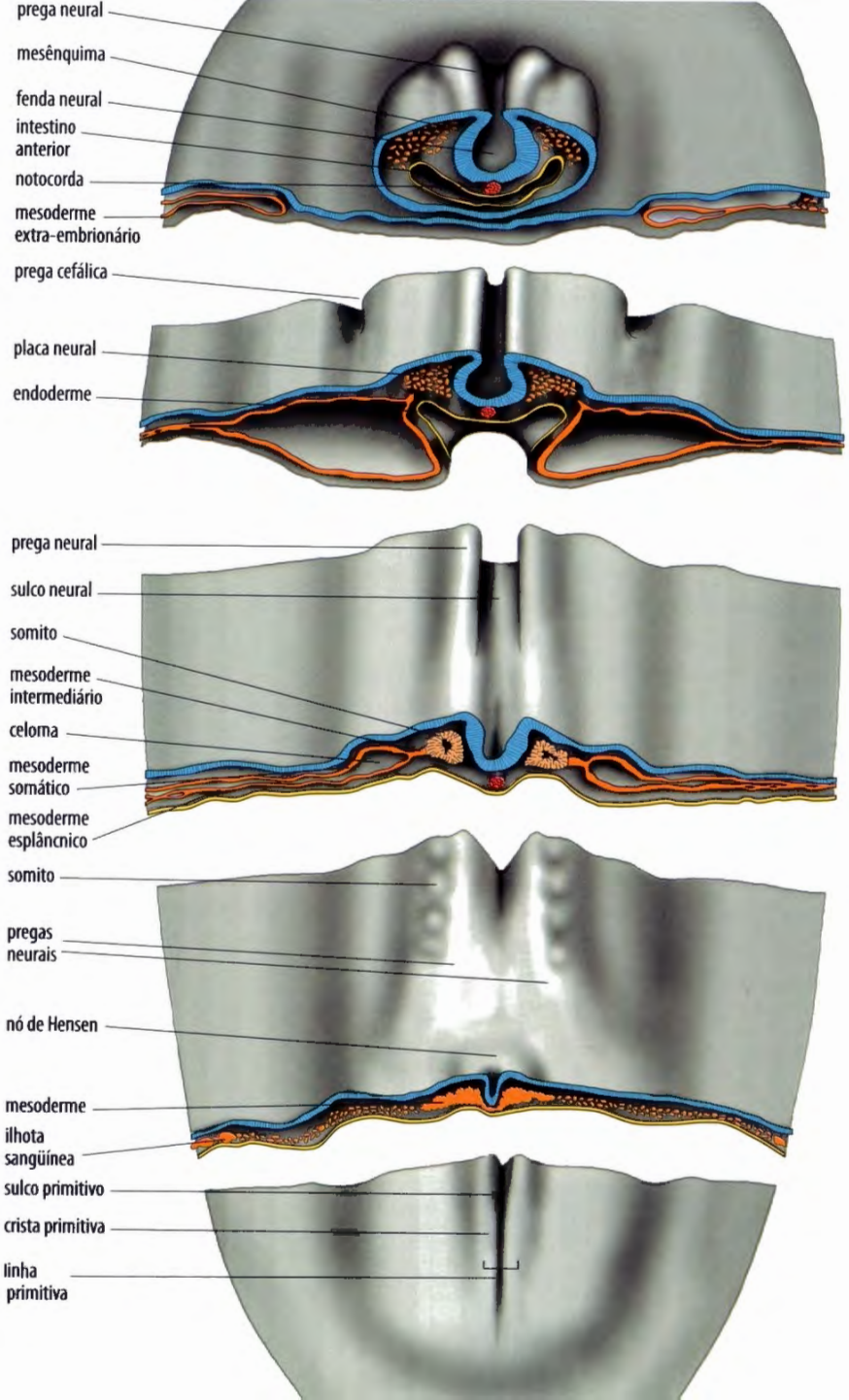
Pontos de dobra.
Ancoragem na notocorda.
Indução de mudanças de forma (induzidas pela notocorda), mudanças no citoesqueleto.
Pressão do ectoderme.

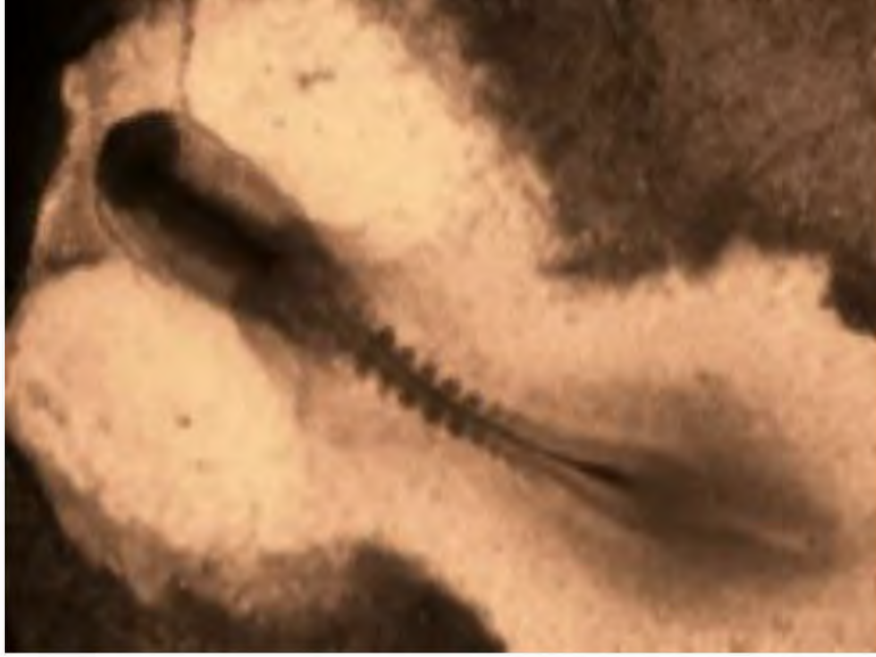
E-Caderinas ↓
N-Caderinas ↑



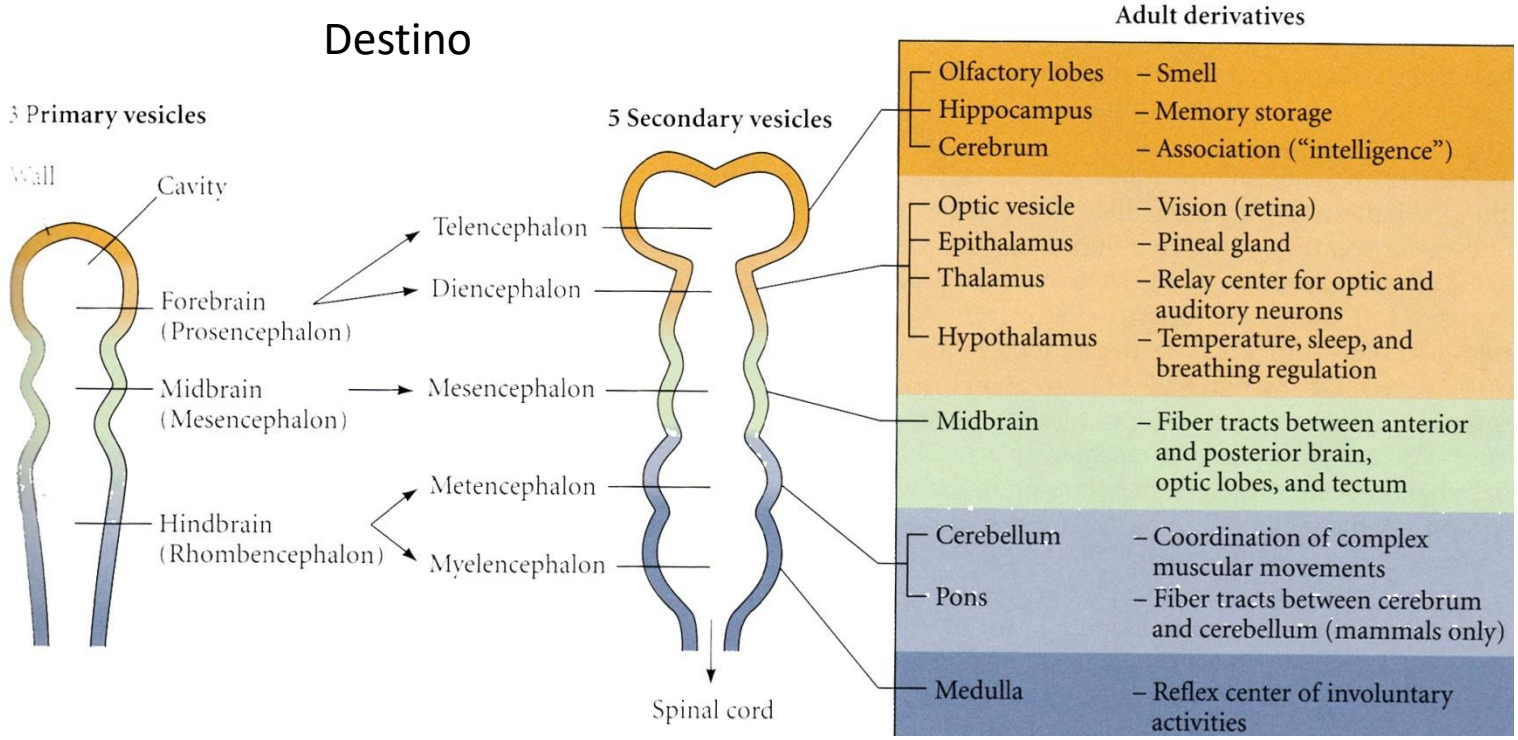

ectoderme
placa neural
movimento celular
constrição apical
dobra neural

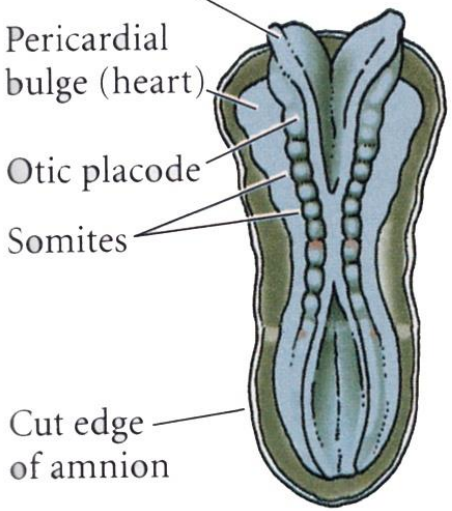

Estágio de linha completa do embrião de galinha
Anterior
nó de Hensen
linha primitiva
Posterior
placa neural
A linha começou a reagir
fenda neural
fenda neural
dobra neural
ponto de dobradiça
dobra neural
Somitos começam a aparecer
dobra cefálica
somito
placa neural
ectoderme superficial
pontos de dobradiça
notocorda


prega neural
mesênquima
fenda neural
intestino anterior
notocorda
mesoderme extra-embrionário
prega cefálica
placa neural
endoderme
prega neural
sulco neural
somito
mesoderme intermediário
celoma
mesoderme somático
mesoderme esplâncnico
somito
pregas neurais
nó de Hensen
mesoderme
ilhota sangüínea
sulco primitivo
crista primitiva
linha primitiva

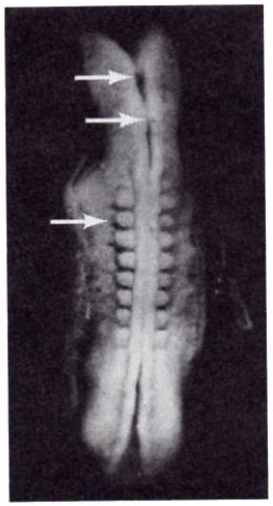


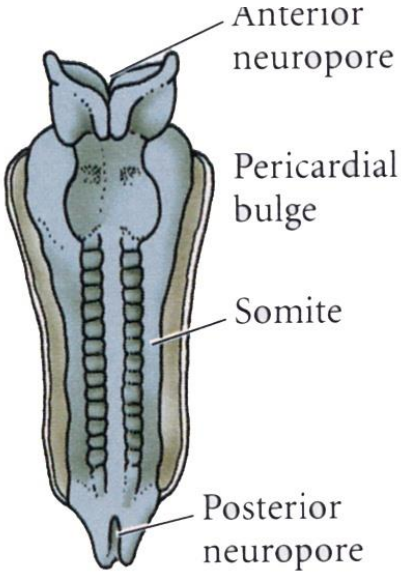
Destino



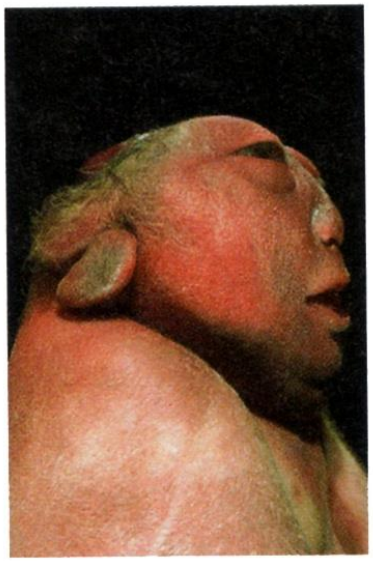


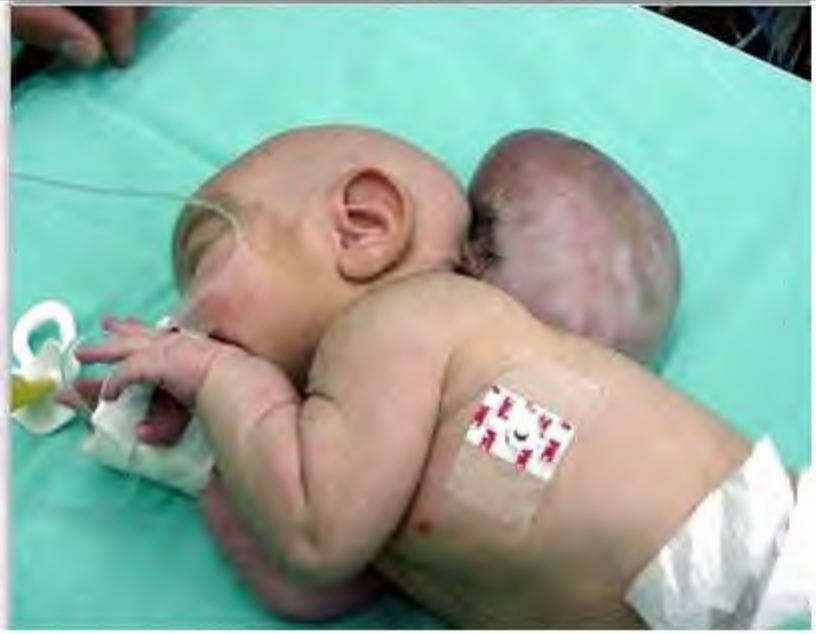
22 days



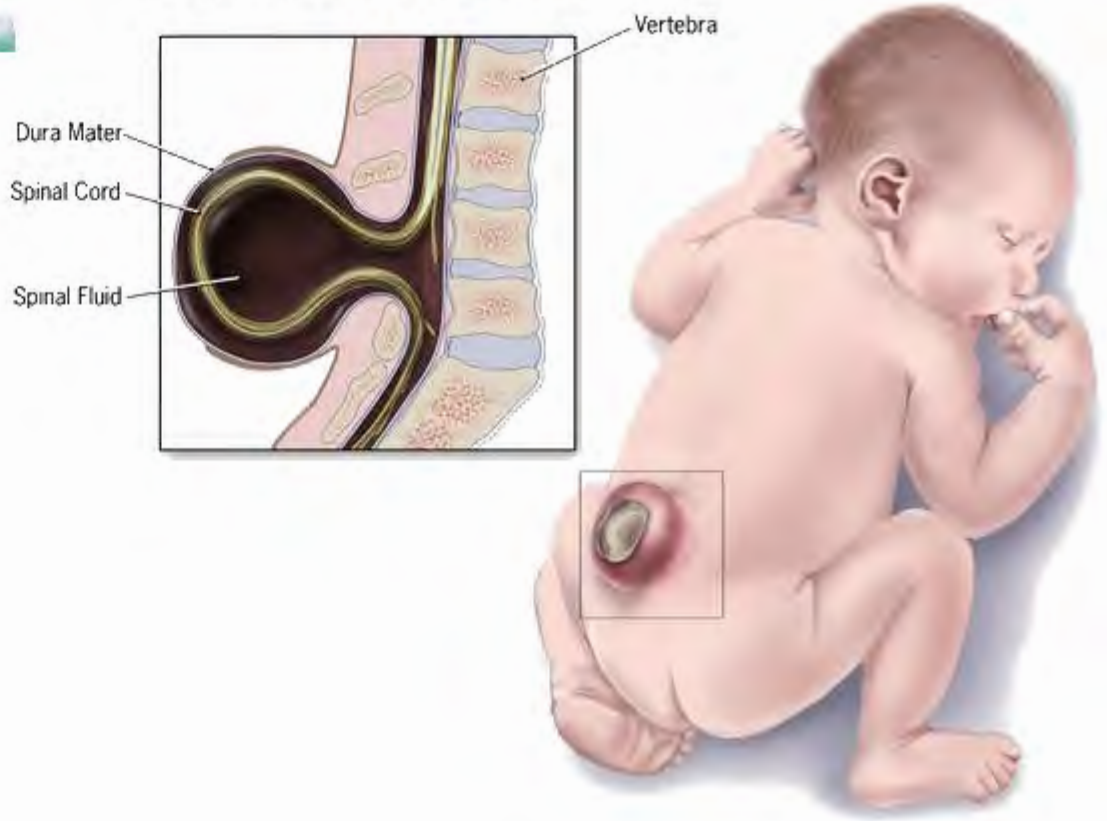


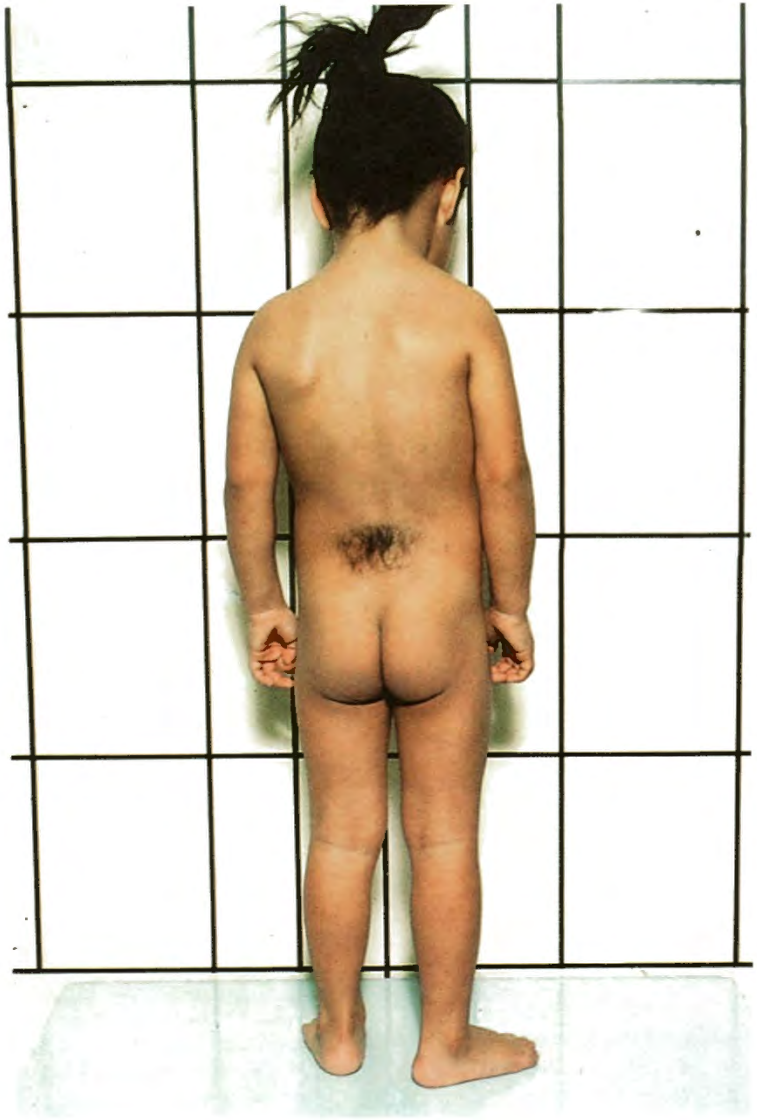
23 days

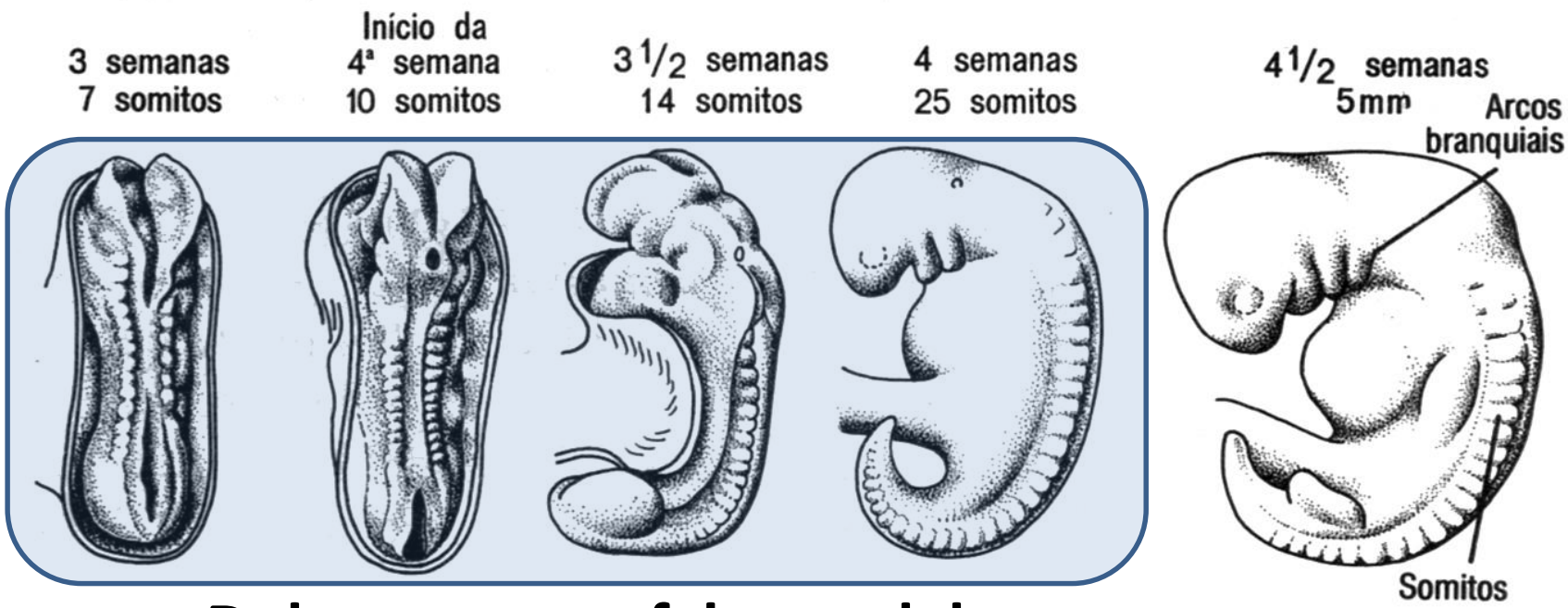




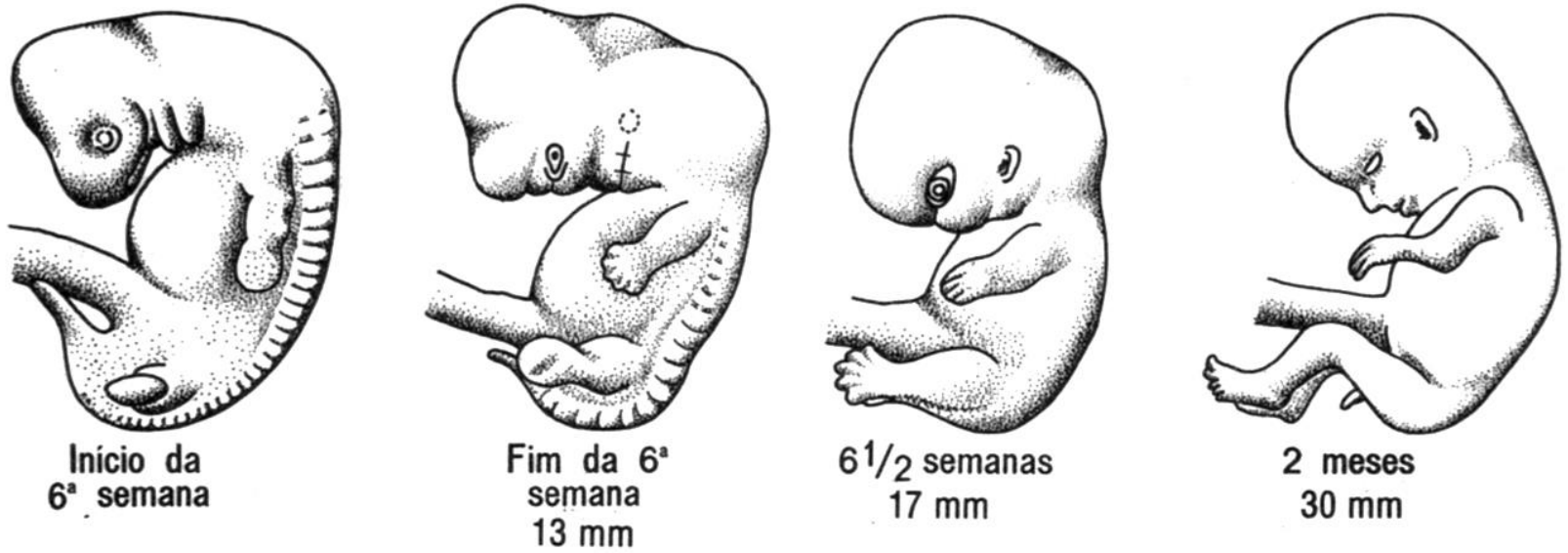
Spina Bifida (Open Defect)







Dobramento cefalo-caudal

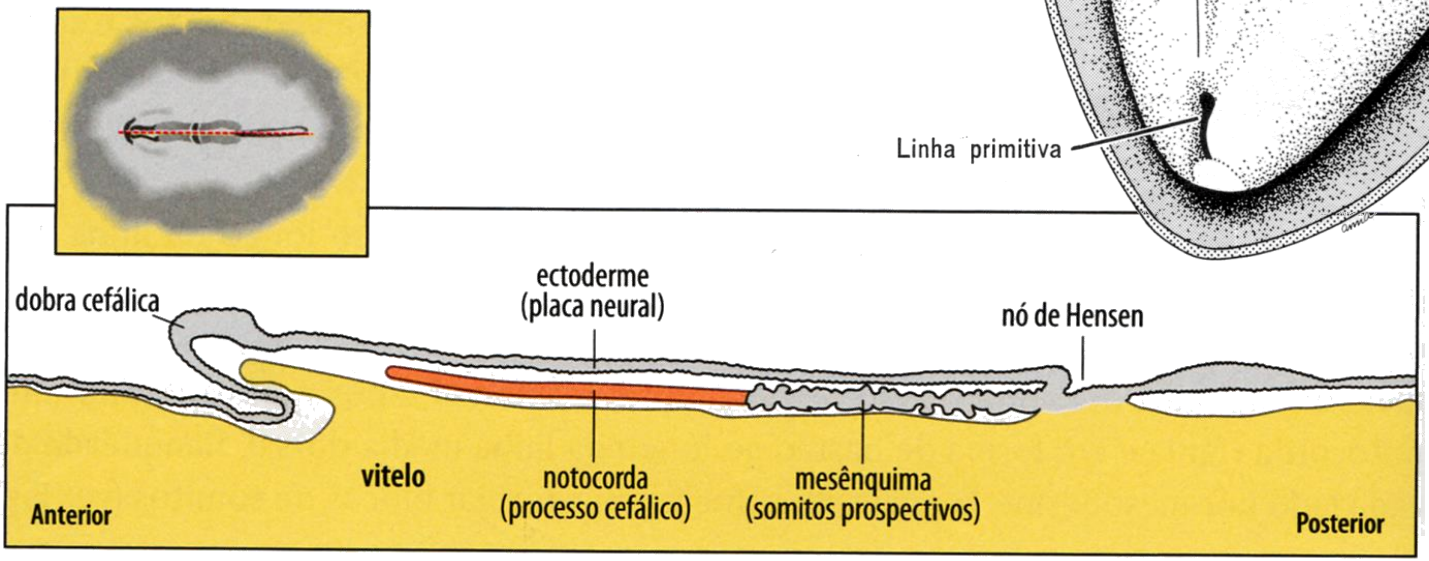


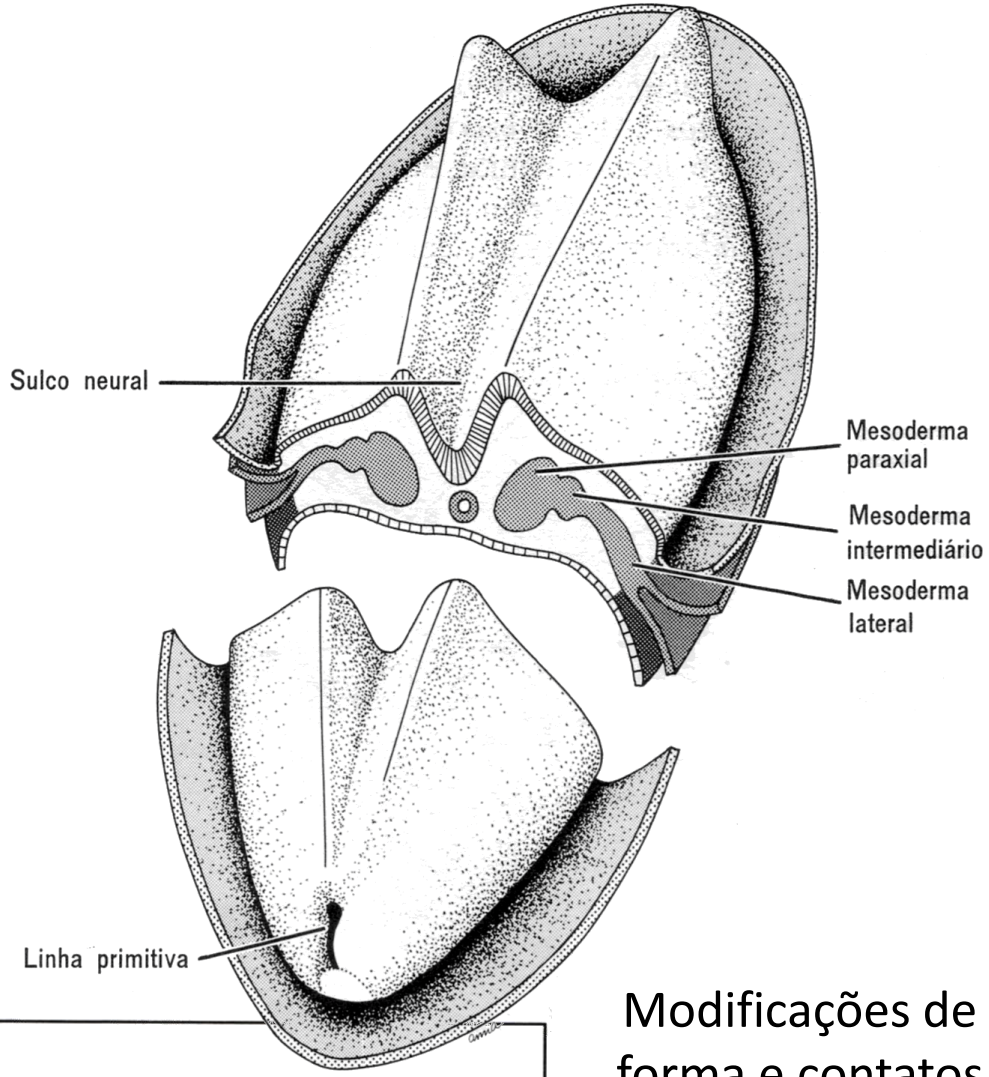
Somitos

Origem mesodérmica (Paraxial)

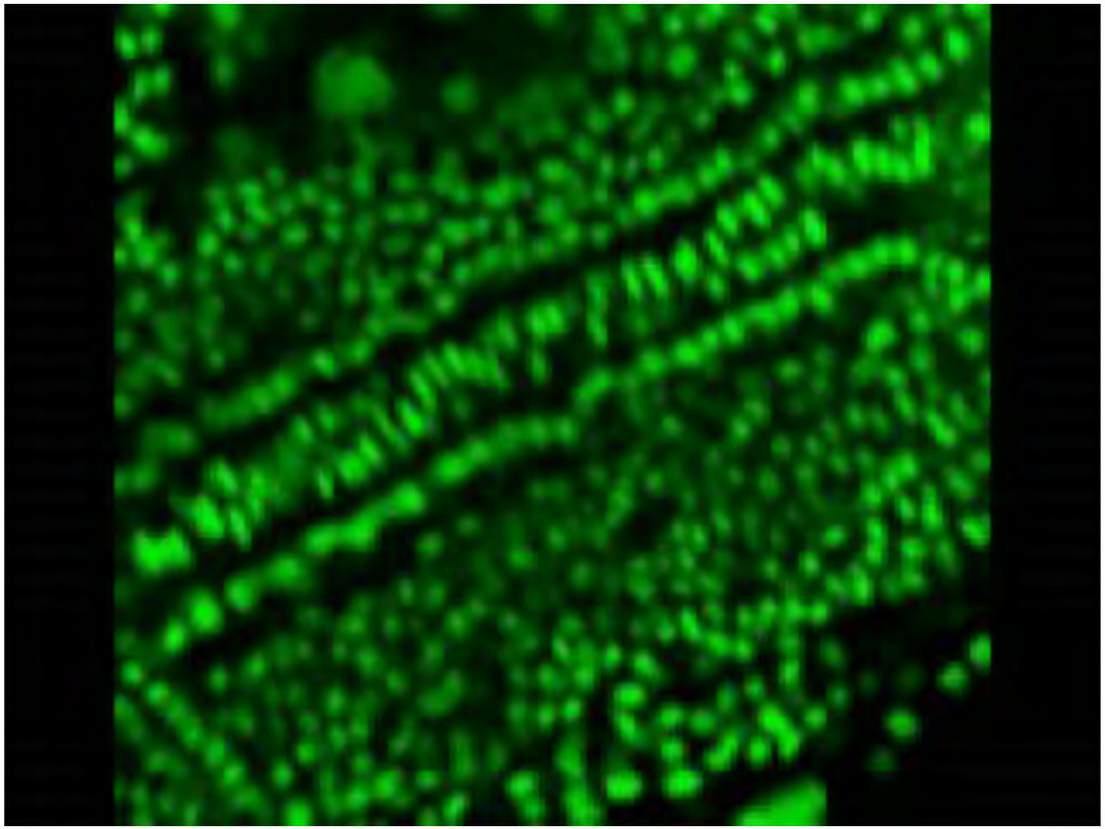
Originam: Ossos e cartilagens do tronco, músculos esqueléticos e derme dorsais

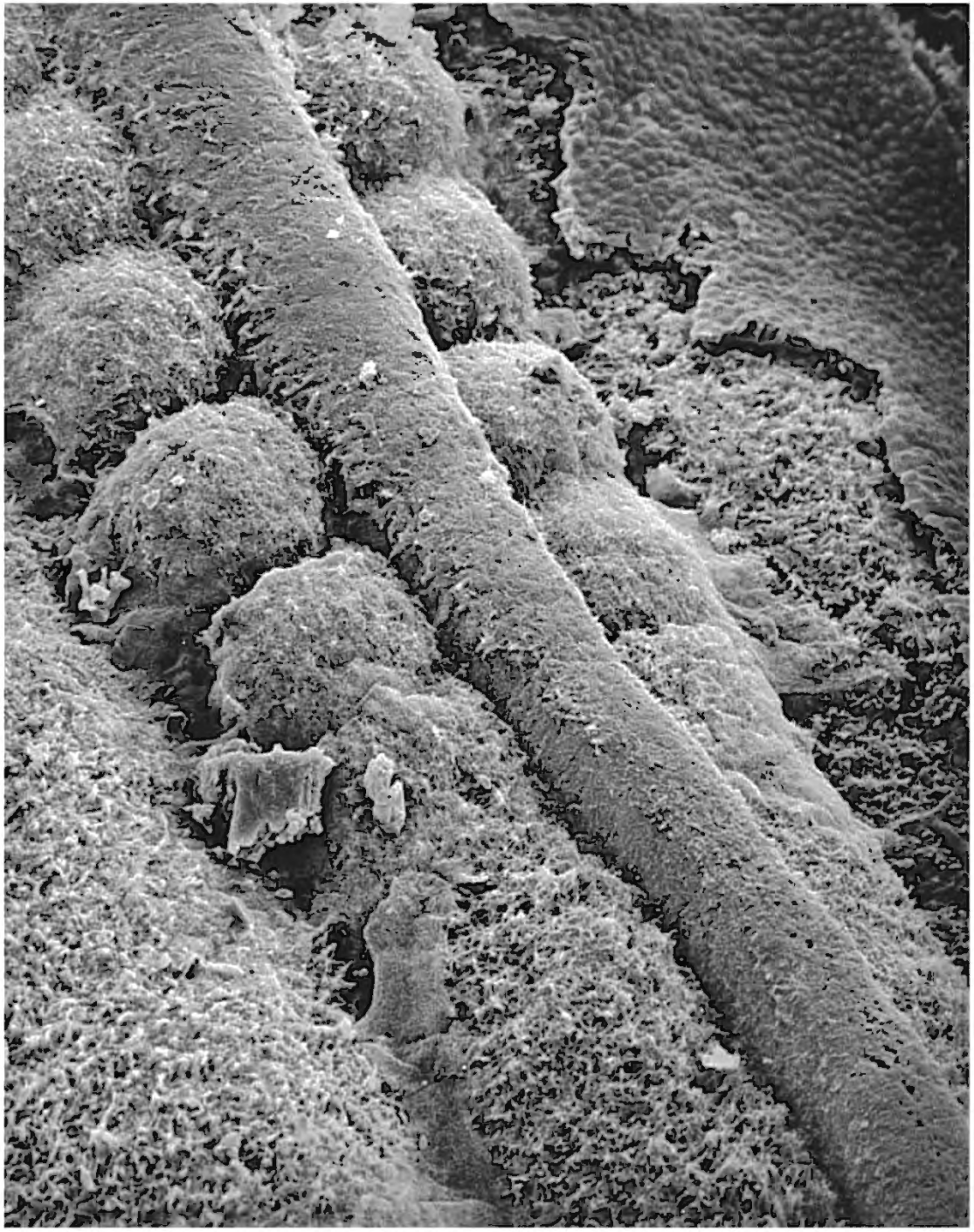
PADRONIZAÇÃO



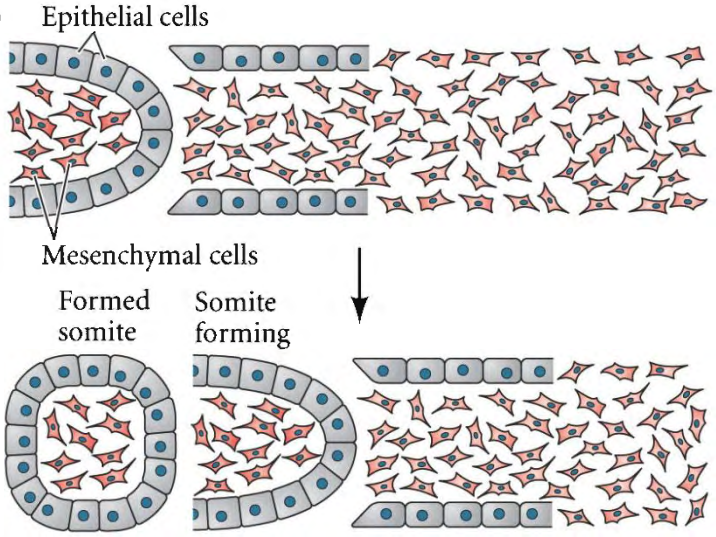


Modificações de forma e contatos intercelulares, dependente de movimentos celulares

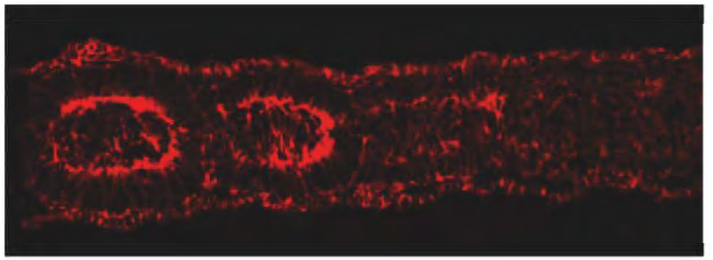


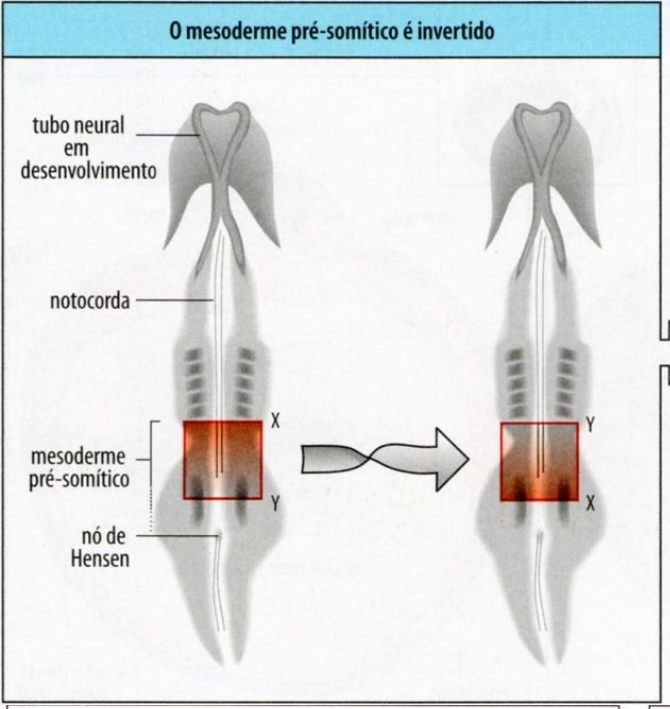


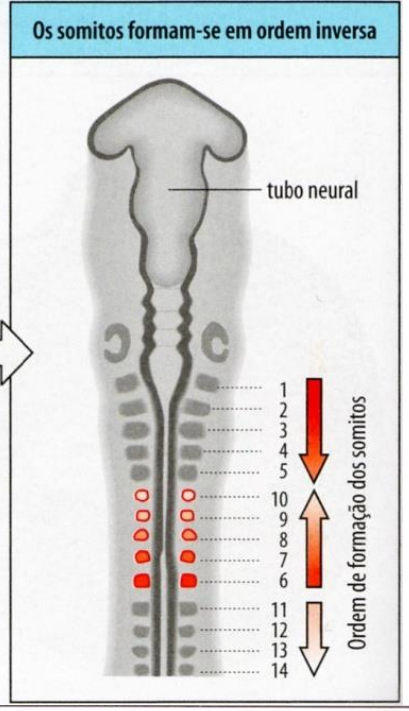
(A)


Epithelial cells
Mesenchymal cells
Formed somite
Somite forming

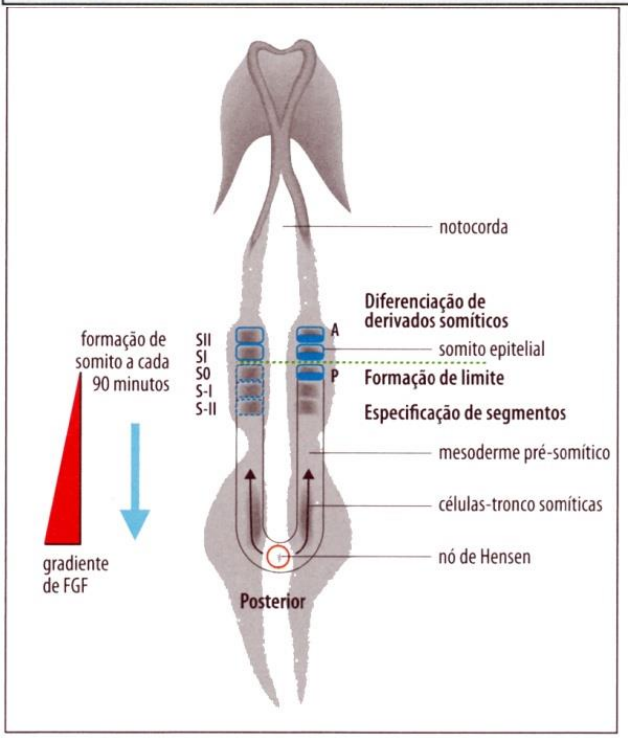
(B)

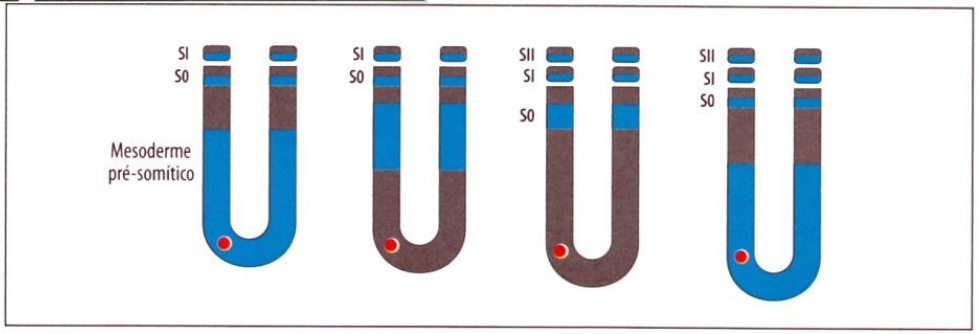


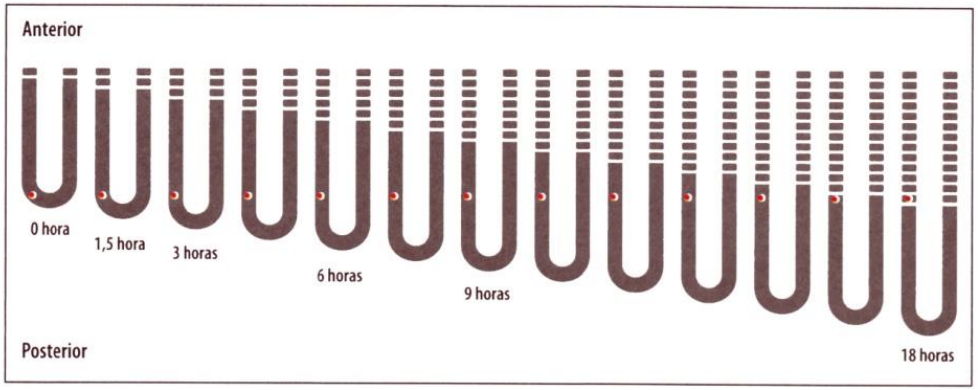


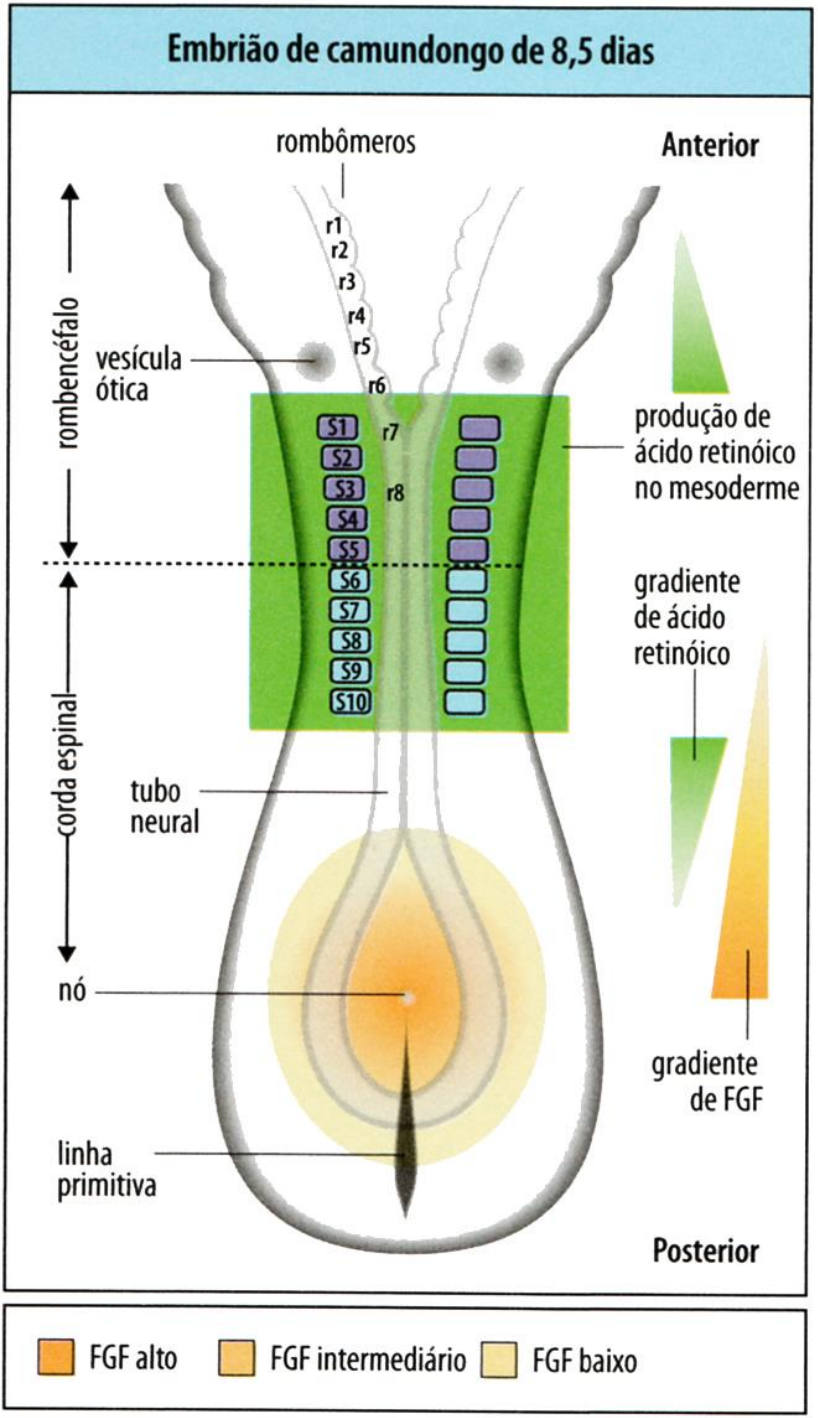


Ordem específica ao longo do eixo ântero-posterior
Células-tronco somitogênicas em torno do nó (Epiblasto)
Pareados
Relógio de segmentação + FGF8





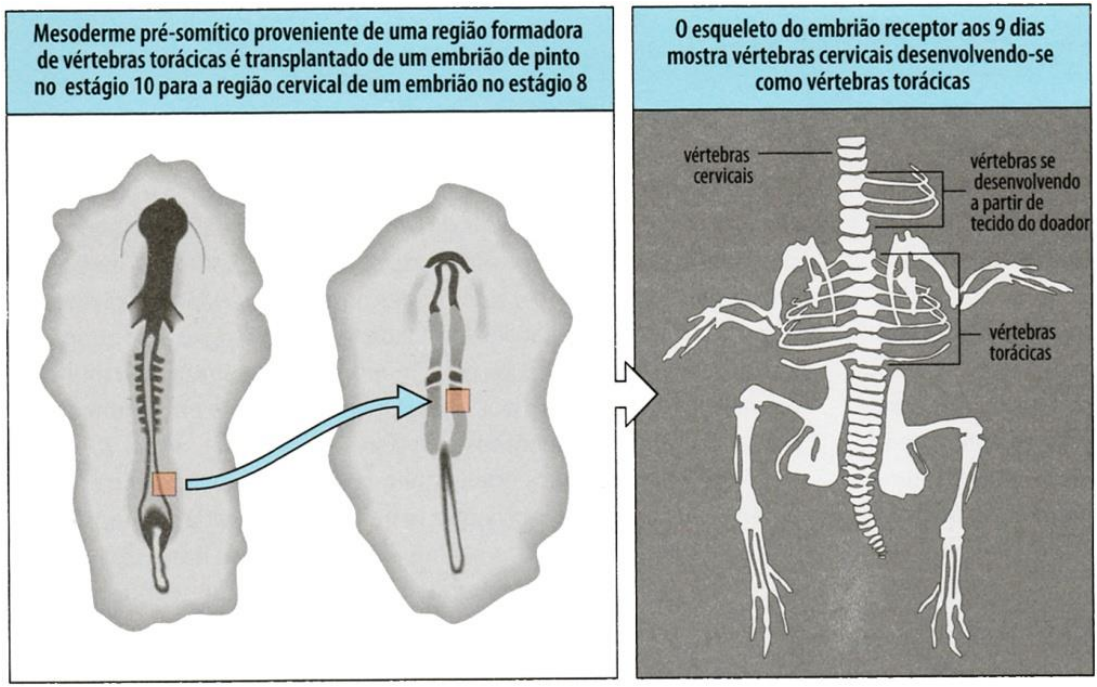


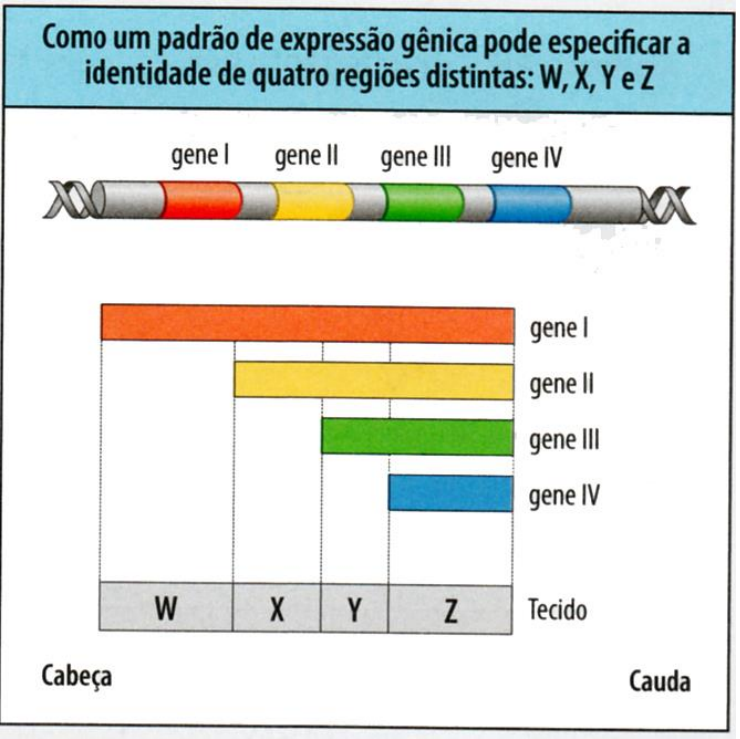


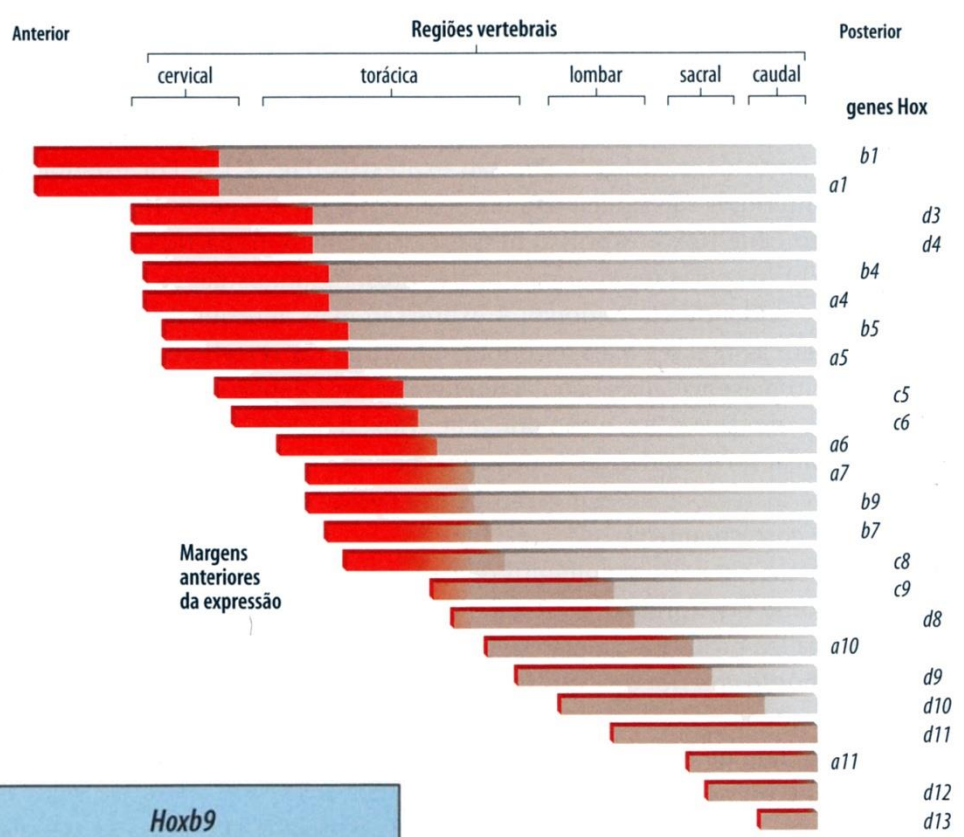
FGF8 + Ácido Retinóico regulam padronização e propagação

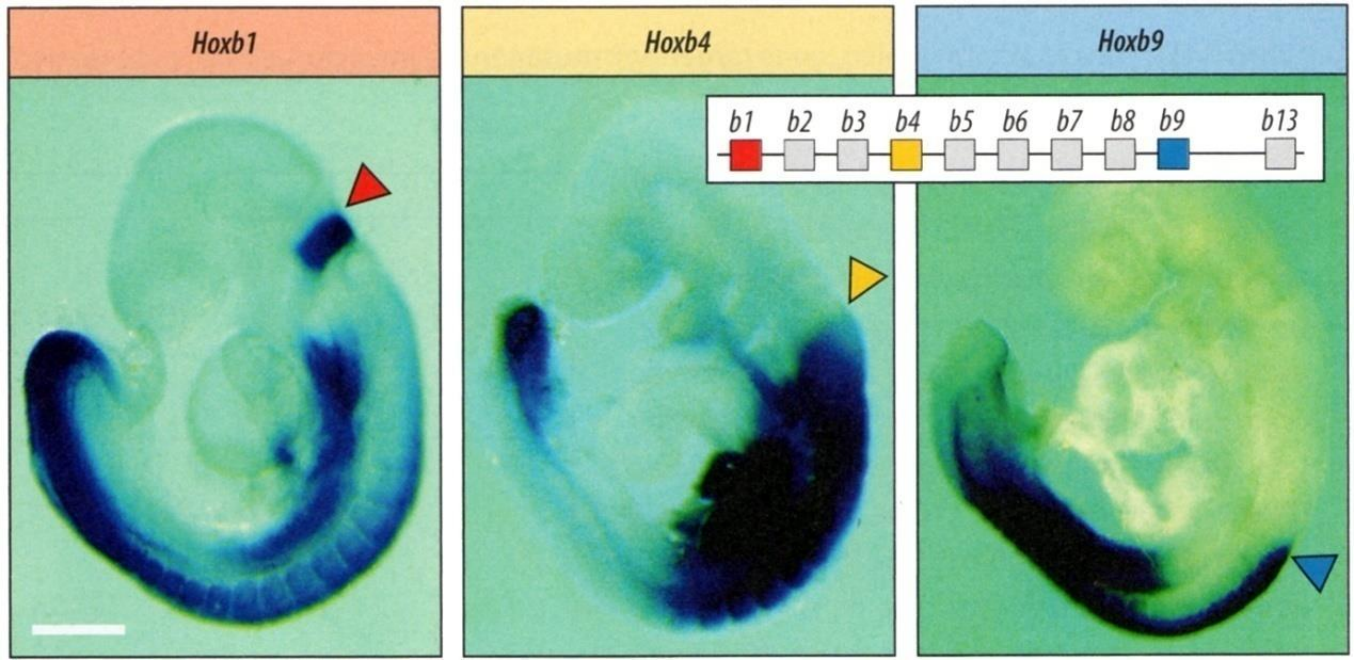
Padronização ântero-posterior precoce

Valor posicional (Identidade Posicional)
Adquirido precocemente também!!

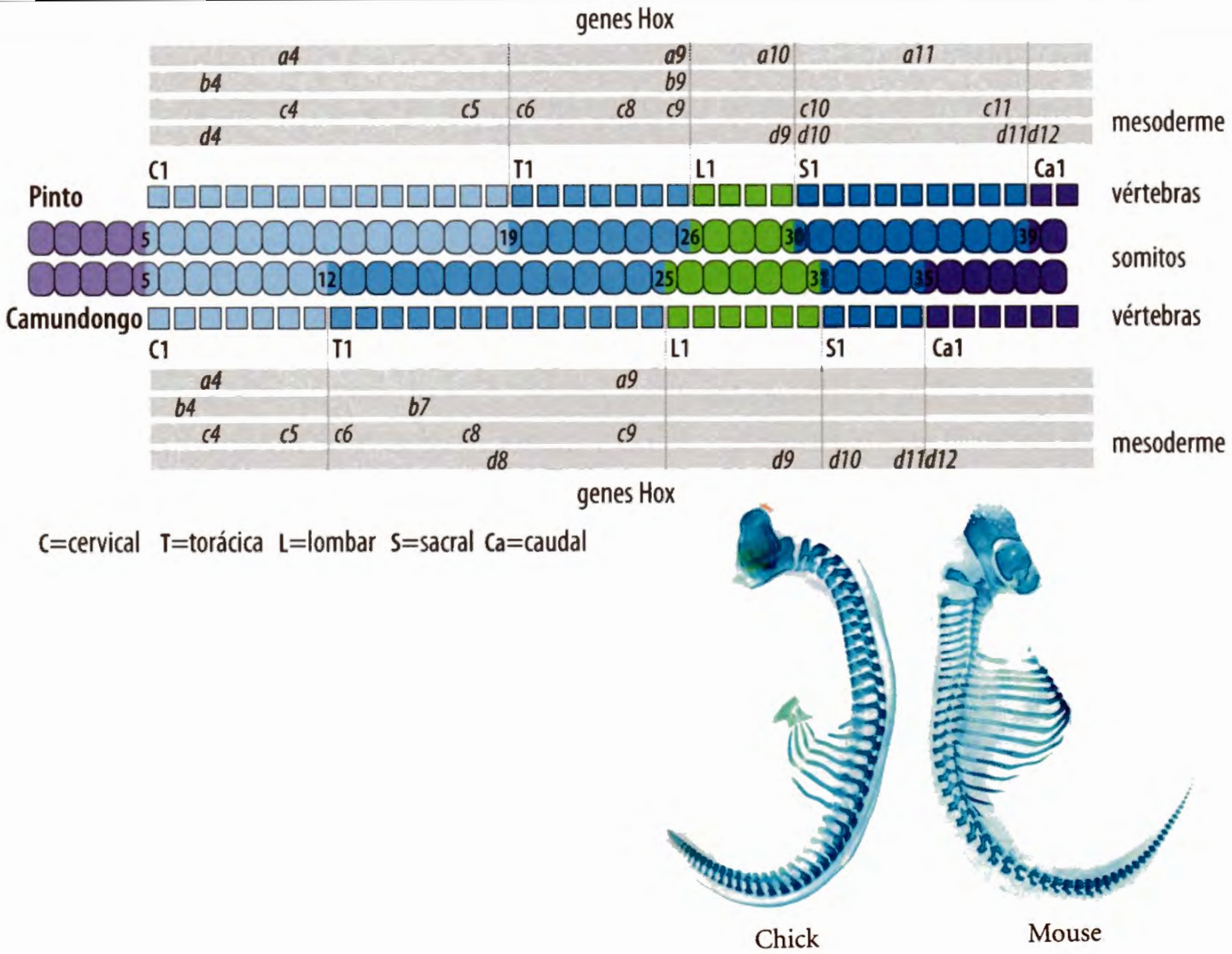


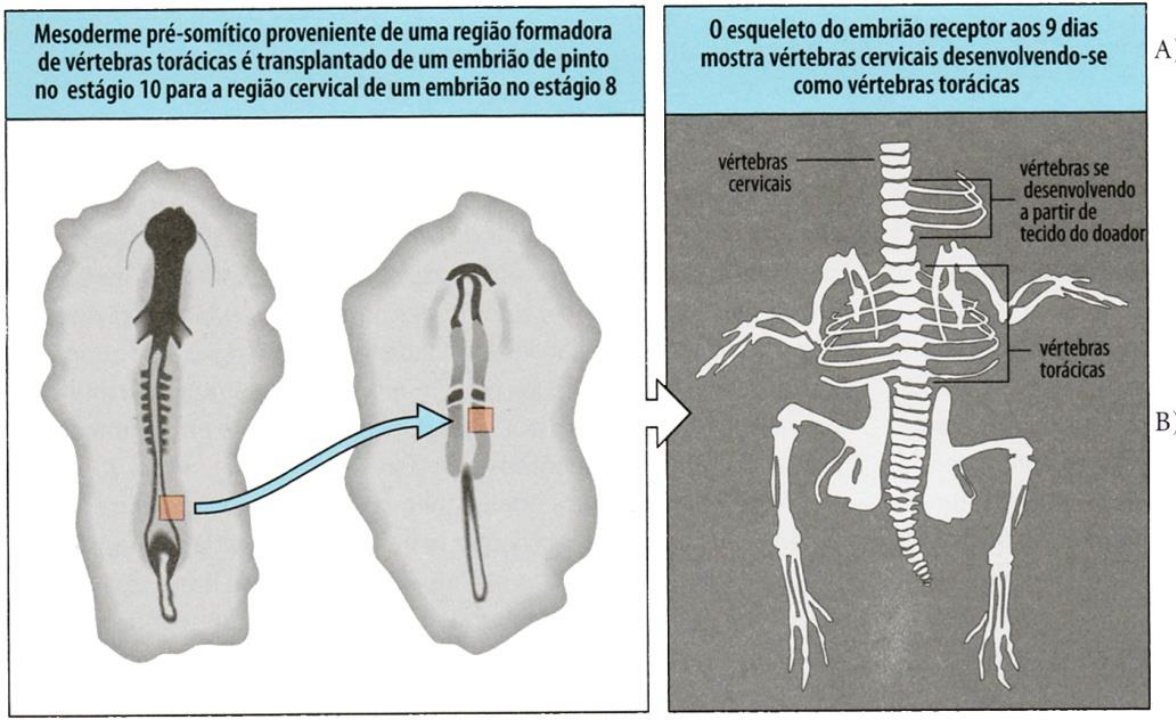


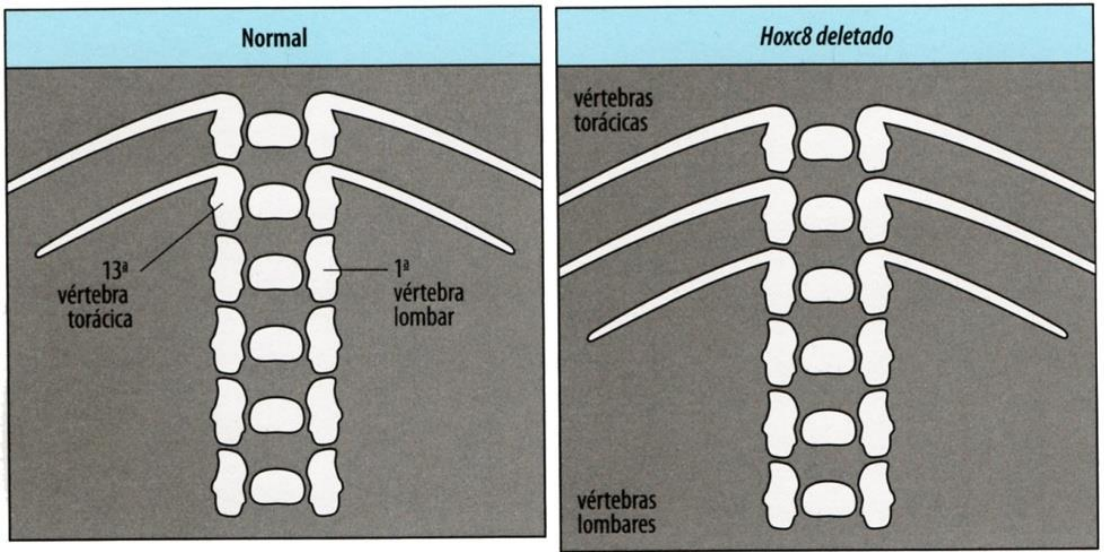


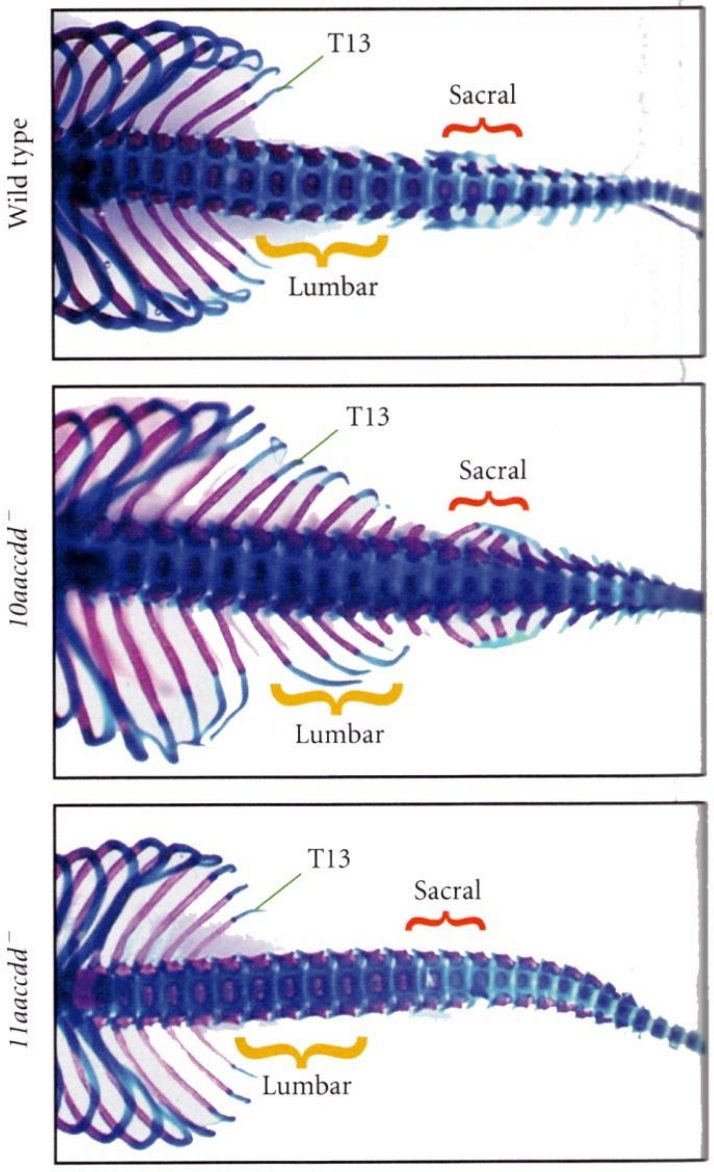


Genes Hox
Superfamília Homeobox
Fatores de transcrição
4 agrupamentos em vertebrados

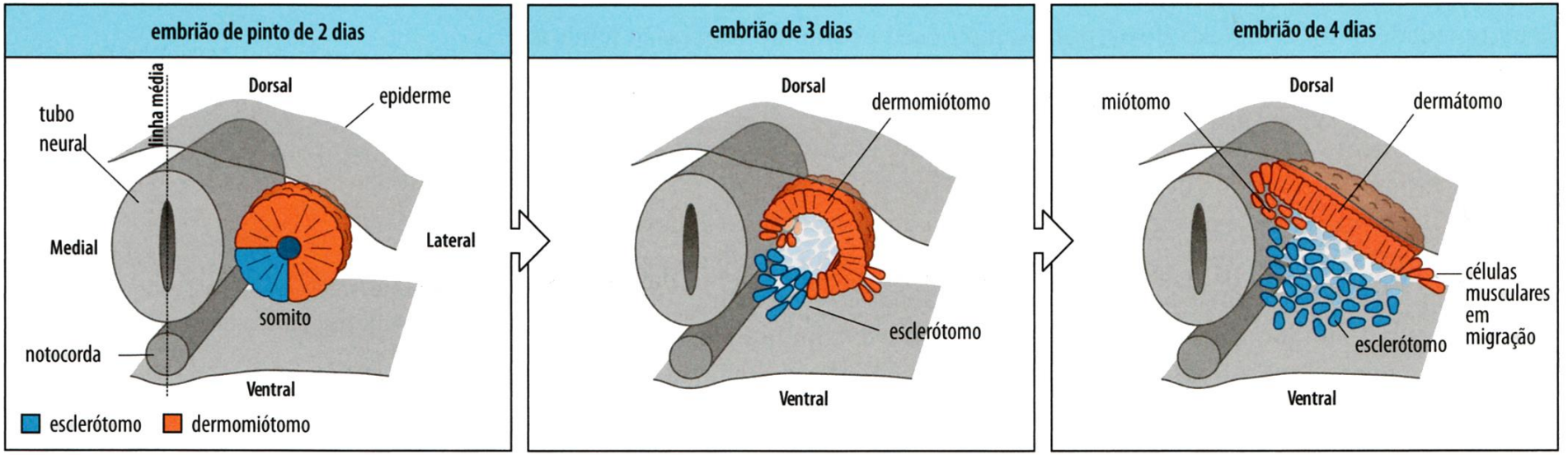

genes Hox
a4
a9
a10
a11
b4
b9
c4
c5
c6
c8
c9
c10
c11
d4
d9
d10
d11
d12
mesoderme
C1
T1
L1
S1
Ca1
Pinto
vértebras
5
19
26
30
39
somitos
5
12
25
31
35
Camundongo
vértebras
C1
T1
L1
S1
Ca1
a4
a9
b4
b7
c4
c5
c6
c8
c9
d8
d9
d10
d11
d12
mesoderme
genes Hox
C=cervical T=torácica L=lombar S=sacral Ca=caudal
Chick
Mouse

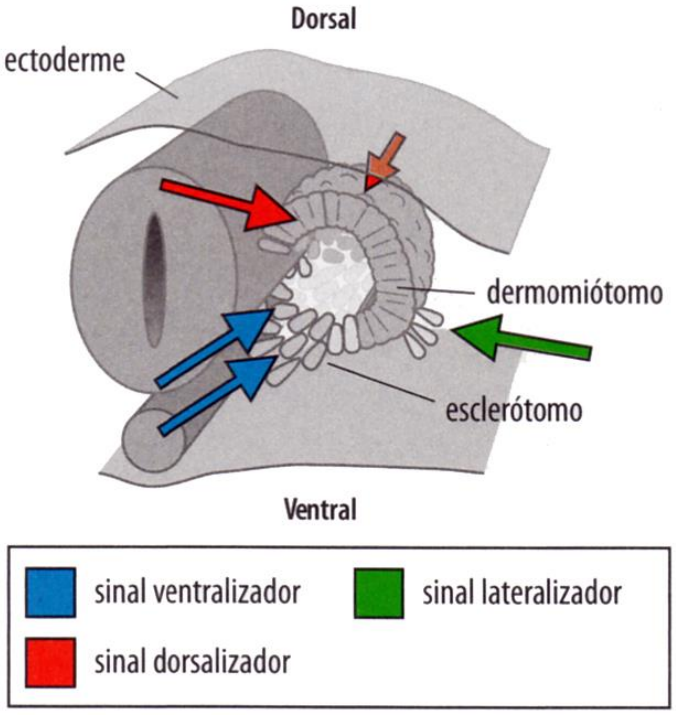






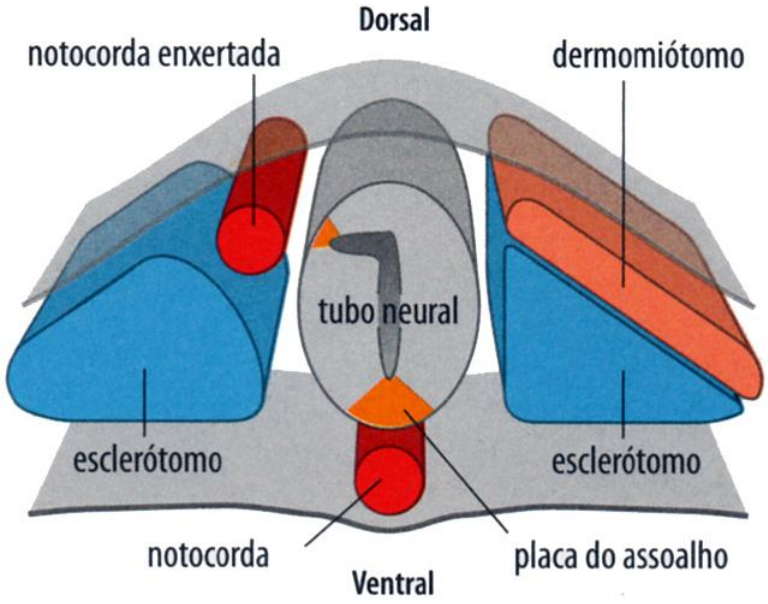
Transformação homeótica

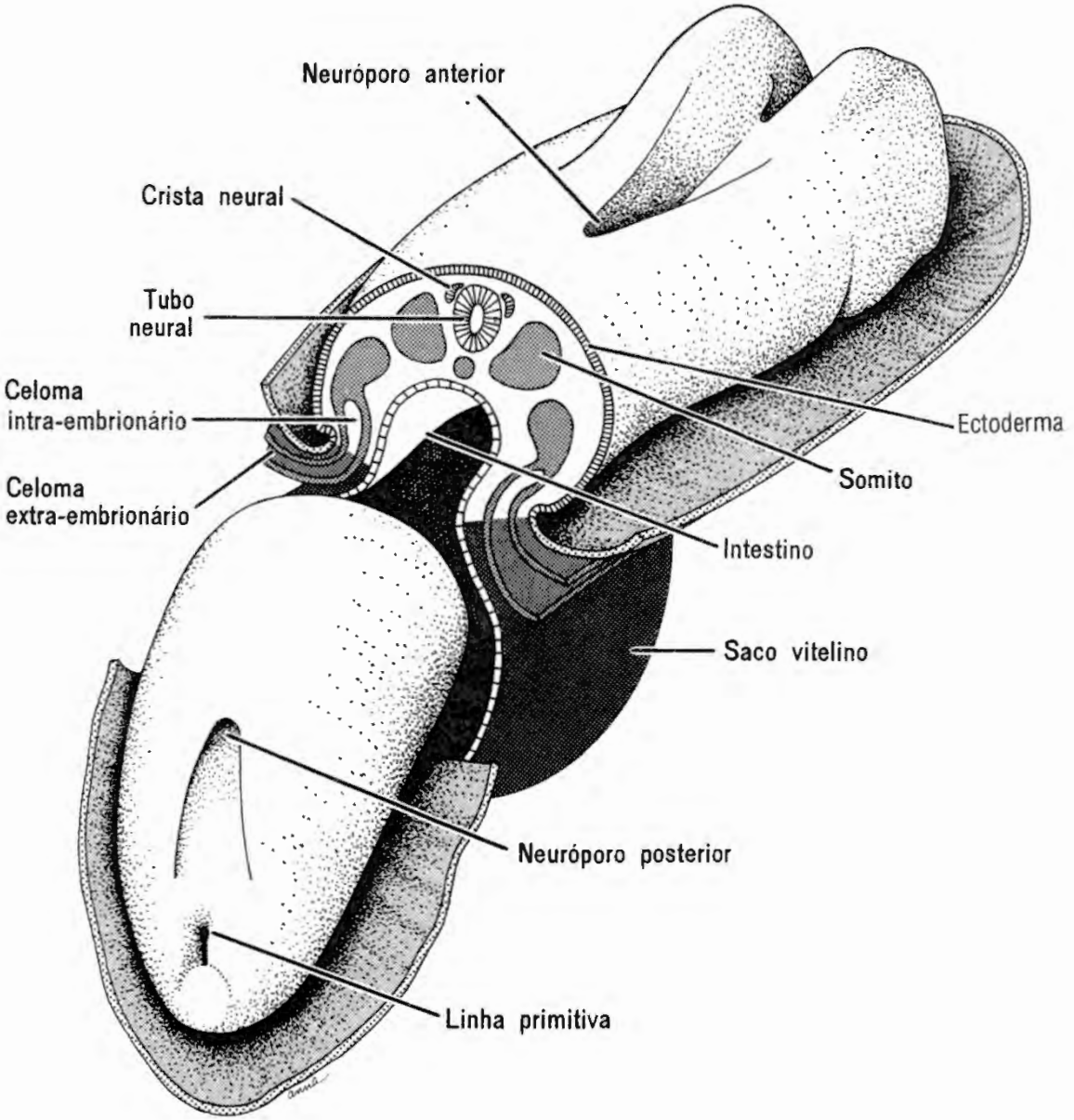

embrião de pinto de 2 dias
linha média
Dorsal
epiderme
tubo neural
Medial
Lateral
somito
notocorda
Ventral
esclerótomo
dermomiótomo
embrião de 3 dias
Dorsal
dermomiótomo
esclerótomo
Ventral
embrião de 4 dias
Dorsal
miótomo
dermátomo
células musculares em migração
esclerótomo
Ventral

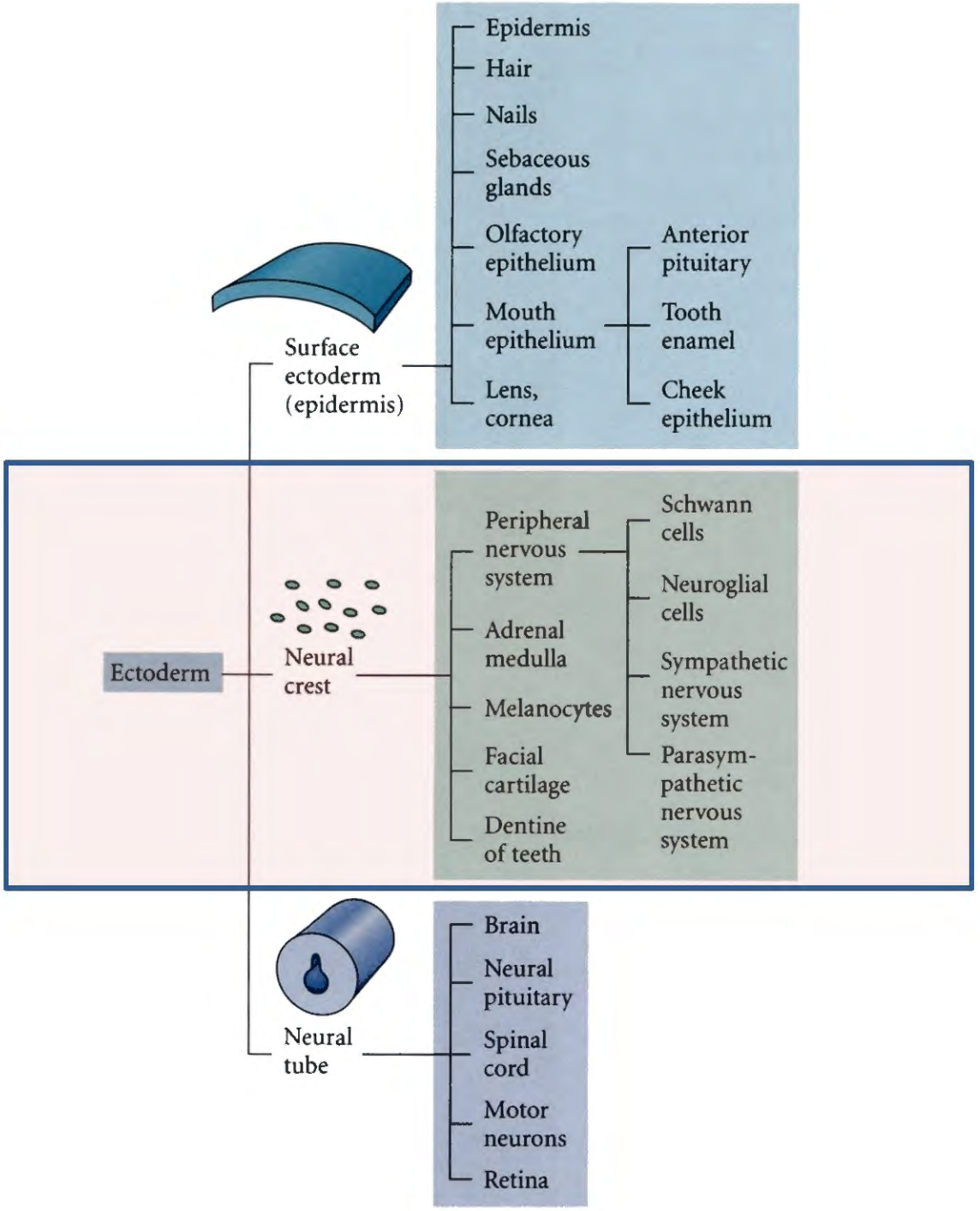

Dorsal
ectoderme
dermomiótomo
esclerótomo
Ventral
sinal ventralizador
sinal lateralizador
sinal dorsalizador

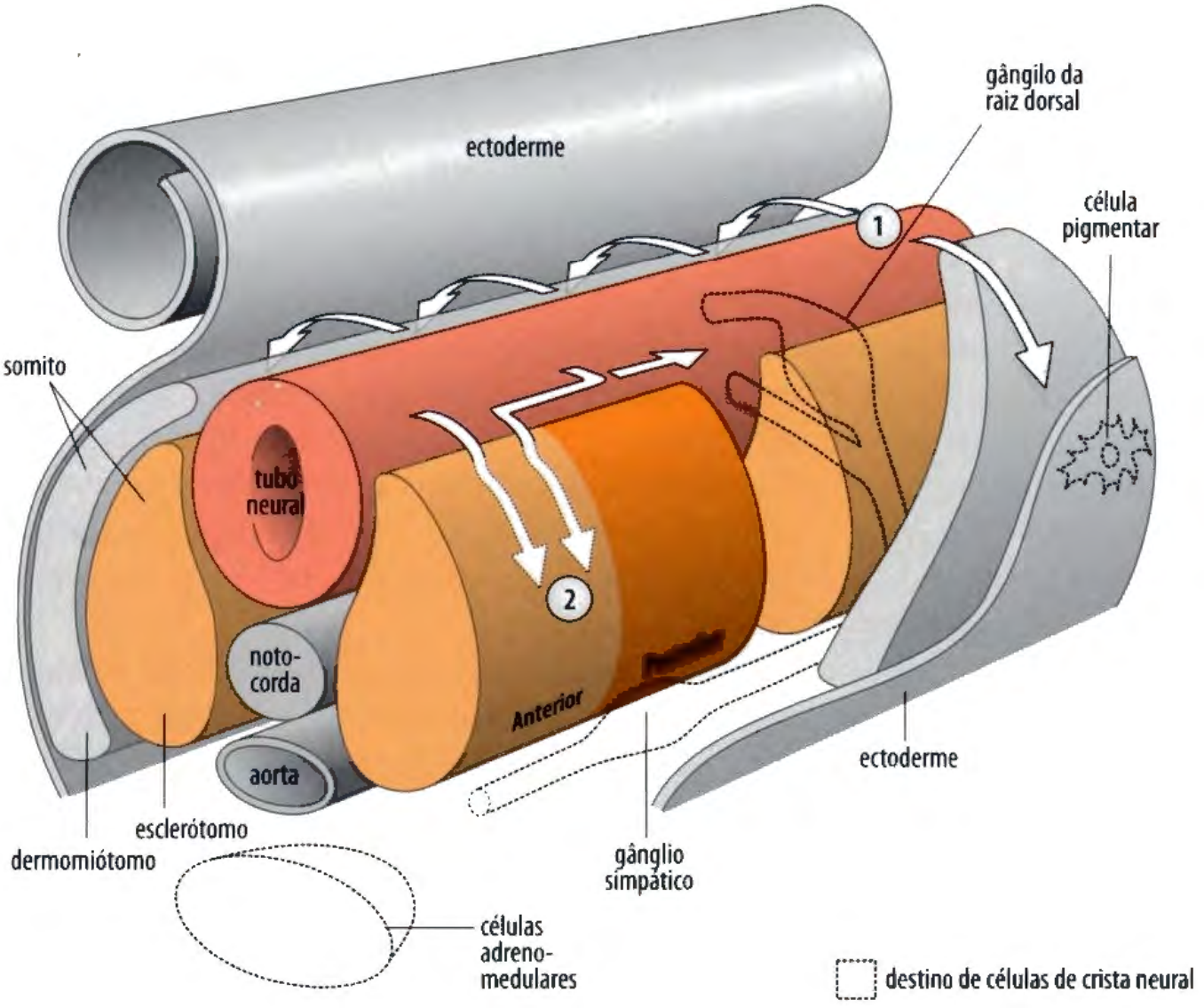
Pax

SHH

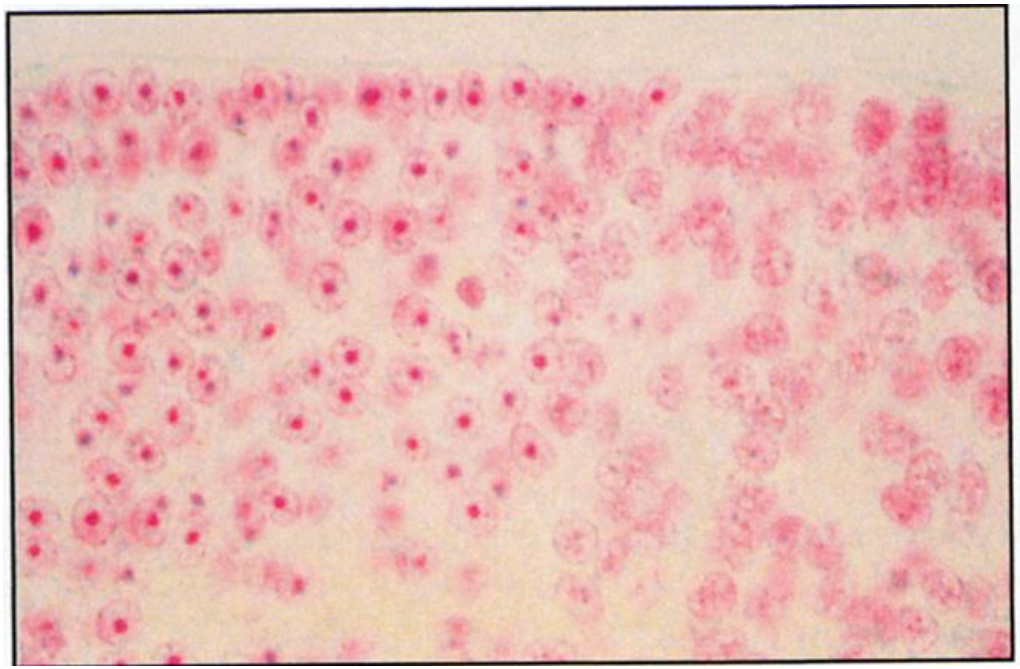

Dorsal
notocorda enxertada
dermomiótomo
tubo neural
esclerótomo
esclerótomo
notocorda
placa do assoalho
Ventral

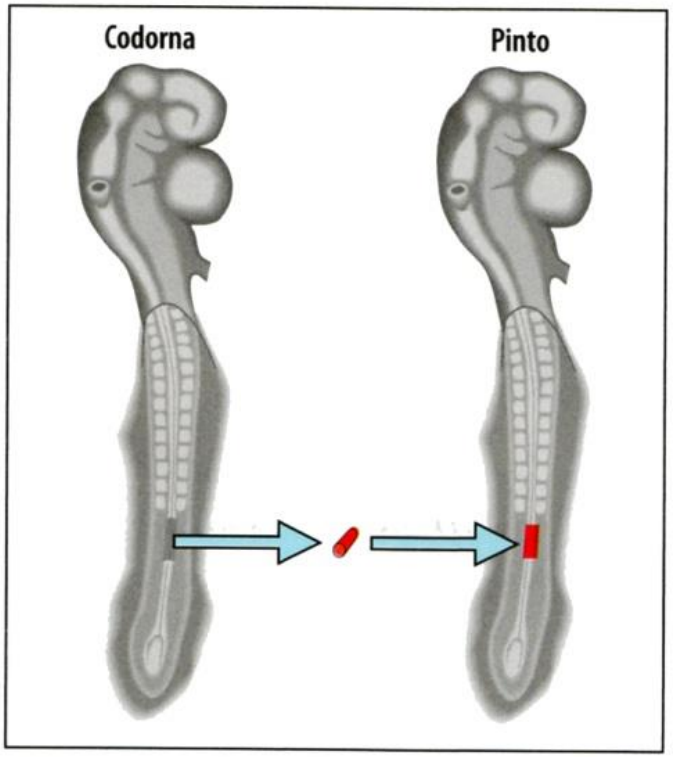

Neuróporo anterior
Crista neural
Tubo neural
Celoma intra-embrionário
Celoma extra-embrionário
Ectoderma
Somito
Intestino
Saco vitelino
Neuróporo posterior
Linha primitiva

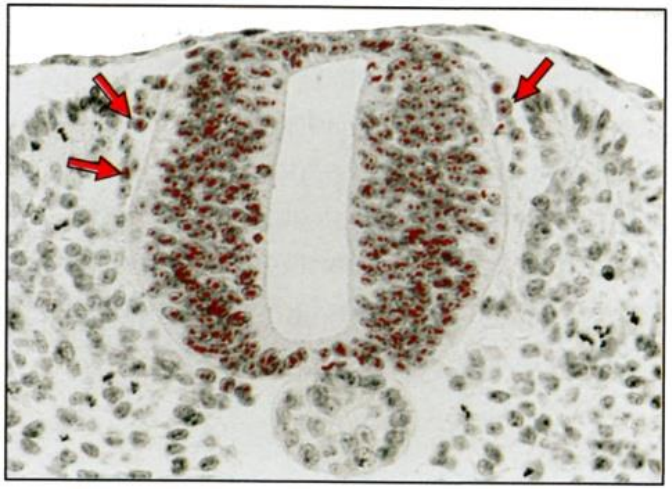

Epidermis
Hair
Nails
Sebaceous glands
Olfactory epithelium
Anterior pituitary
Mouth epithelium
Tooth enamel
Lens, cornea
Cheek epithelium
Surface ectoderm (epidermis)
Peripheral nervous system
Schwann cells
Neuroglial cells
Adrenal medulla
Sympathetic nervous system
Melanocytes
Parasym-pathetic nervous system
Facial cartilage
Dentine of teeth
Ectoderm
Neural crest
Brain
Neural pituitary
Spinal cord
Motor neurons
Retina
Neural tube


ectoderme
gângilo da raiz dorsal
célula pigmentar
somito
tubo neural
1
2
noto-corda
Anterior
aorta
ectoderme
esclerótomo
dermomiótomo
gânglio simpático
células adreno-medulares
destino de células de crista neural

Como sabemos?????

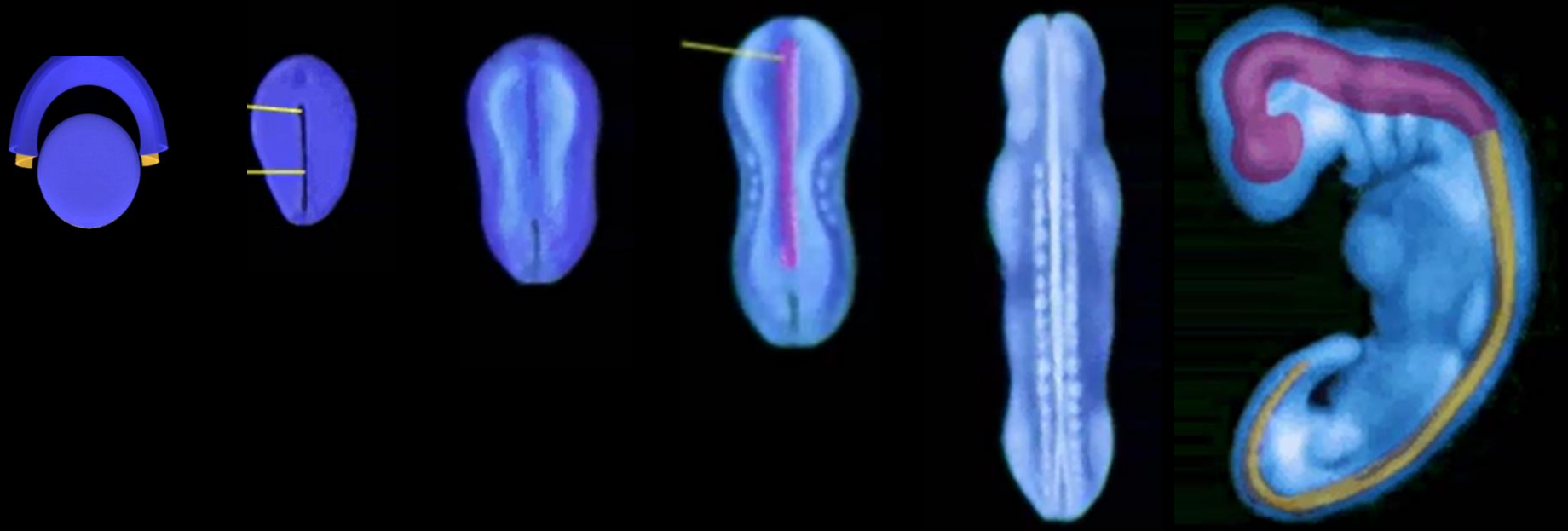






Aspectos anatômicos do desenvolvimento neural inicial

Epiblasto | Ectoderma | Neurectoderma | Progenitores neurais

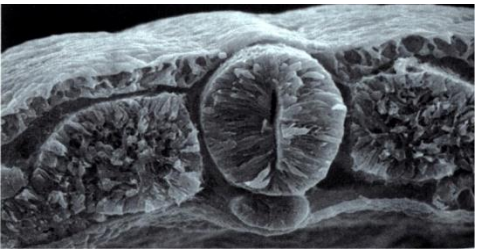


1. Aumento do NÙMERO CELULAR
    1. Proliferação celular
    2. Pressão intraventricular

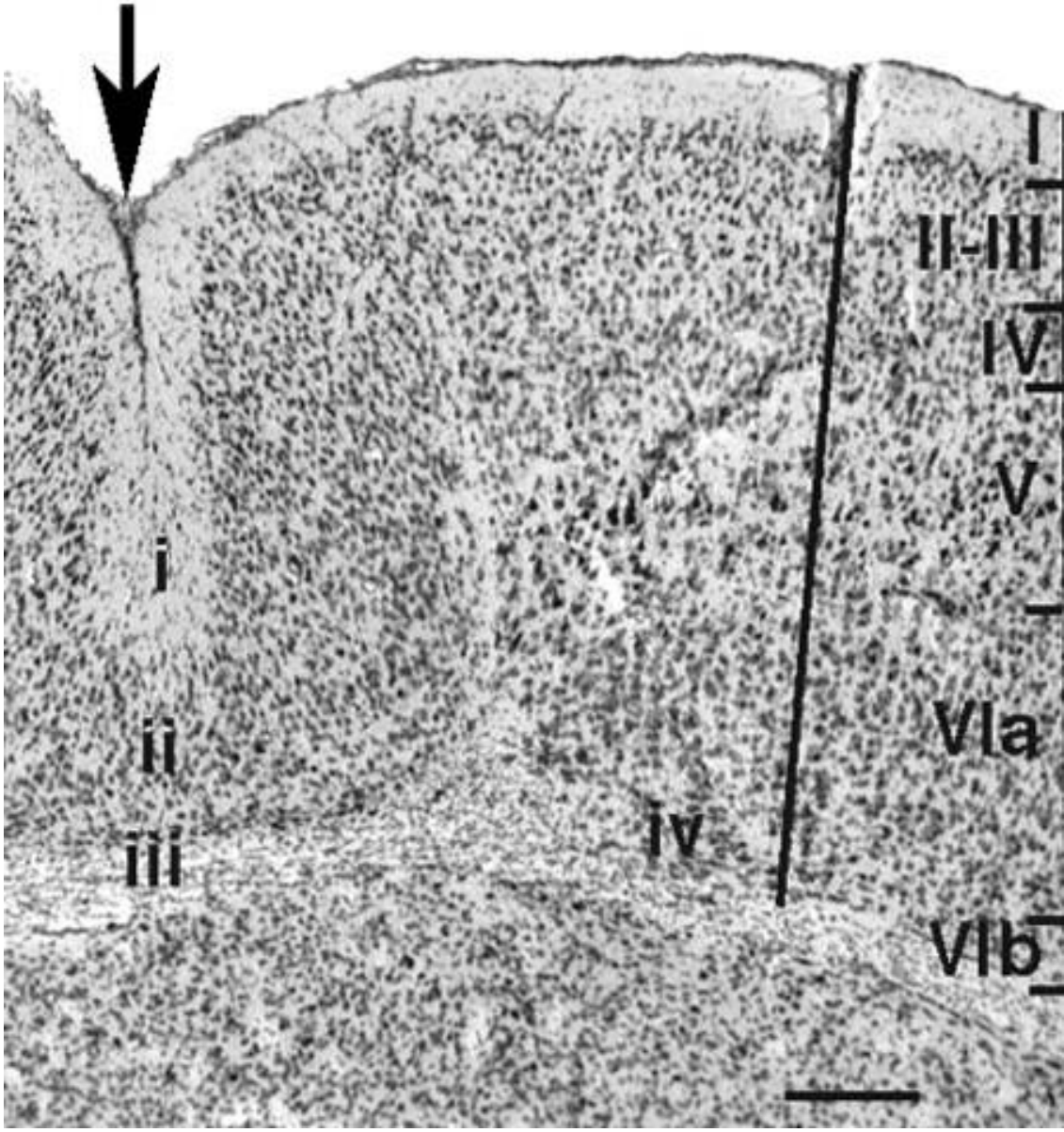
2. Diferenciação DORSO-VENTRAL

3. Emissão de neuritos e mielinização

4. Dobramento do tubo neural

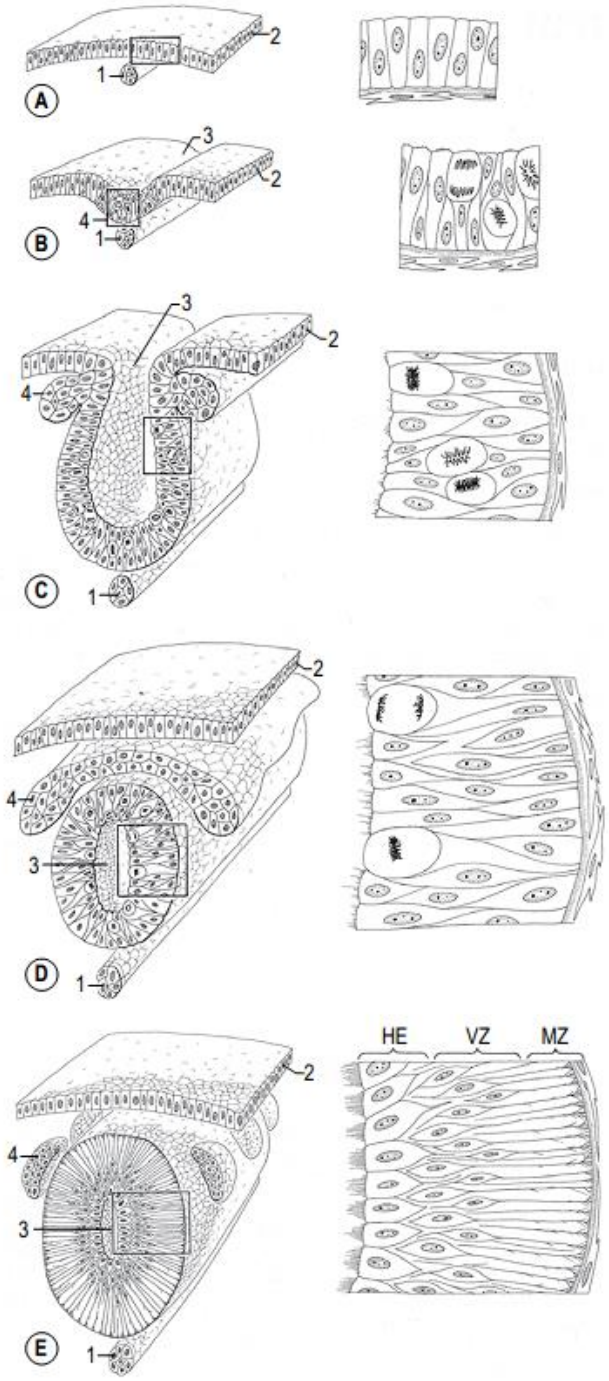


MONOCAMADA



www.nevernet.org

VÀRIAS CAMADAS



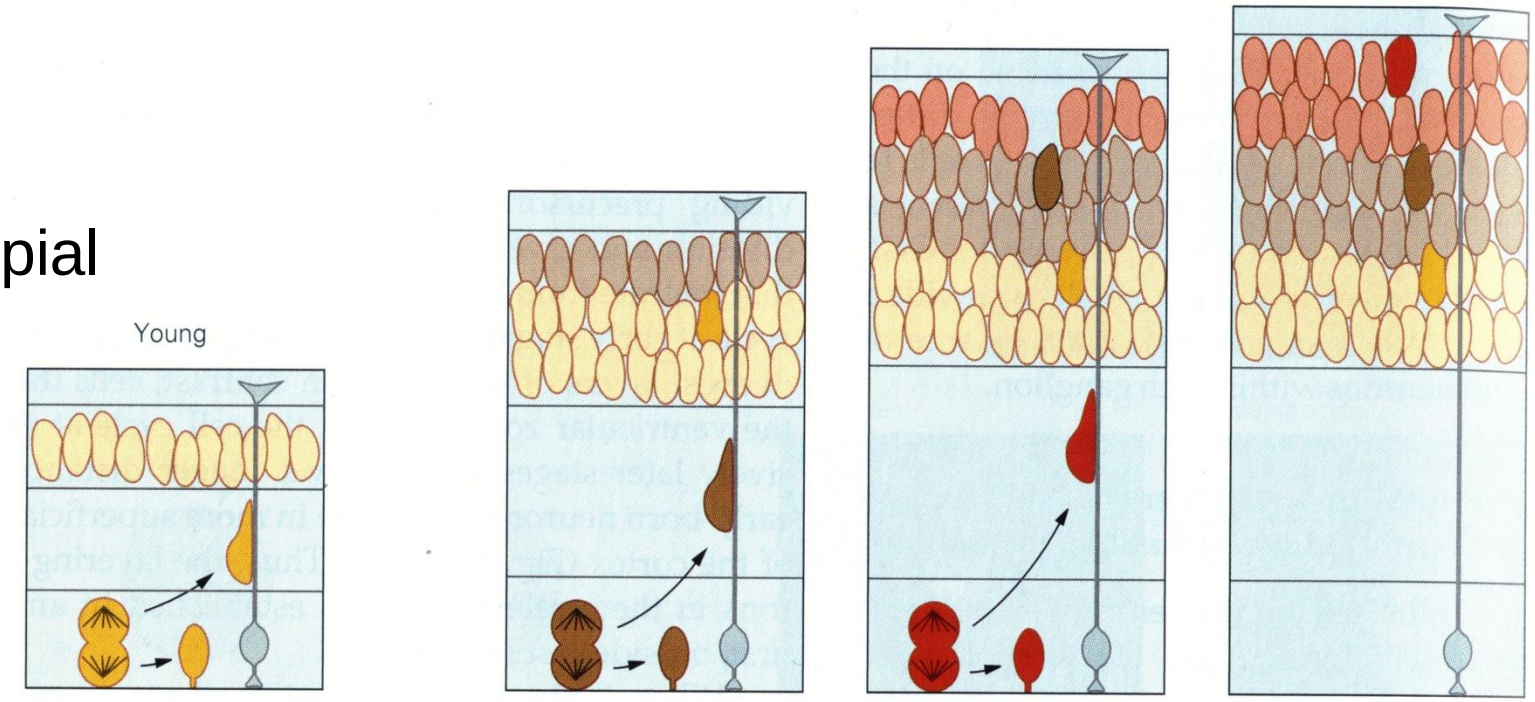
As células do tubo neural proliferam na região CENTRAL (próximas ao canal do tubo neural) >>CANAL VENTRICULAR

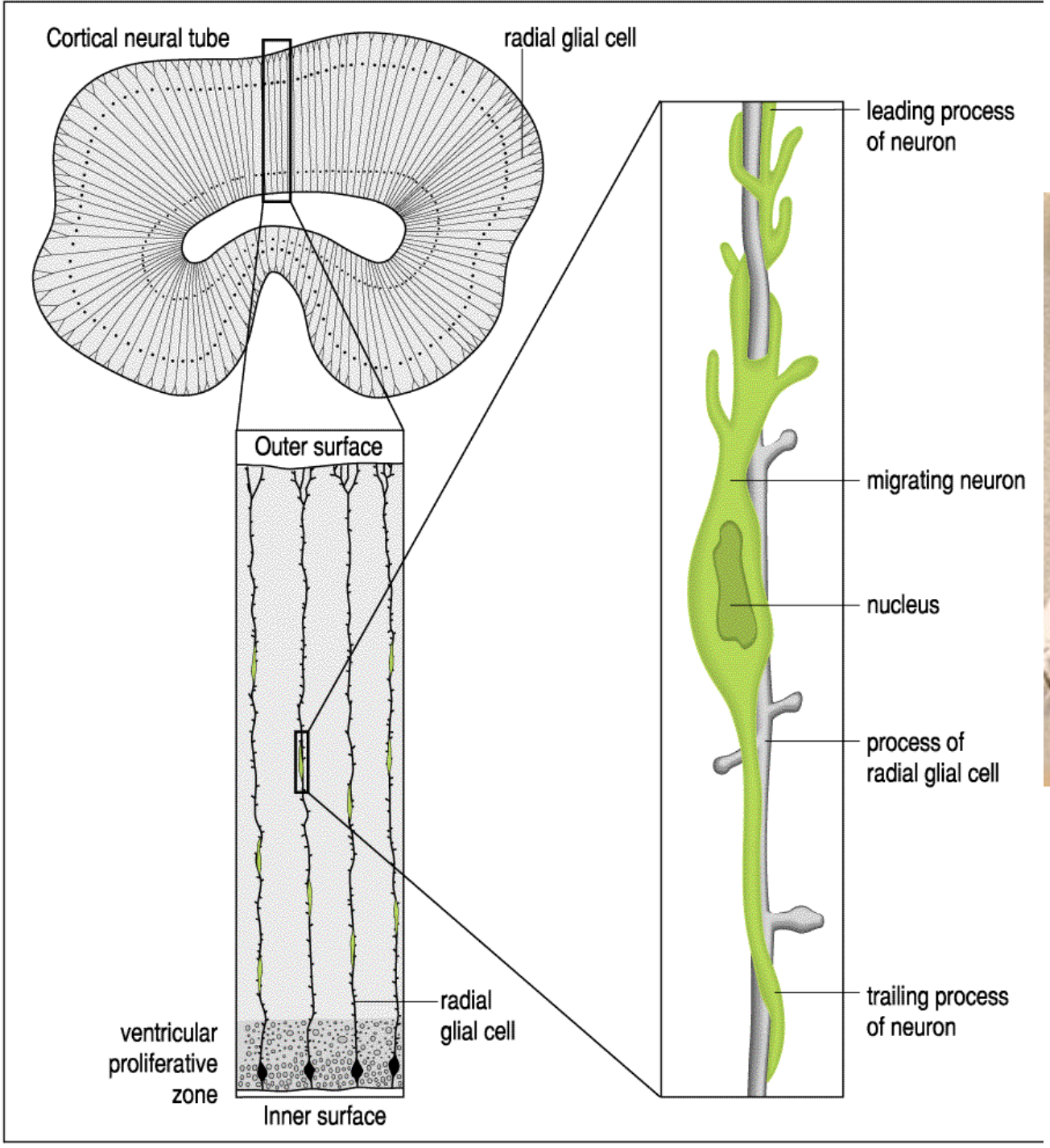
Os precursores de neurônios migram do ventrículo em direnção a superfície.

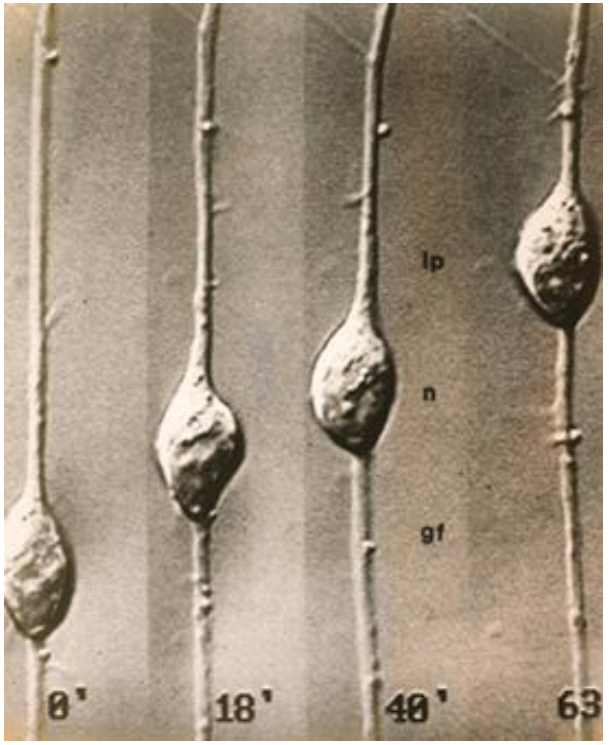
OU SEJA, os neurônios mais novos são mais superficiais

Superfície pial

Ventrículo

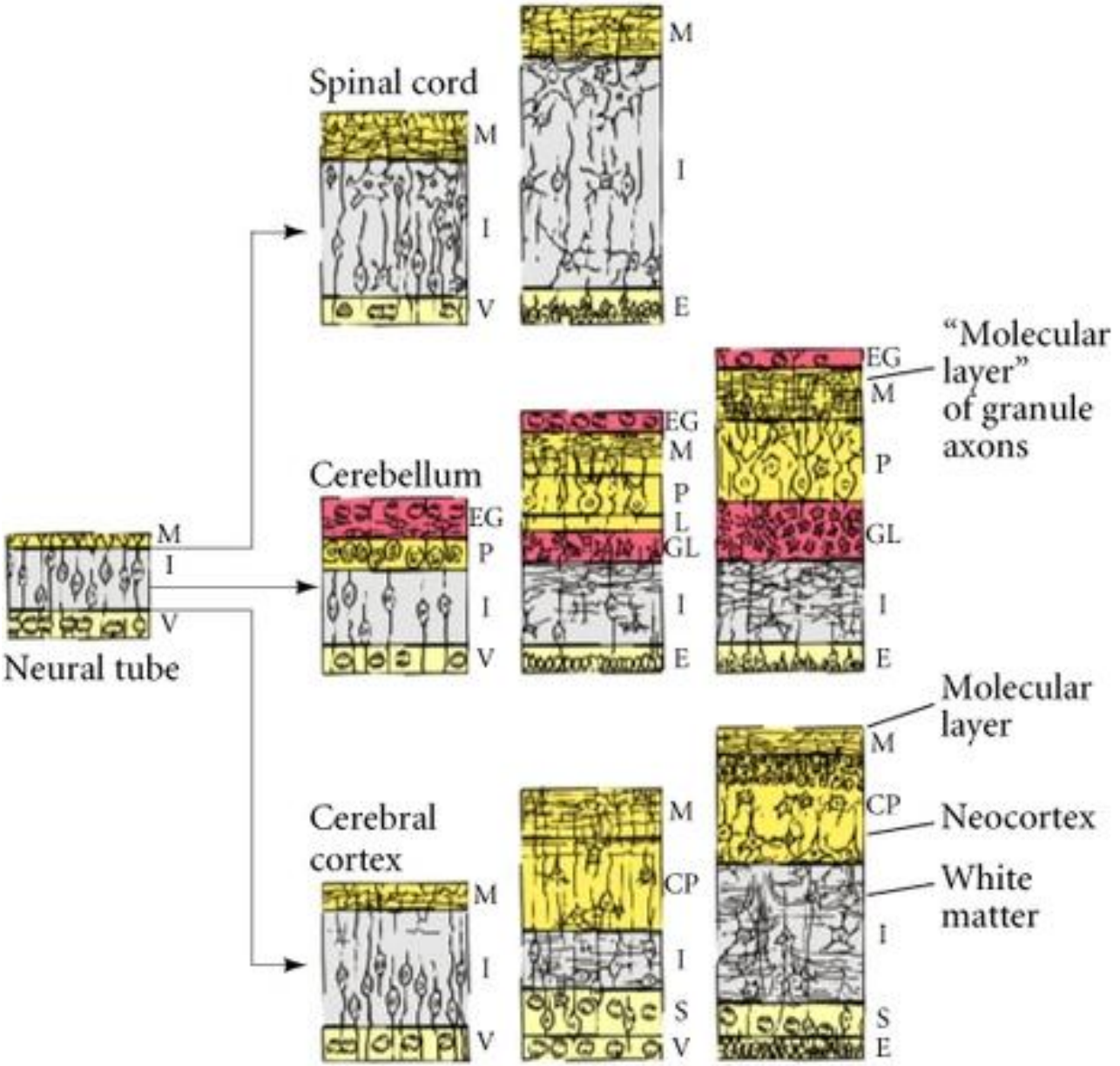



Cortical neural tube
radial glial cell
Outer surface
leading process of neuron
migrating neuron
nucleus
process of radial glial cell
trailing process of neuron
radial glial cell
ventricular proliferative zone
Inner surface


lp
n
gf
0'
18'
40'
63

Hatten et al.

Cada estrutura do SNC têm número diferente de camadas



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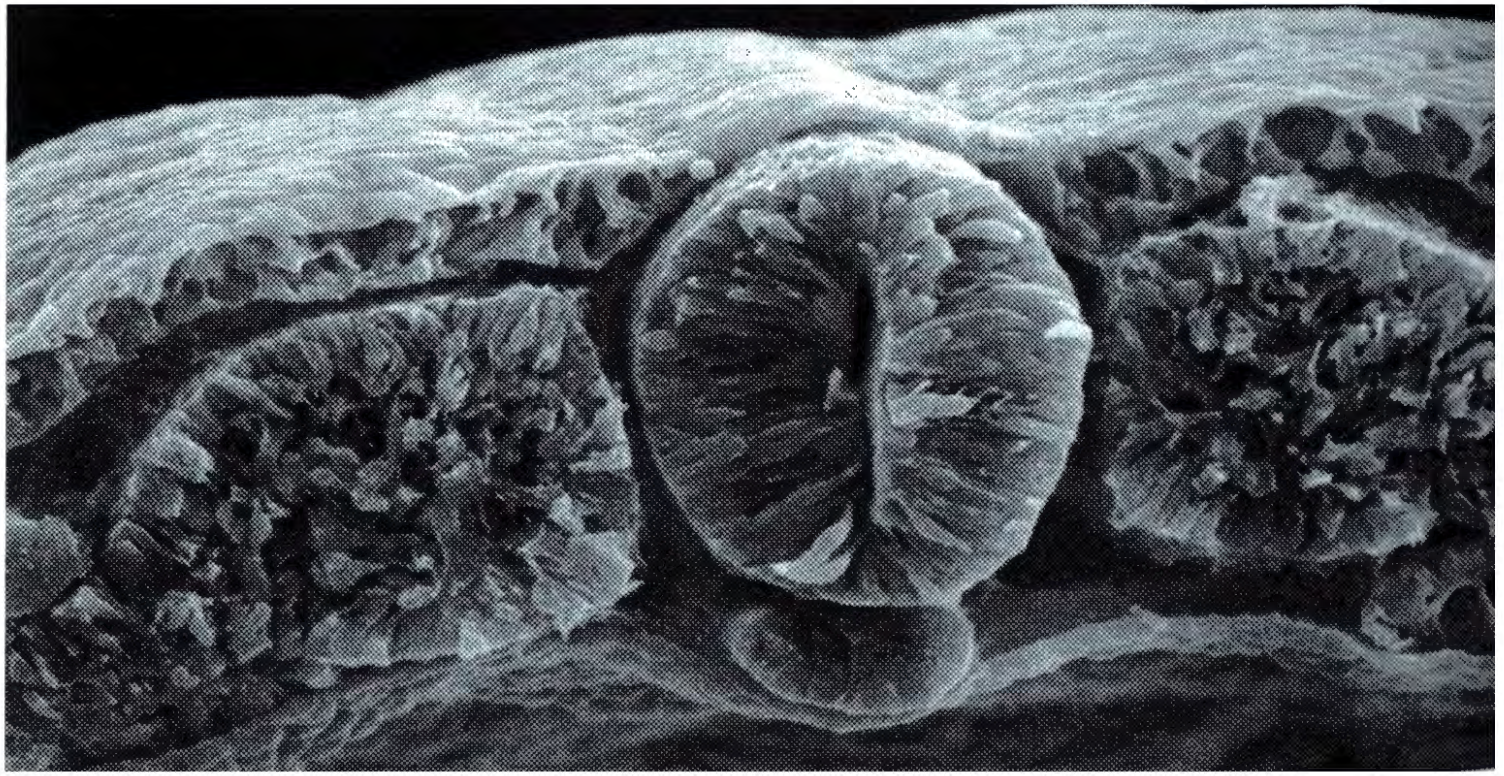
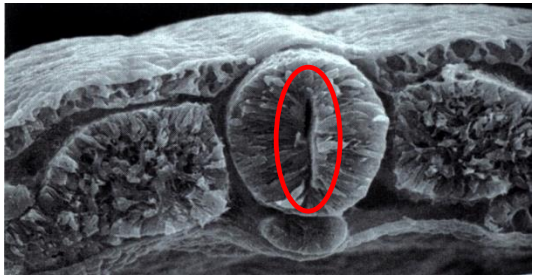
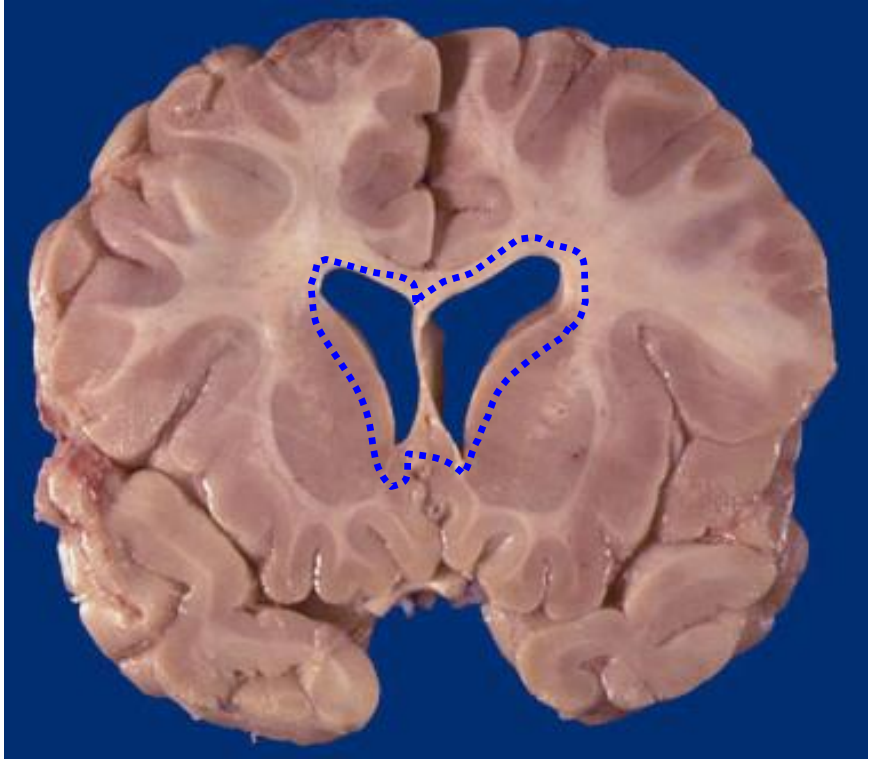
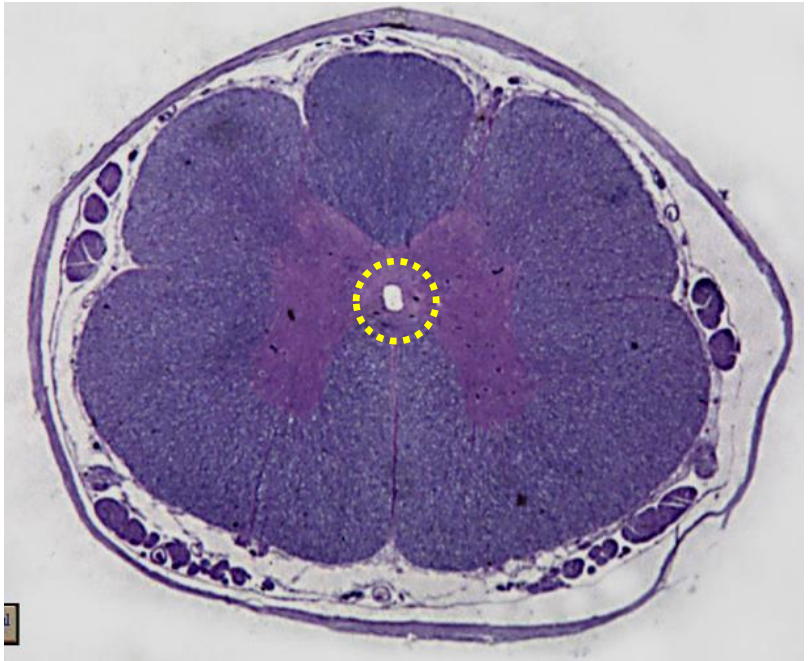
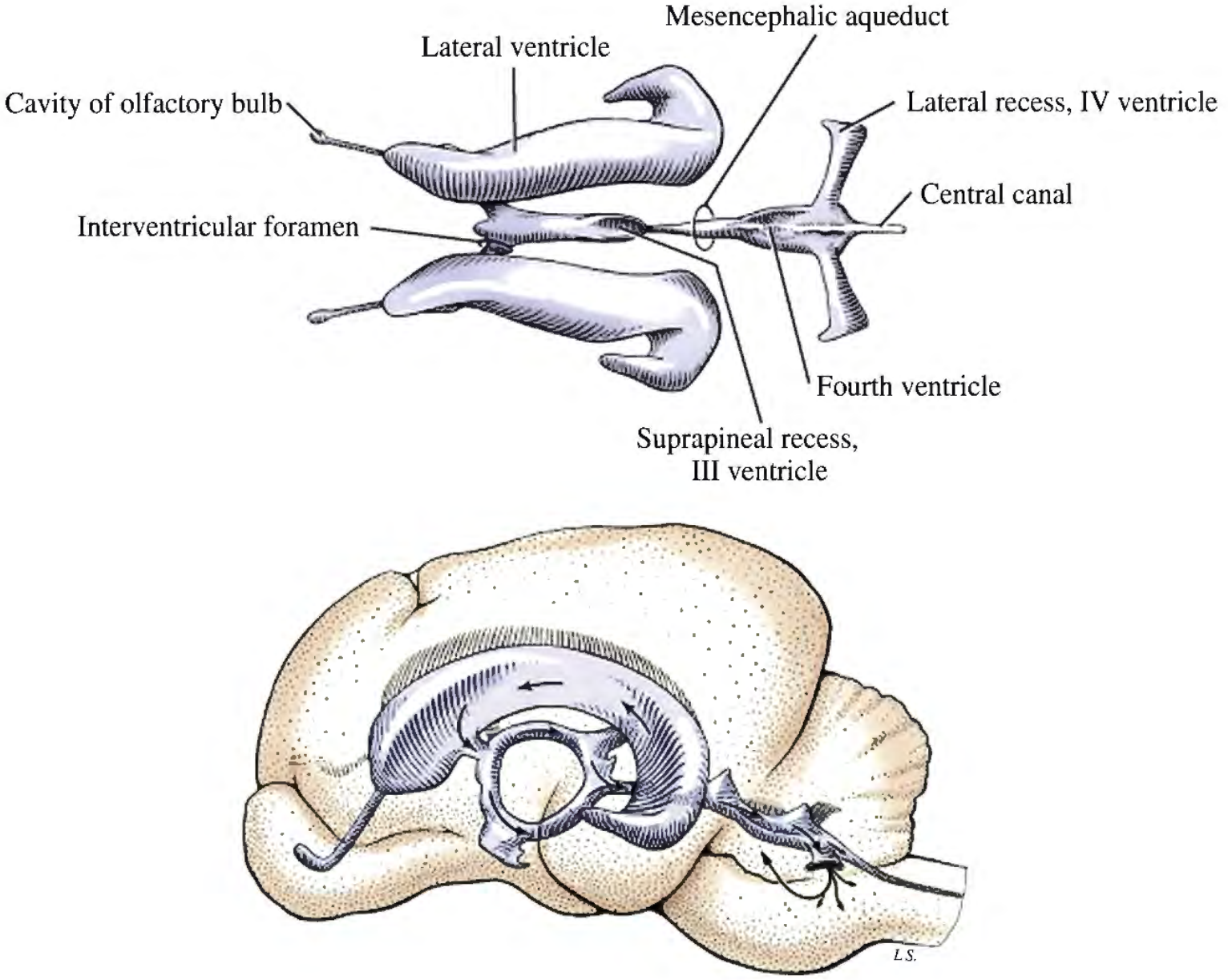


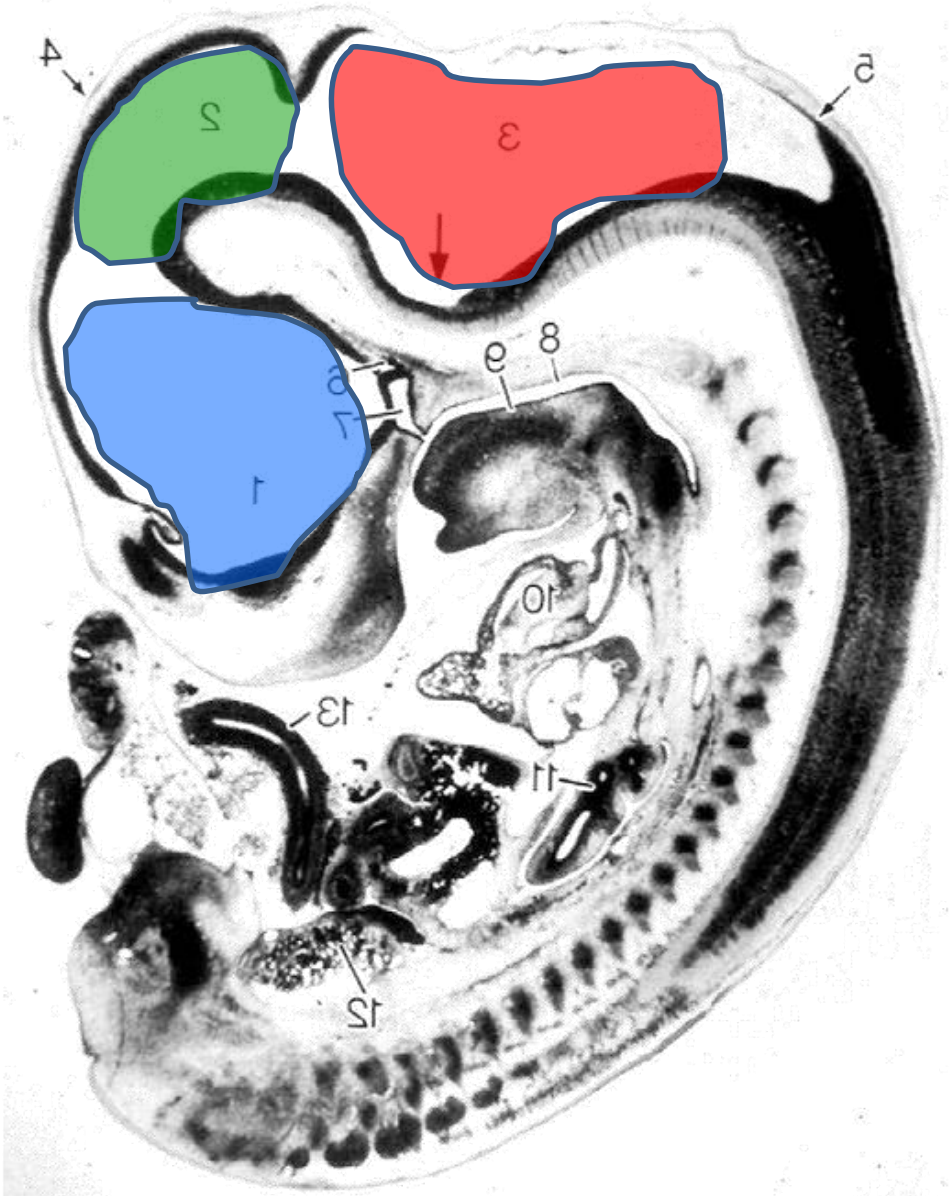







Mesencephalic aqueduct
Lateral ventricle
Cavity of olfactory bulb
Lateral recess, IV ventricle
Central canal
Interventricular foramen
Fourth ventricle
Suprapineal recess,
III ventricle
L.S.

VETRÍCULOS: visão Lateral



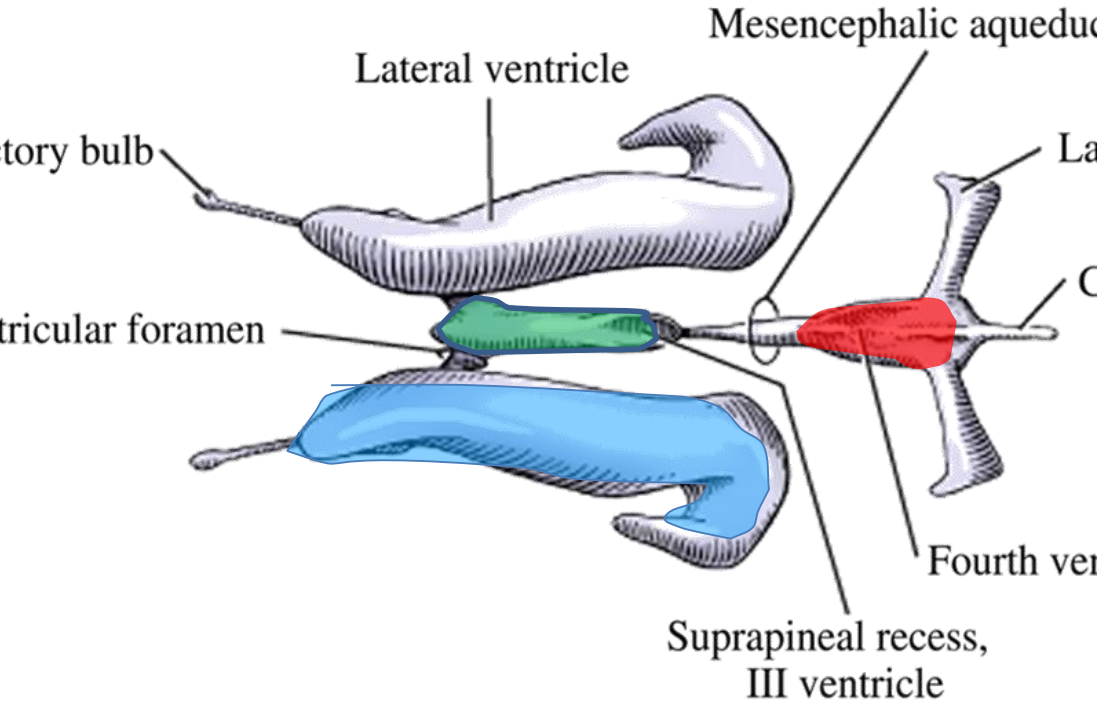
Os ventrículos são nomeados seguindo o eixo cefalo-caudal:

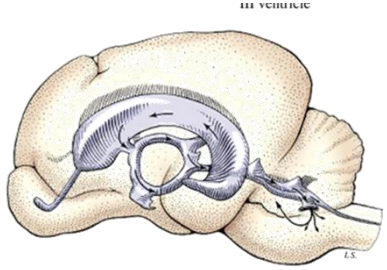
Laterais: Hemisférios cerebrais

III Ventrículo: Talámo e hipotálamo

IV ventrículo: Tronco encefálico

VETRÍCULOS: visão dorsal





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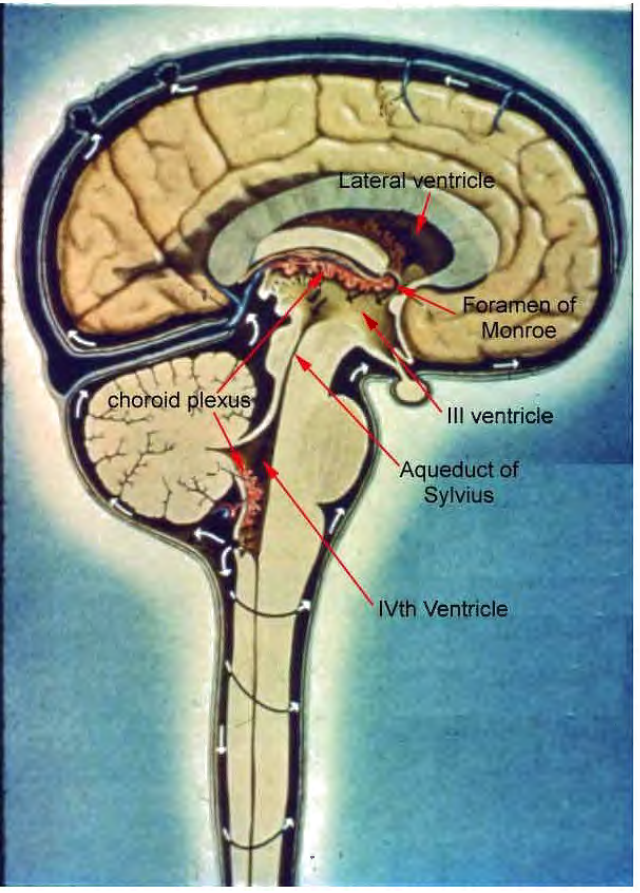
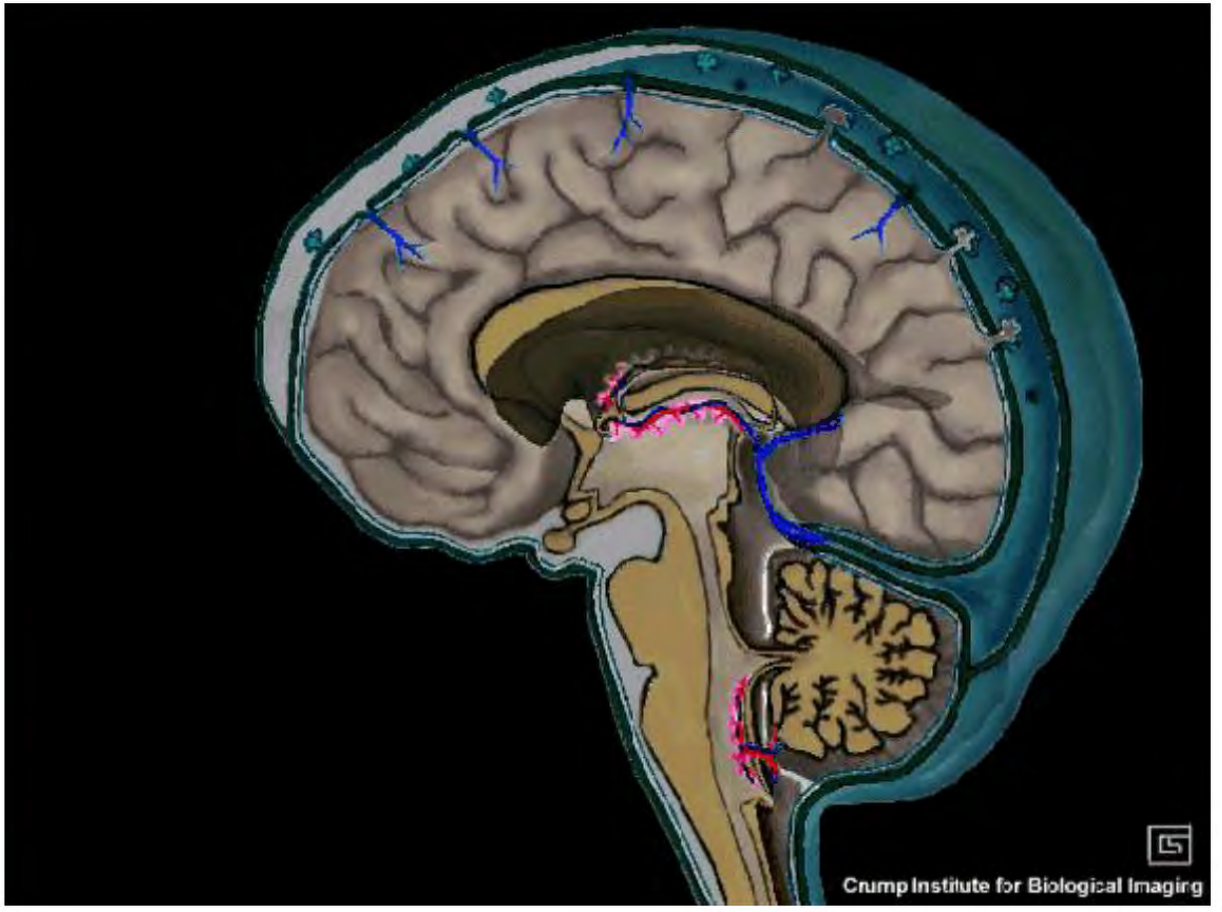
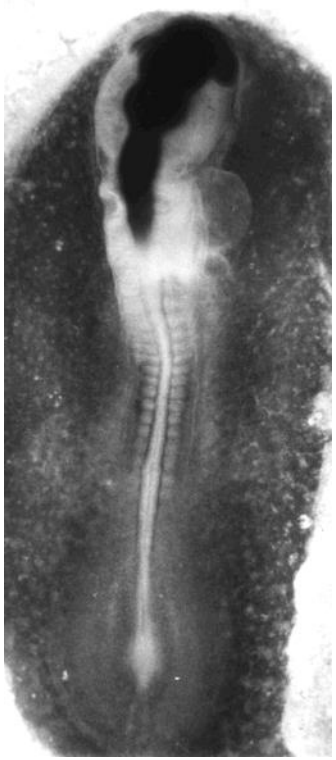
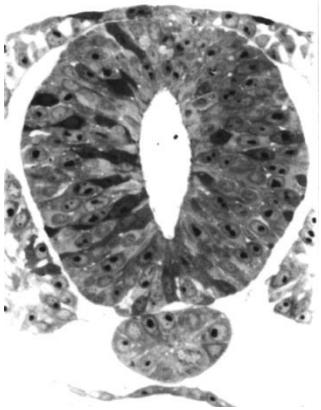
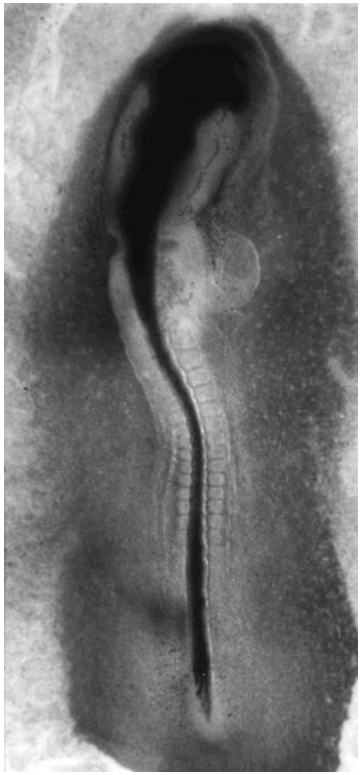

Lateral ventricle
Foramen of Monroe
choroid plexus
III ventricle
Aqueduct of Sylvius
IVth Ventricle


Crump Institute for Biological Imaging

A pressão do líquido cefalorraquidiano contribui para o crescimento da região anterior do tubo neural







1. Aumento do NÙMERO CELULAR
    1. Proliferação celular
    2. Pressão intraventricular

2. DIFERENCIAÇÂO DORSO-VENTRAL
    1. Vias EFERENTES (saída) ventrais
    2. Vias AFERENTES (entrada) dorsais

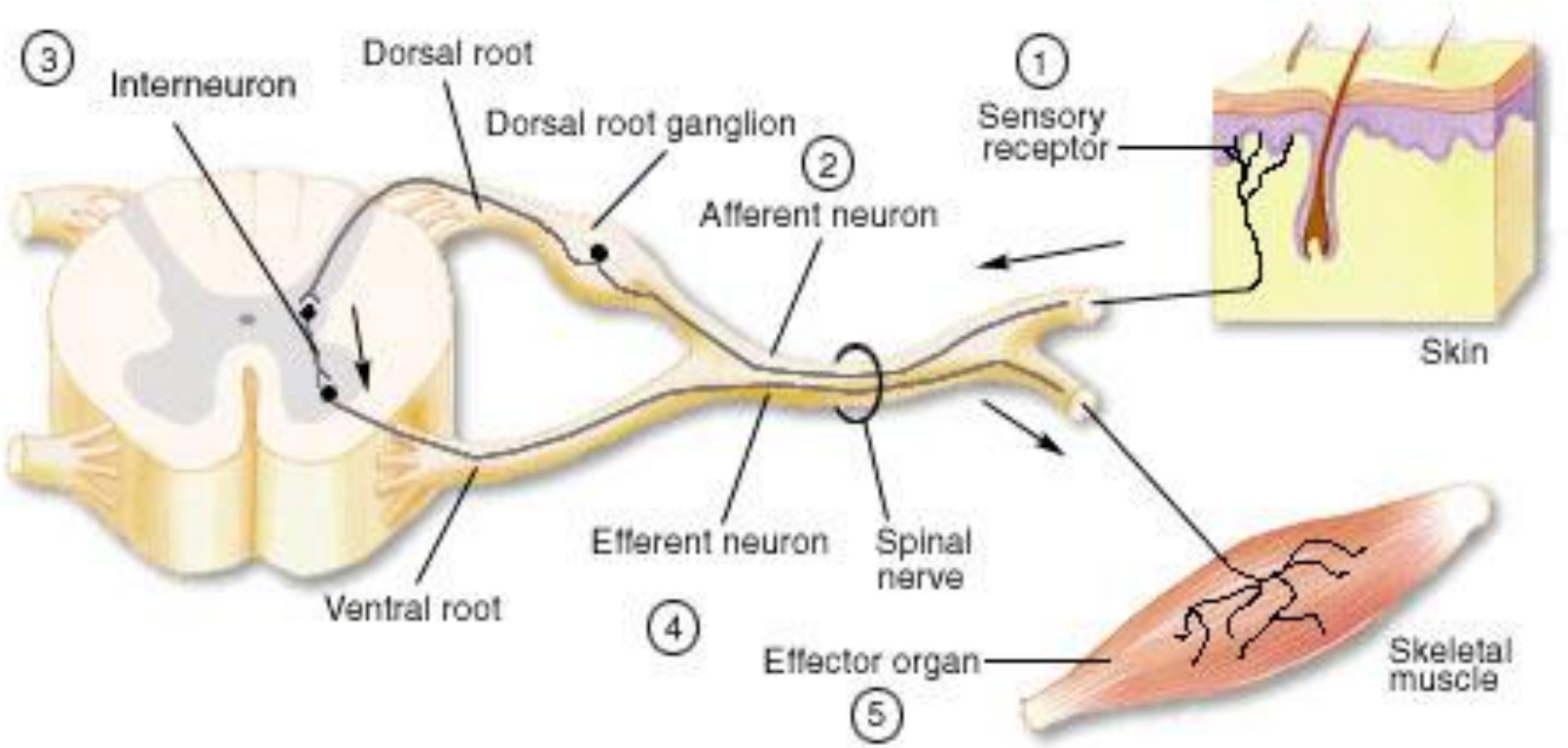
3. Emissão de neuritos e mielinização

4. Dobramento do tubo neural

O sistema nervoso central

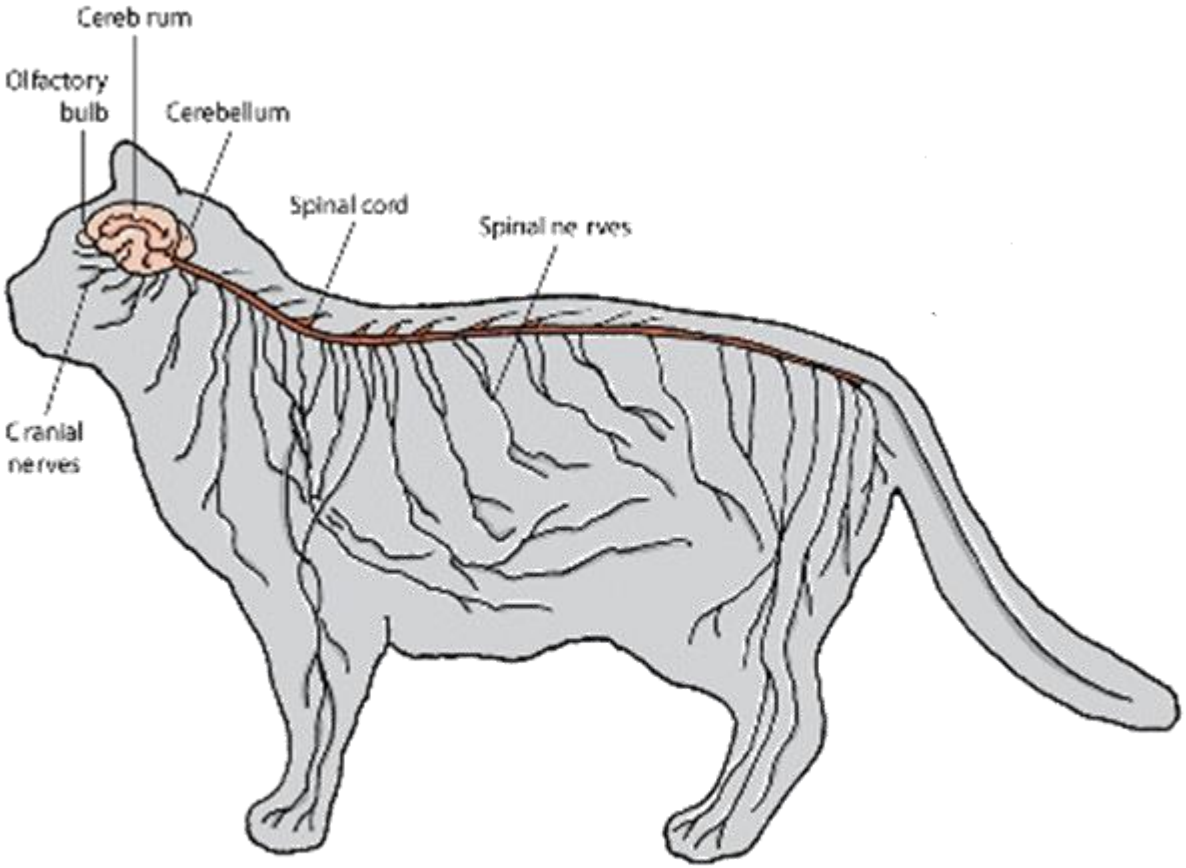
ACOLHE informações SENSORIAIS > AFERENTE

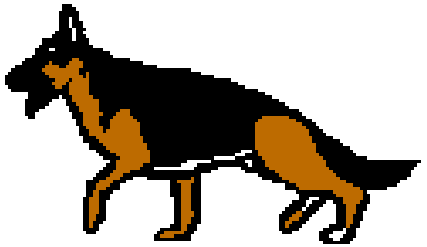
EMITE informações MOTORAS > EFERENTE



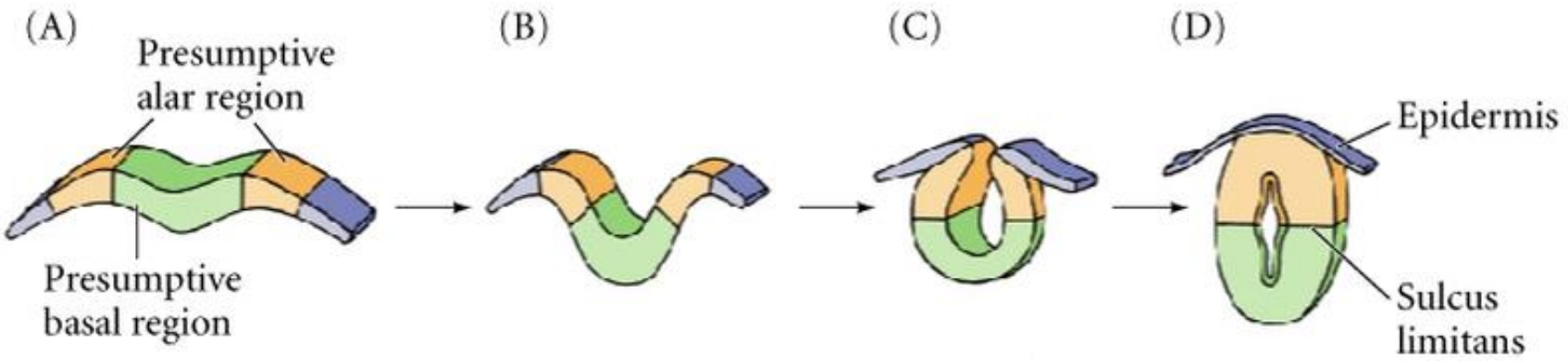
ACOLHE informações SENSORIAIS > AFERENTE--dorsal

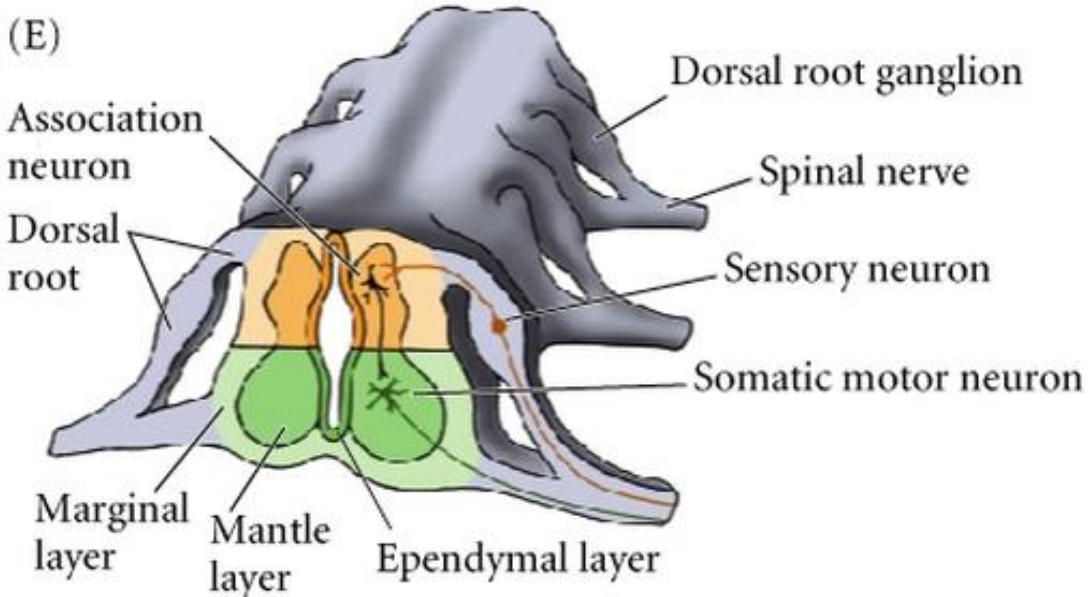
EMITE informações MOTORAS > EFERENTE- ventral

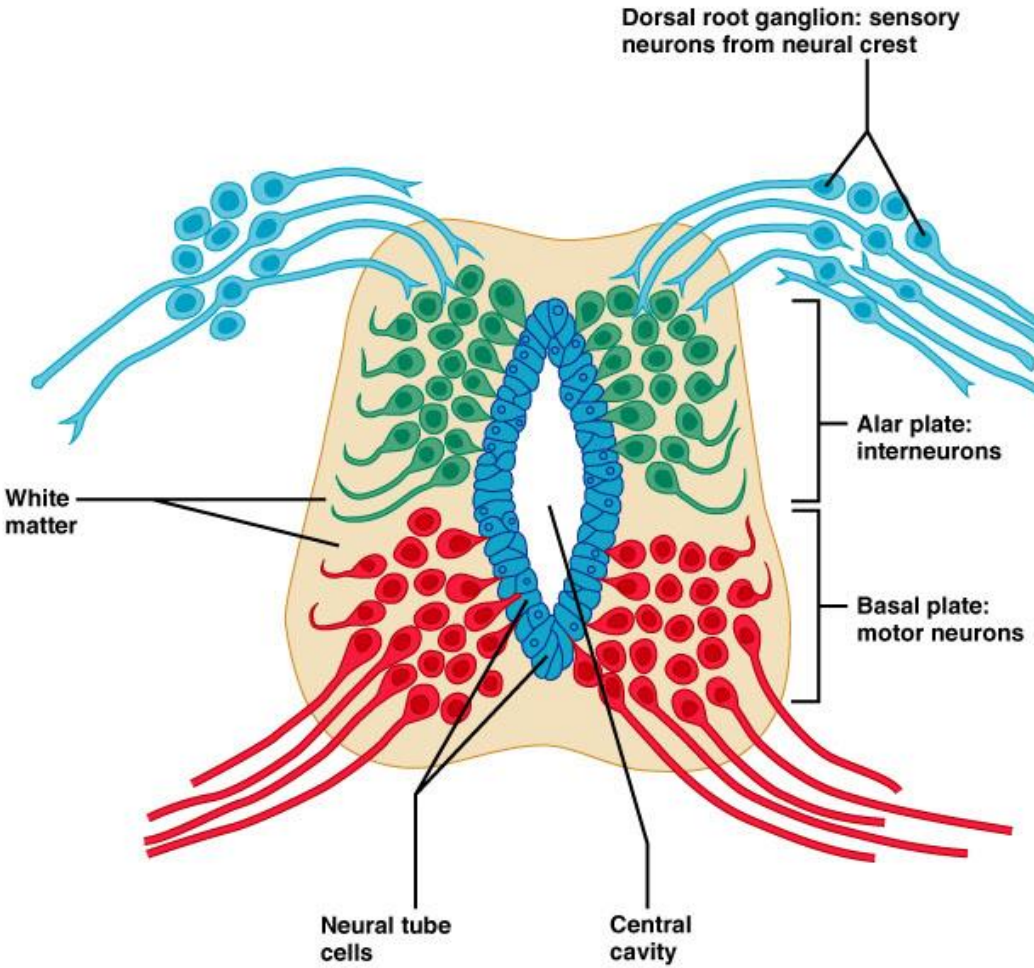




Após o fechamento do Tubo neural, ele se diferencia dorso-ventralmente em: SENSORIAL e MOTOR







- Placa do Teto
- Placa Alar (dorsal e sensitivo-AFERENTE)
- Placa Basal (ventral e motor EFERENTE)
- Placa do Assoalho

1. Aumento do NÙMERO CELULAR
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    1. Vias AFERENTES (entrada) dorsais - sensorial
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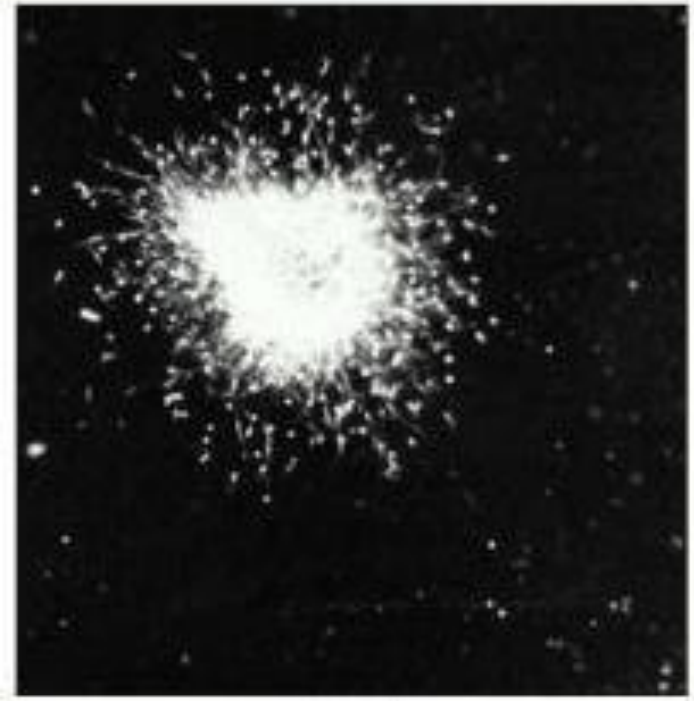
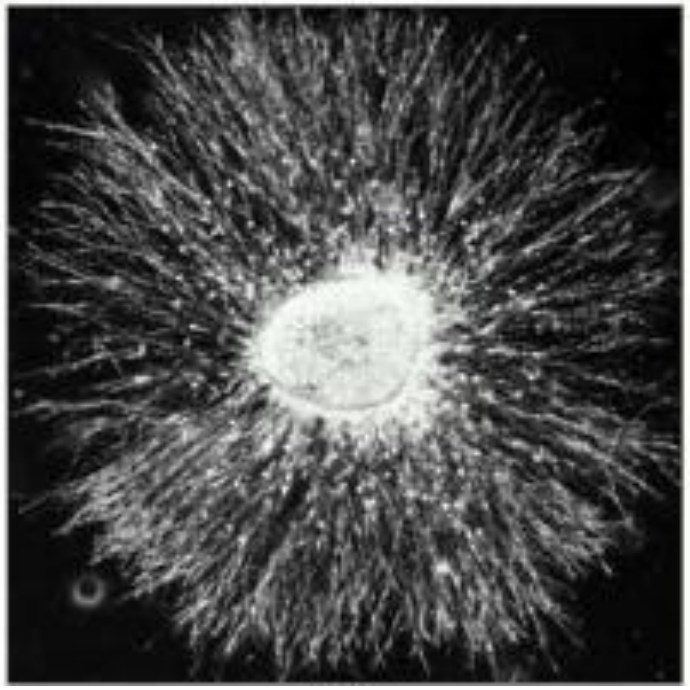
Emissão de Neuritos
Atração pela região - alvo
Interação com o substrato
CONTATO E SINAPSE

FATORES NEUROTRÓFICOS (proteínas secretadas) estimulam a emissão de neuritos

Cultura de neurônios



COM ADIÇÂO DE Fator Neurotófico

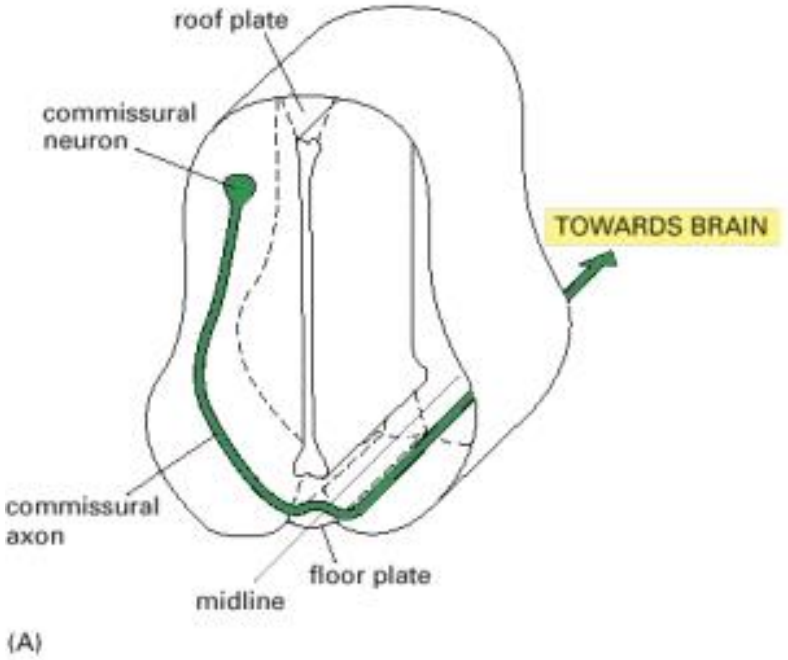


Naomi Kleitman Molecular Biology of the Cell, Alberts 4ª Ed.

Day 1

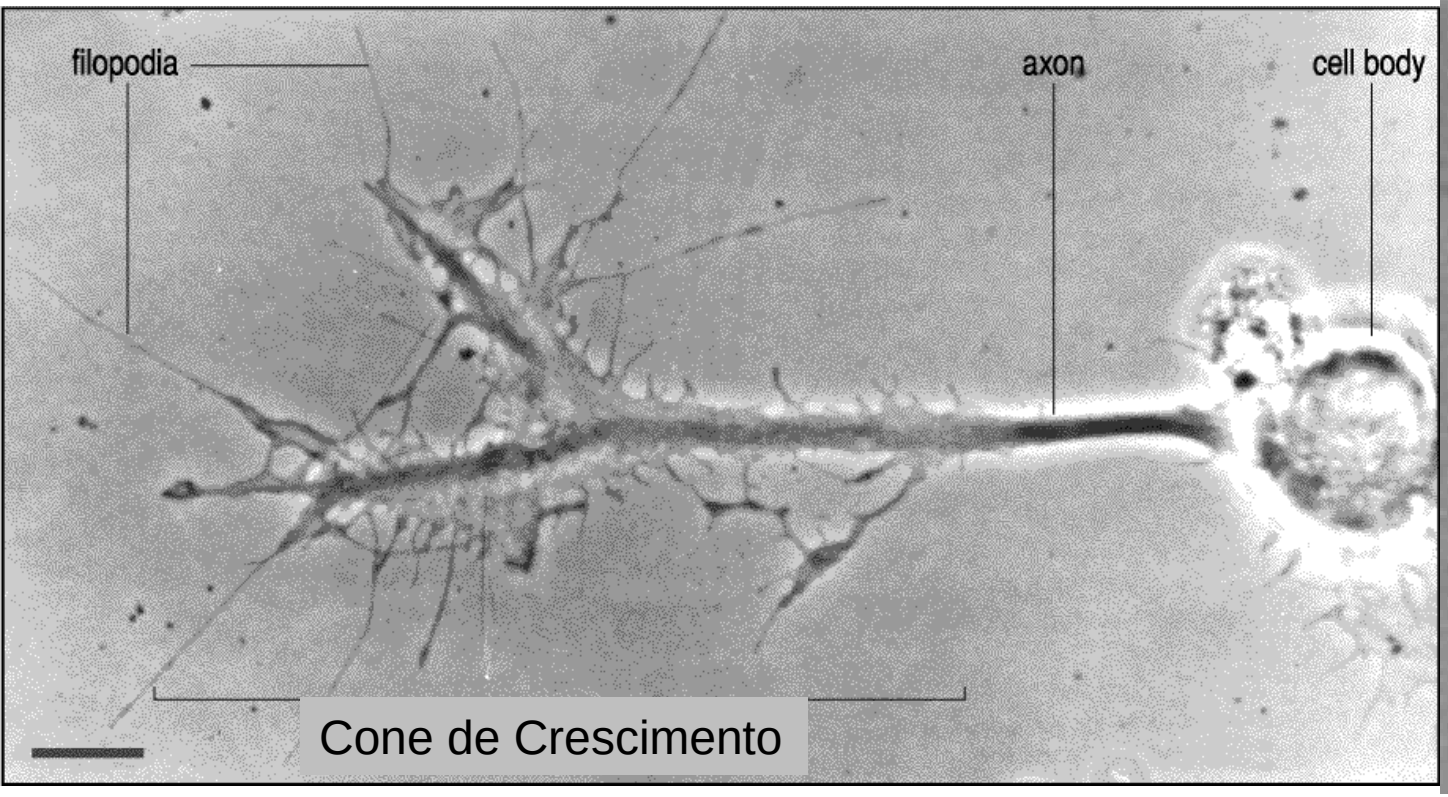
4-24 hours
after plating

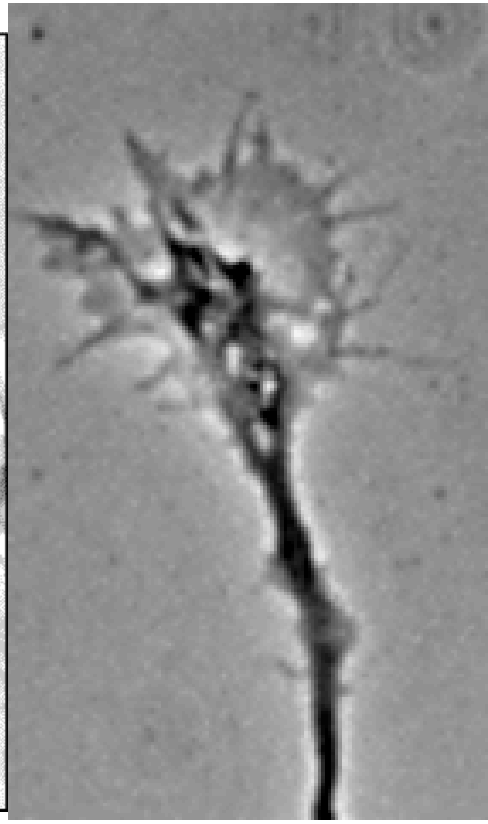
O caminho adotado pelo neurito depende da sinalização do microambiente



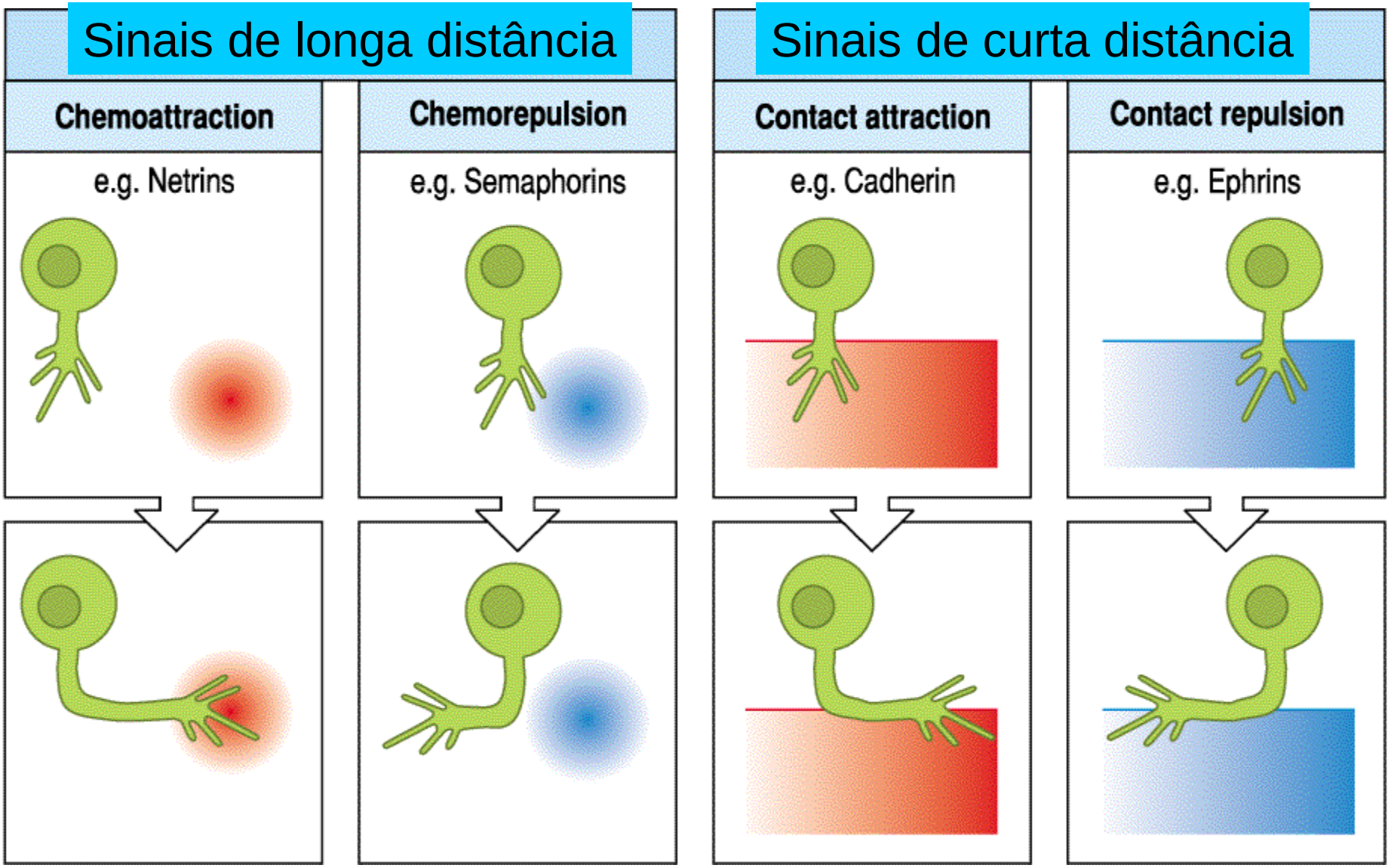
Molecular Biology of the Cell, Alberts 4ª Ed.

O CONE DE CRESCIMENTO é o “sensor” do neurito que gerencia seu crescimento de acordo com os sinais existentes no microambiente externo





Direcionamento do crescimento axonal a partir do microambiente

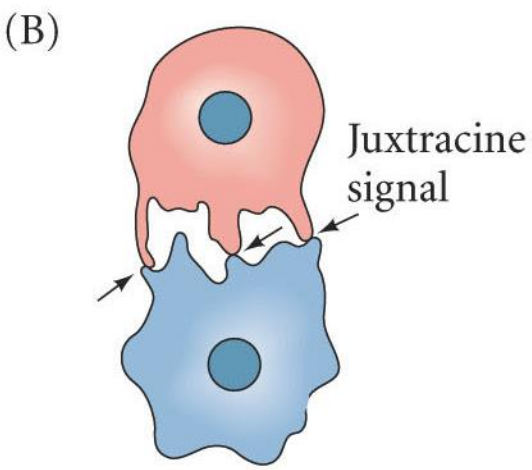


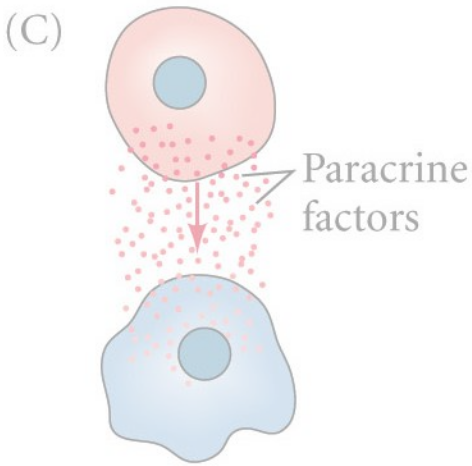
Existem várias modalidades de comunicação intercelular:

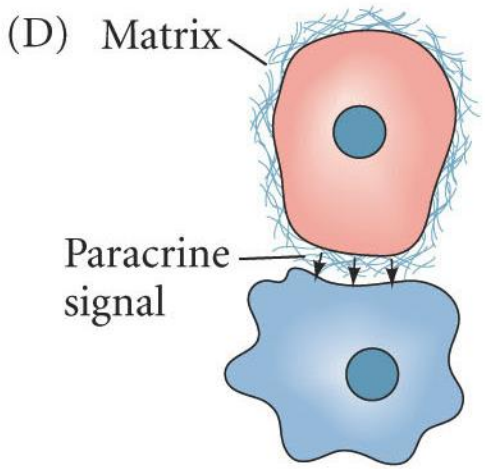
Por contato direto

Por difusão de proteínas extracelulares

Por matriz extracelular







Existem várias modalidades de comunicação intercelular:

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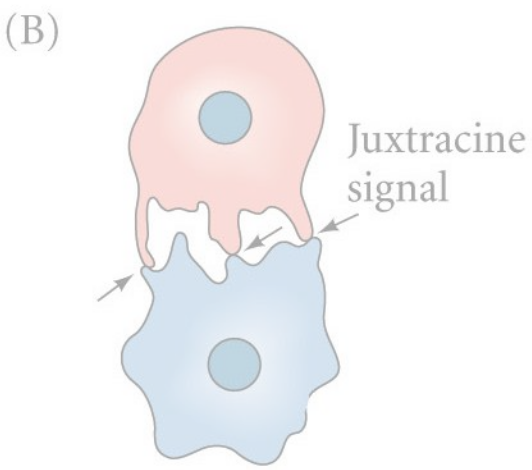
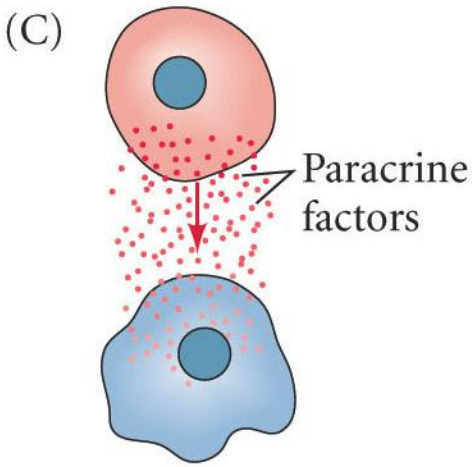
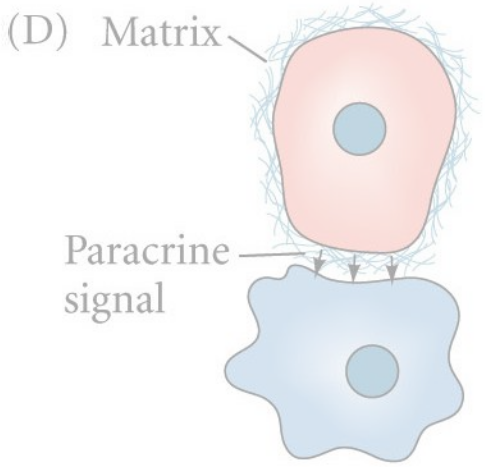
Por difusão de proteínas extracelulares

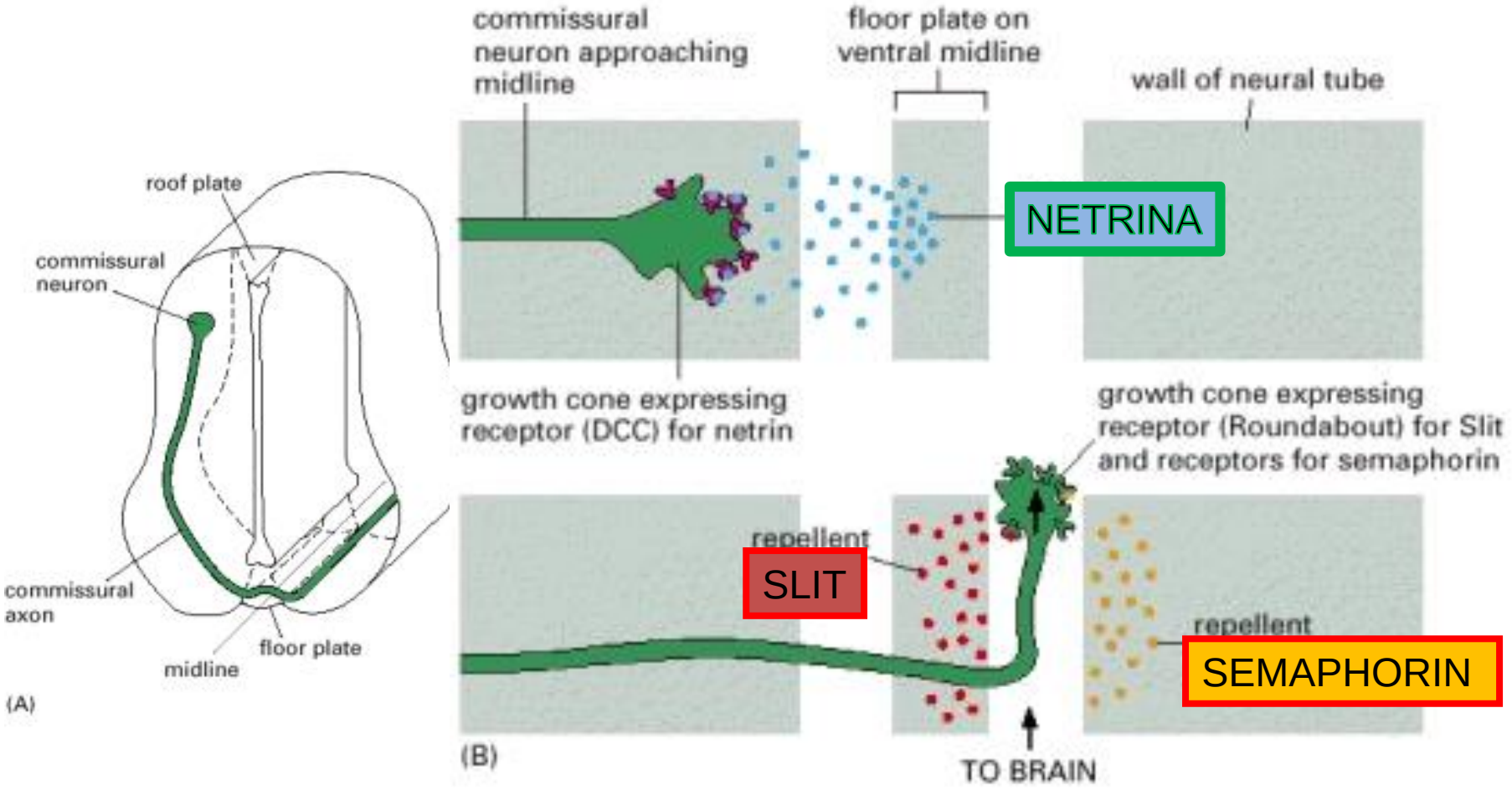
Por matriz extracelular







O somatório dos sinais irá guiar a direção do neurito



Molecular Biology of the Cell, Alberts 4ª Ed.

O caminho adotado pelo neurito depende da sinalização do microambiente

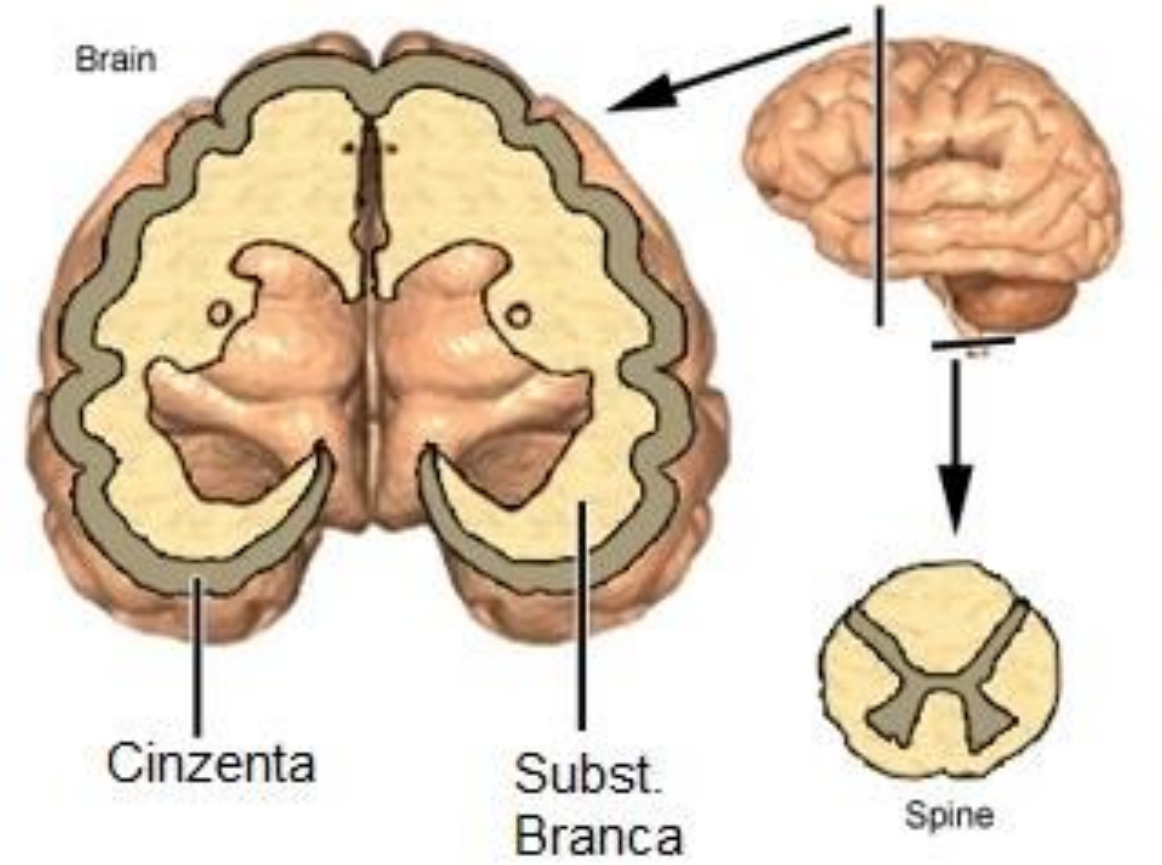
1. Depende dos SINAIS EXTRACELULARES

2. Depende dos RECEPTORES/Proteínas de membrana expressos pelo cone de crescimento. Cada cone de crescimento é provido de uma coleção diferente determinado durante a diferenciação

A disposição de Subs Branca e Cinzenta são diferentes no

Encéfalo : Branca Interna>> extensas conexões internas

e na Medula >>> mielinização na camada externa



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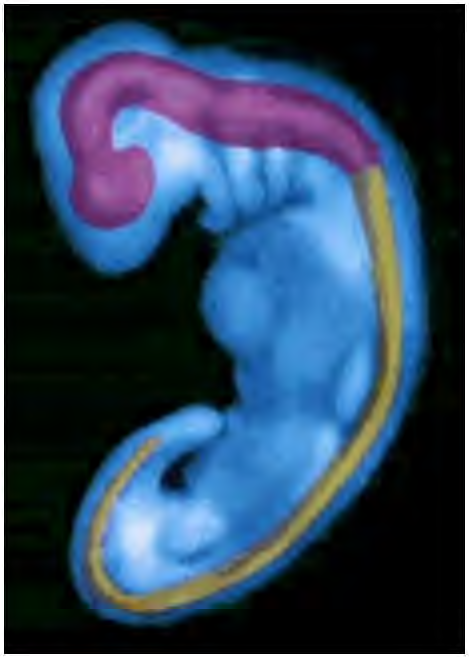
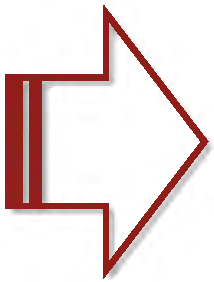
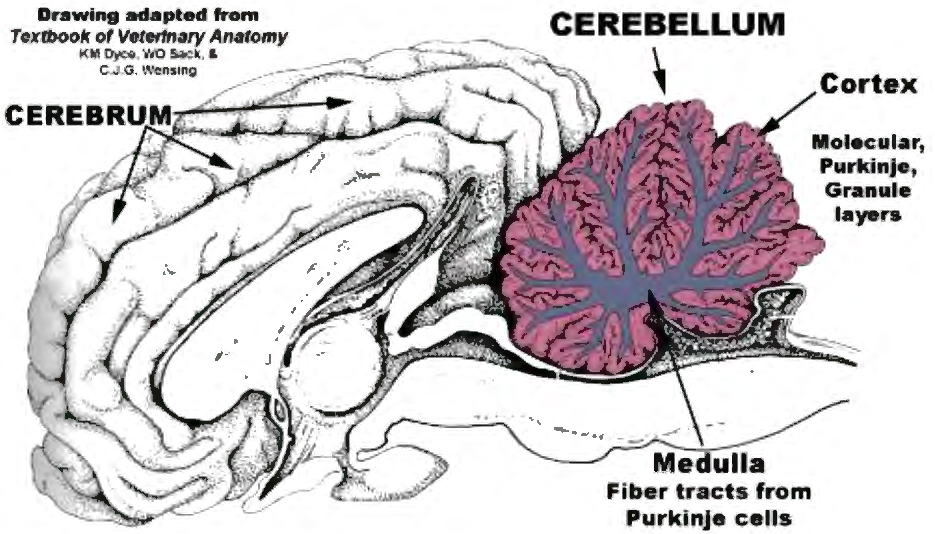
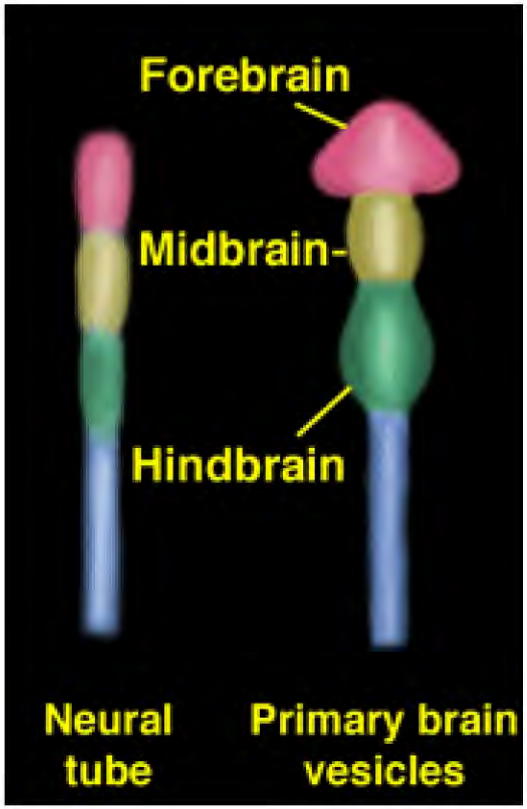
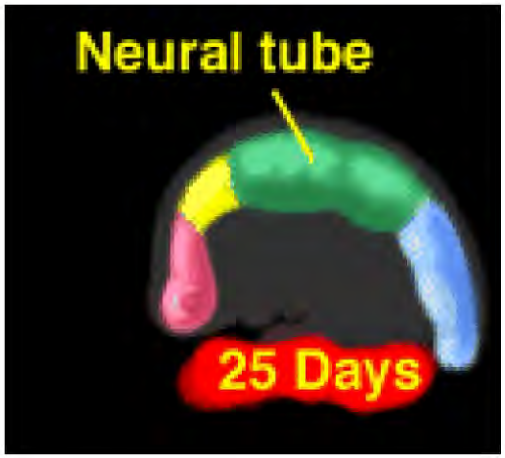
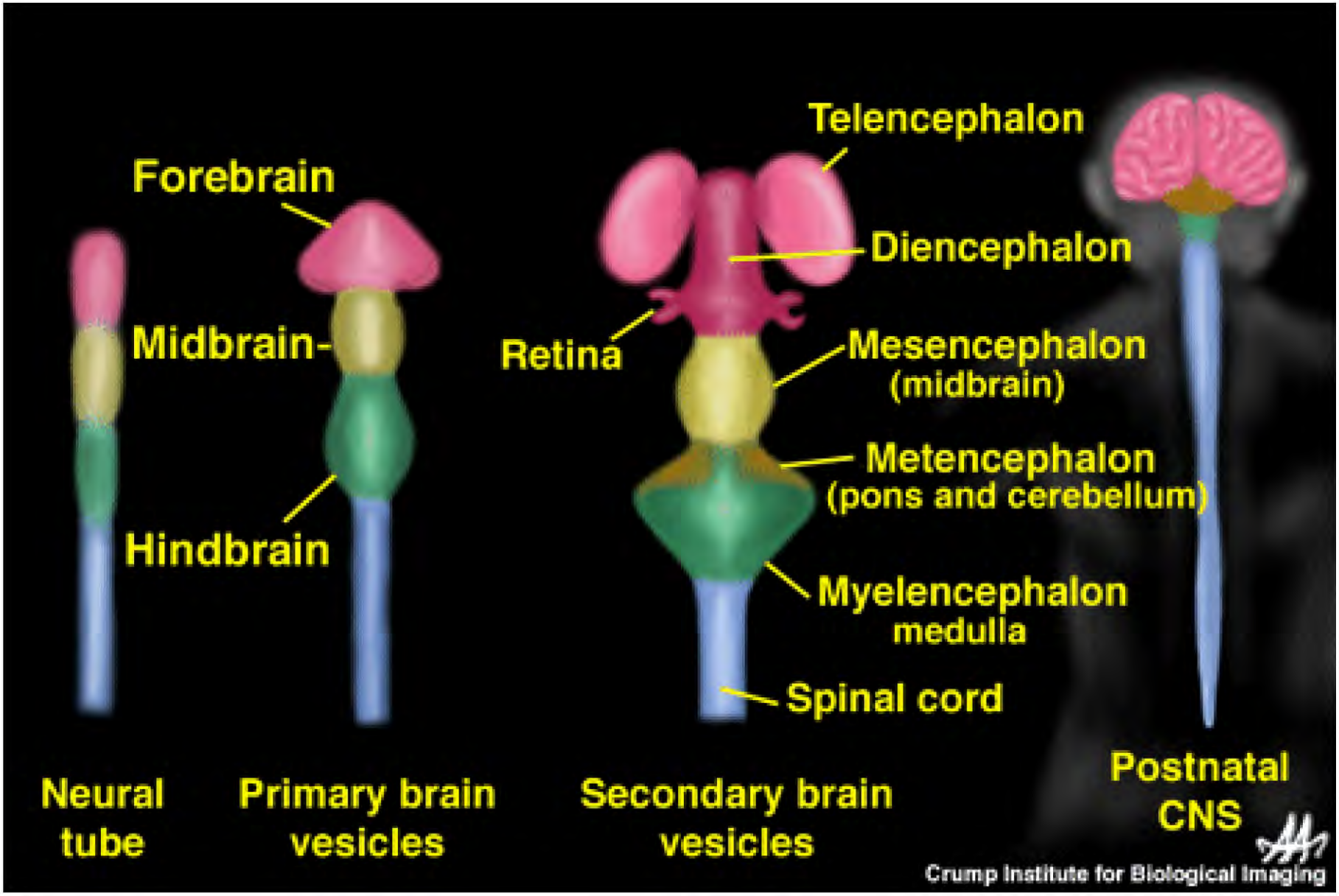


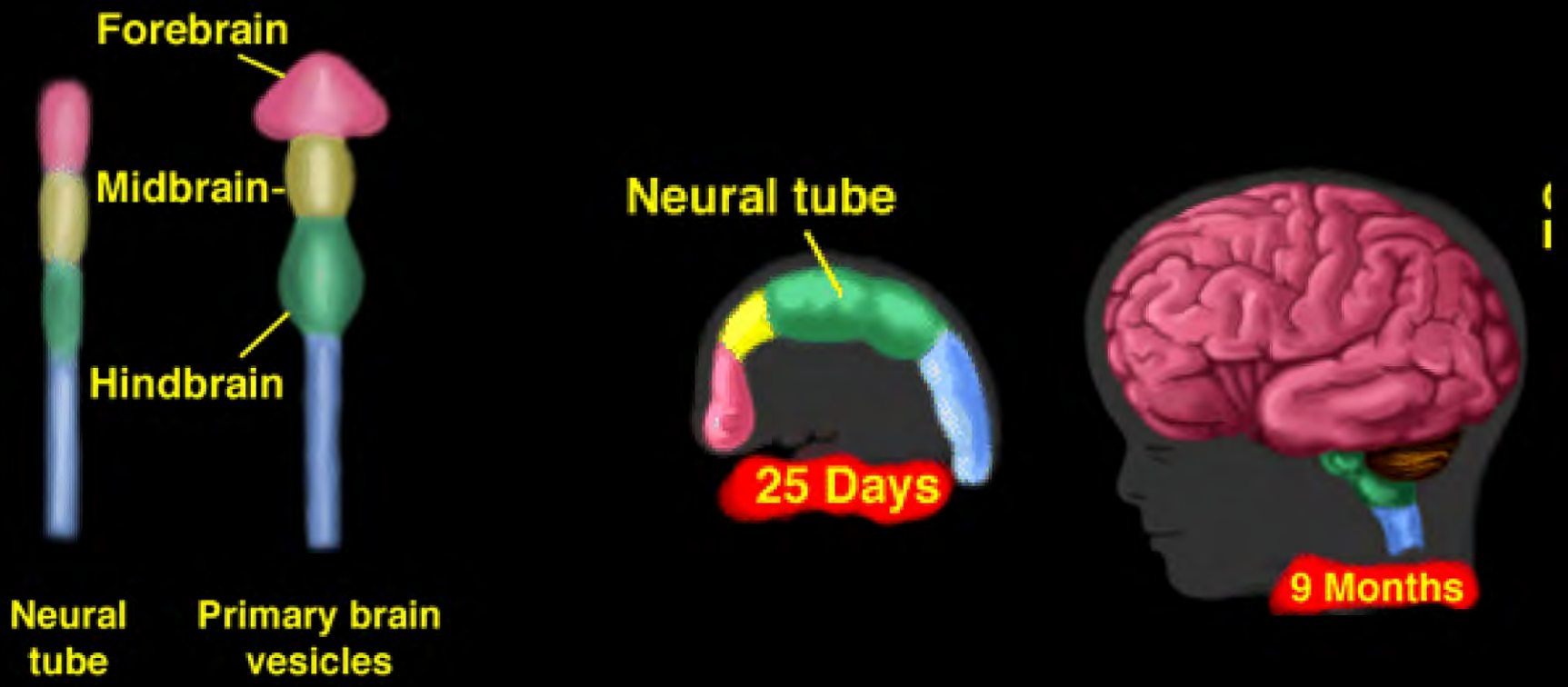


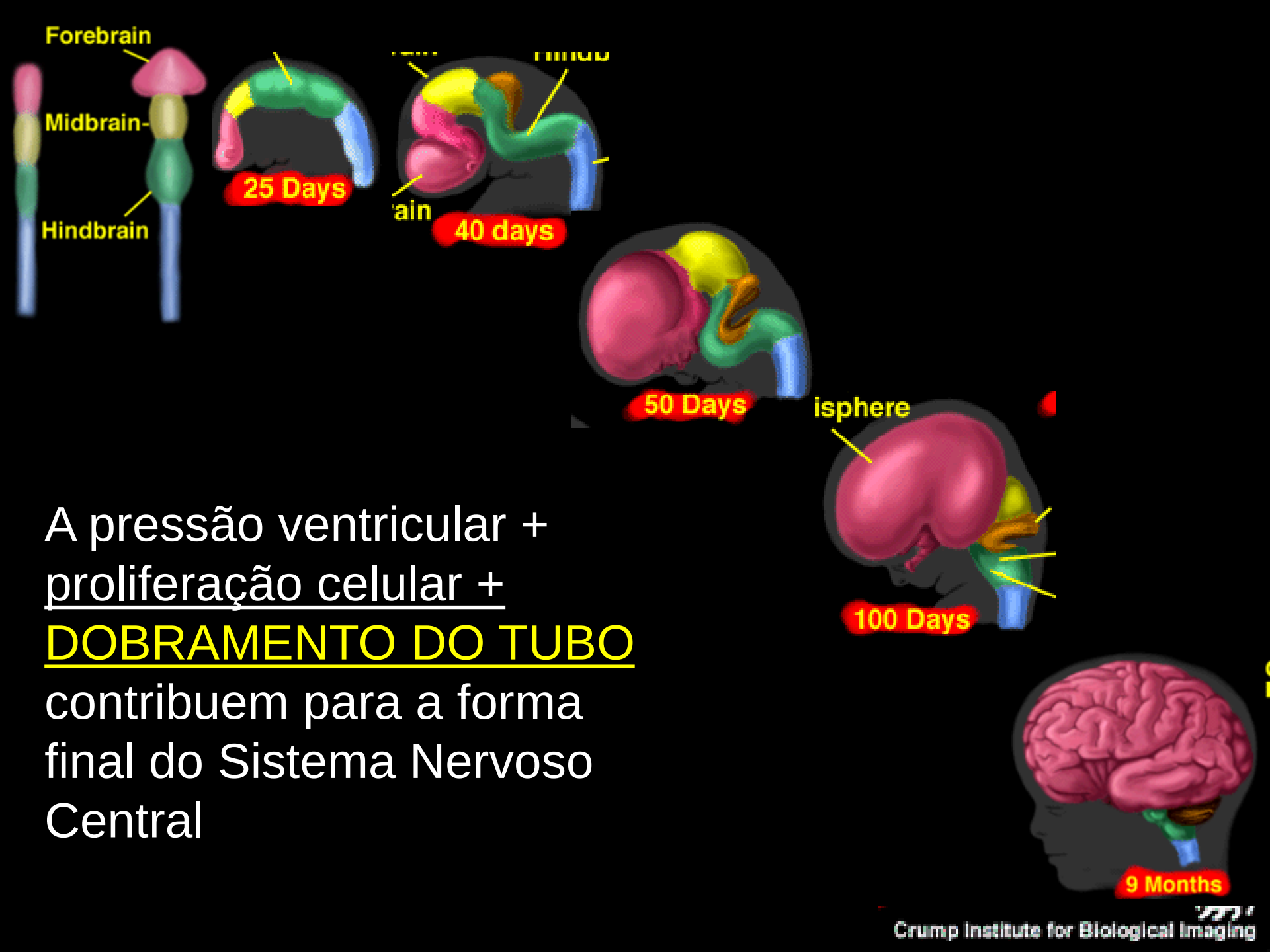

Drawing adapted from
Textbook of Veterinary Anatomy
KM Dyce, WO Sack, &
C.J.G. Wensing
CEREBELLUM
Cortex
CEREBRUM
Molecular,
Purkinje,
Granule
layers
Medulla
Fiber tracts from
Purkinje cells


Forebrain
Midbrain
Hindbrain
Neural tube
Primary brain vesicles

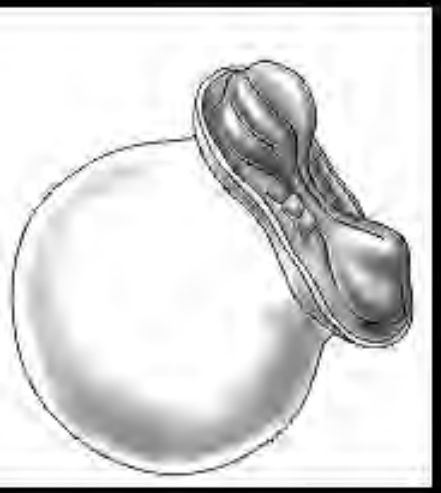

Neural tube
25 Days

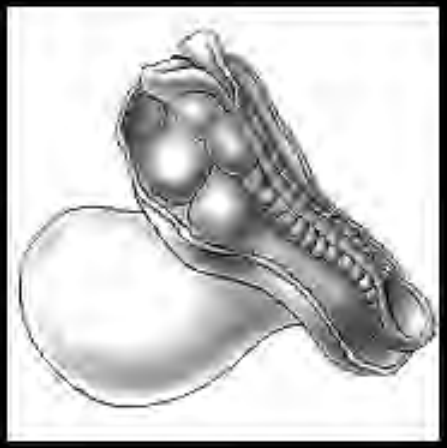
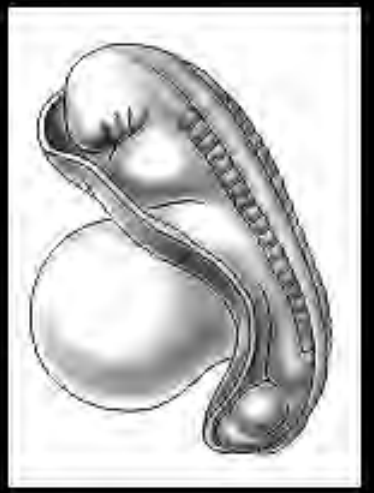

Forebrain
Midbrain
Hindbrain
Telencephalon
Diencephalon
Retina
Mesencephalon
(midbrain)
Metencephalon
(pons and cerebellum)
Myelencephalon
medulla
Spinal cord
Neural tube
Primary brain vesicles
Secondary brain vesicles
Postnatal CNS
Crump Institute for Biological Imaging

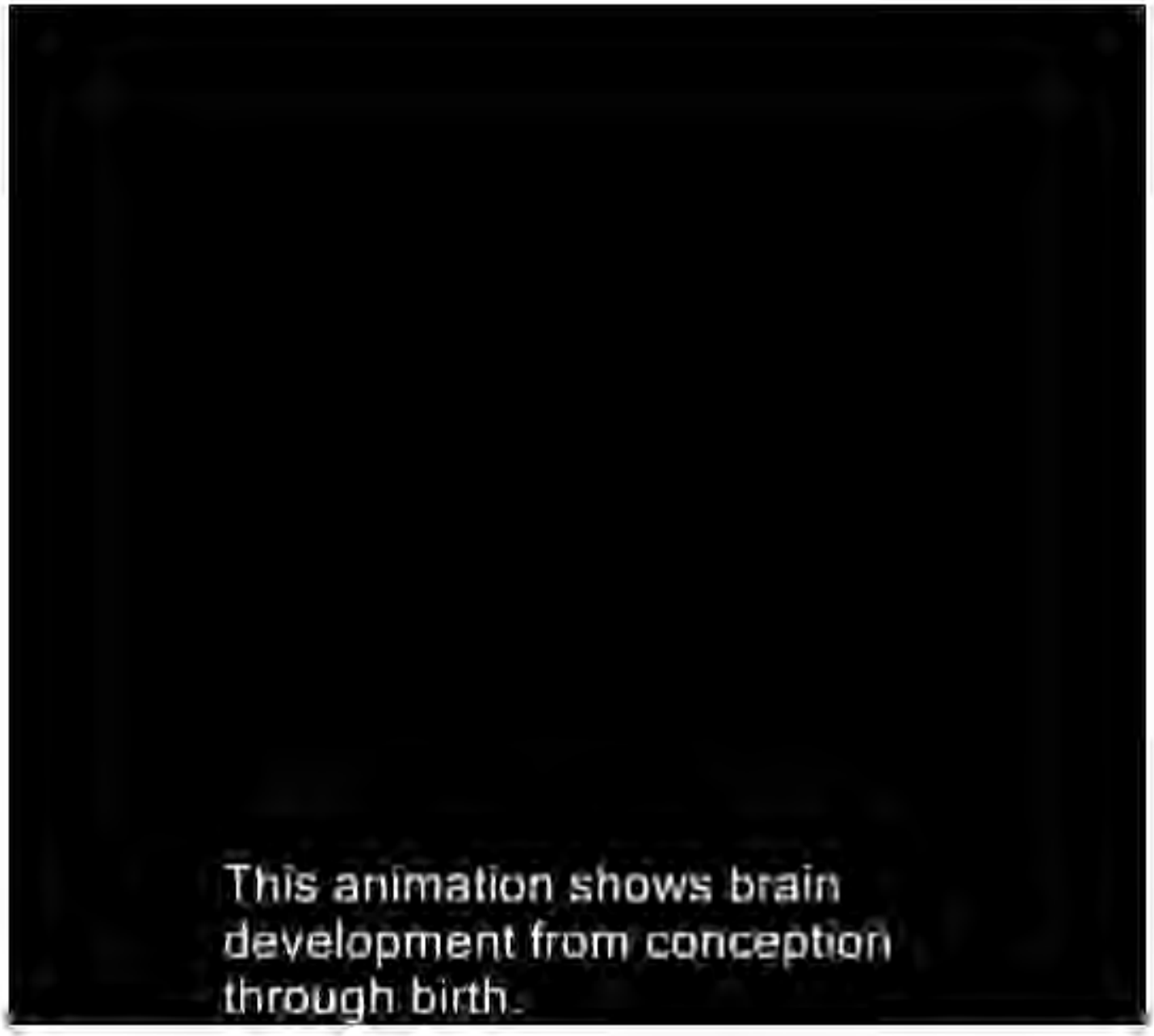

Forebrain
Midbrain
Hindbrain
Neural tube
Primary brain vesicles
Neural tube
25 Days
9 Months



A pressão ventricular + proliferação celular + DOBRAMENTO DO TUBO contribuem para a forma final do Sistema Nervoso Central



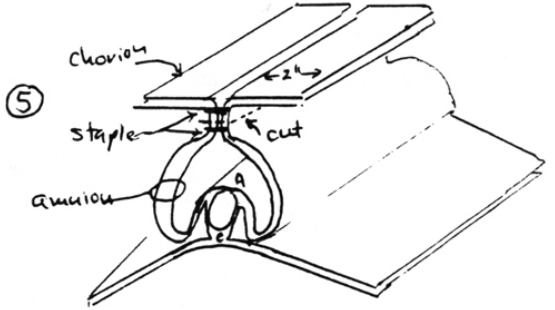




This animation shows brain
development from conception
through birth.

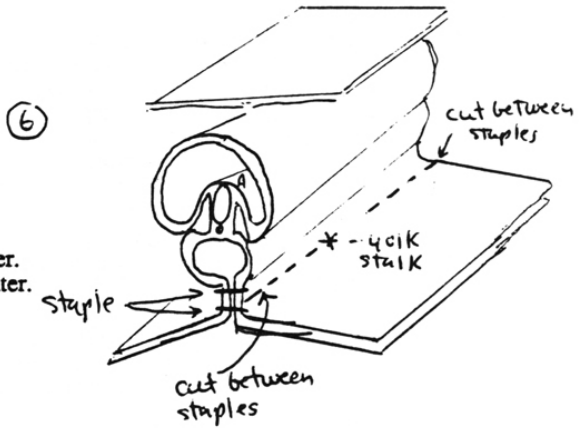
Dicas de estudo do Fábio

- Faça um Origami!!!
- Sugestões de leitura:
- Wolpert 3ª. Ed.
- Kierszenbaum 1ª. ou 2ª. Ed.

5. Form the amnion and the chorion
Fold the ectoderm and somatic mesoderm upwards
Staple these two sheets together
with two parallel lines of staples
about 2 inches from the end of the sheets.
Cut between the line of staples,
releasing the chorion from the amnion.
The chorion you made is small. In the embryo, this layer would have extended all around the yolk. You made the chorion small so the origami embryo would have a large enough amnion to make body walls later. Pay particular attention to the relative positions of ectoderm and somatic mesoderm: i.e., which is inside the amnion? Which is toward the egg shell?



6. Form the gut and yolk stalk.
Fold down the splanchnopleure (yellow endoderm and pink splanchnic mesoderm)
to form a tube 1 inch in diameter.
Staple two parallel lines from anterior to near the center.
Staple two parallel lines from posterior to near the center.
Cut between the stapled lines
from the anterior and from the posterior,
but do not completely sever the sheets.
Leave the sheets attached at the center.
The attached region is the yolk stalk where the inside of the gut is open to the inside of the yolk sac.



⑦ attach allantois at *, above

7. Form the allantois
Attach your balloon to the yolk stalk.
The balloon represents an outpocketing of the gut at the yolk stalk.
Ask yourself: which color would be on the outer surface of the allantois, blue (ectoderm) or pink (mesoderm). Why?

8. Form the lateral body walls
Bring the amnion down around the gut.
Staple in two lines except at the yolk stalk.
Cut between the two lines
except at the yolk stalk.
This procedure separates the amnion from the lateral body walls and leaves the embryo floating within the amniotic sac.