University of Zurich[UZH]

ETH Zürich

Development of the Nervous System

BIO 344/376-1305-00L/10L

HS17

https://lms.uzh.ch/dmz/

Check OLAT BIO344 regularly for information about

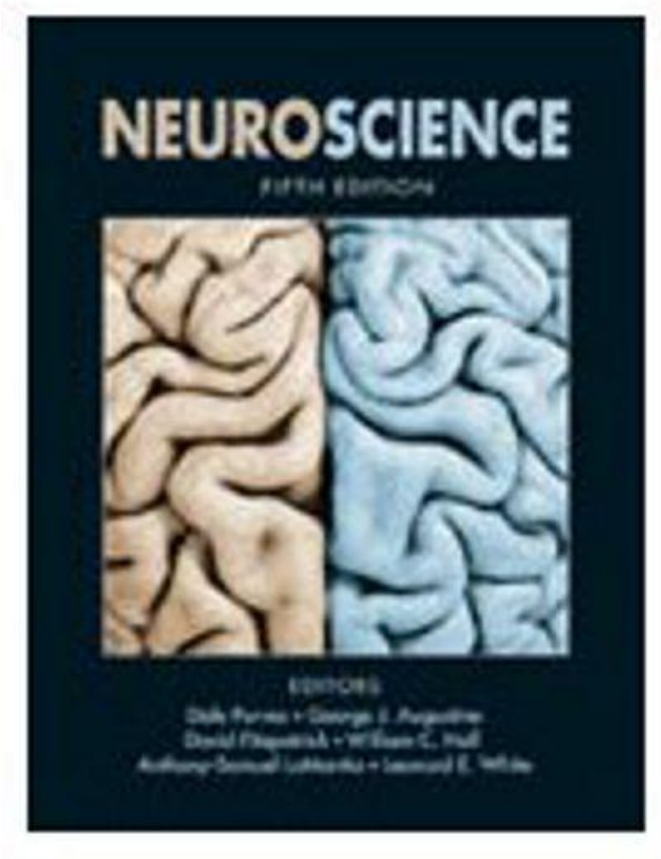
-lectures
-exams (date, location)

-to download PDFs of lectures and additional material
that is relevant for the exam

Note: All PDFs of reviews and papers uploaded on OLAT are **mandatory reading** for the exams

Students enrolled at the ETH should be able to access the website via the link on the ETH website (login via aai-logon.ethz.ch with your nethz username and password)

recommended text books:

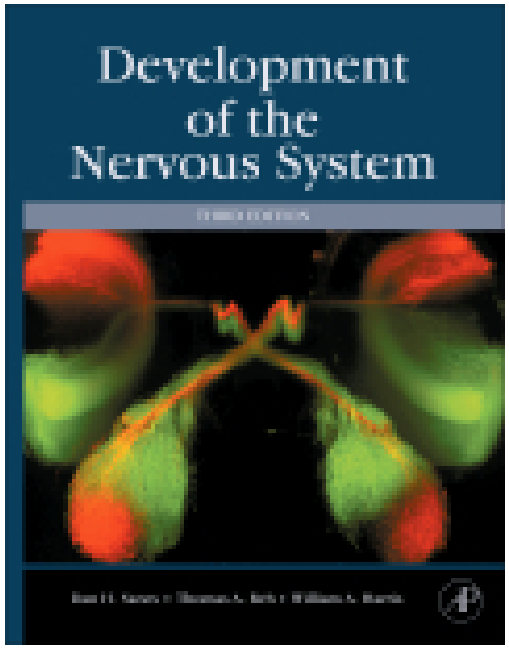


Purves, Augustine, Fitzpatrick, Hall, LaMantia, McNamara, Williams

fifth edition, 2012, Sinauer

recommended text book for neuroscience in general

For developmental neuroscience:

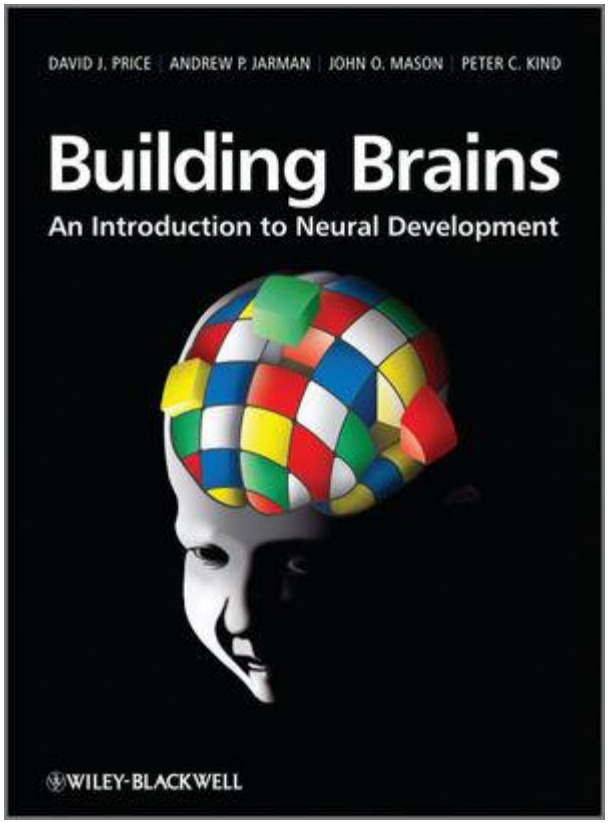


Sanes, Reh, Harris

third edition, 2012
Academic Press
ISBN: 978-0-12-374539-2

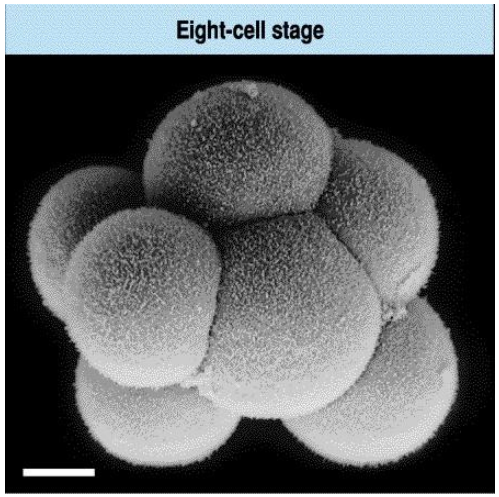
excellent text book for developmental neuroscience

For developmental neuroscience:

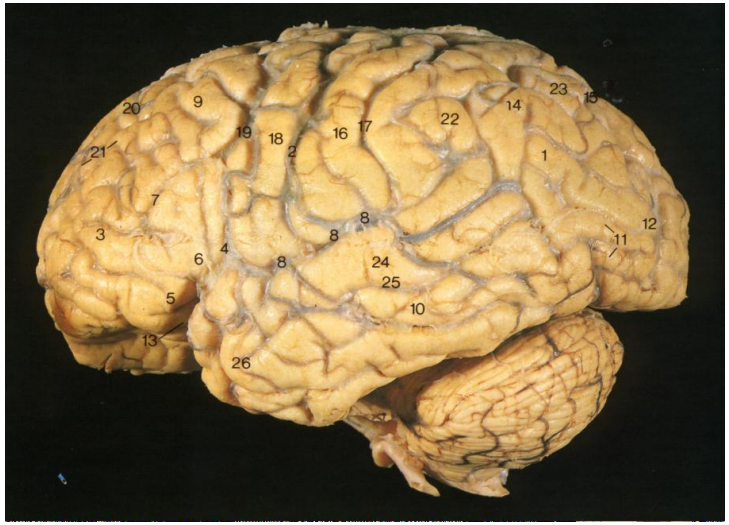


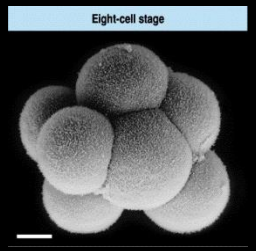
Price, Jarman, Mason, Kind

1st edition, 2011
Wiley-Blackwell
ISBN 978-0-470-71229-0


Eight-cell stage

?


20
9
19
18
2
16
17
22
14
23
15
21
1
7
3
8
8
12
11
6
4
8
24
25
5
10
13
26



Proliferation

Differentiation

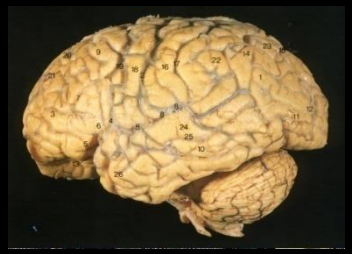
Cell migration

Connectivity

Axonal pathfinding
Synapse formation
Circuit formation

Maturation

Cell death
Pruning



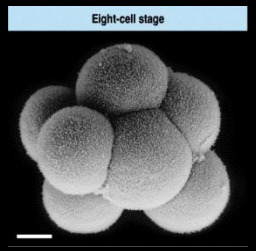
Aberrant development can lead to disease

18.09.2017	Introduction	ES
25.09.2017	Neurogenesis	ES
02.10.2017	Axon Growth & Survival	ES
09.10.2017	Axon Guidance	ES
16.10.2017	Neural Circuits	ES
23.10.2017	Cell Migration	DZ
30.10.2017	Synapse Formation	MM
06.11.2017	Synaptic Homeostasis	MM
13.11.2017	Neural Circuits of Behavior	AH
20.11.2017	Adult Neural Stem Cells	SJ
27.11.2017	Sleep and Development	RH
04.12.2017	Neural Crest Cells	LS
11.12.2017	Developmental Disorders of the NS	ES
18.12.2017	Developmental Disorders of the NS	ES

	BIO344/376-1305		Development of the Nervous System	Purves Neuroscience
Date	Title	Lecturer	Content	required knowledge
18.09.2017	Introduction	ES	Overview/Introduction	Ch. 1,22,23
25.09.2017	Neurogenesis	ES	Neurulation, generation of cells in the NS, patterning	22
02.10.2017	Axon Growth & Survival	ES	Molecular mechanisms of axon growth and neuronal survival	23
09.10.2017	Axon Guidance	ES	How do axons navigate through the preexisting tissue?	23
16.10.2017	Neural Circuits	ES	Integration of basic mechanisms to neural circuit formation and maturation	23
23.10.2017	Cell Migration	DZ	Mechanisms and importance of cell migration in neural development	22, 23
30.10.2017	Synapse Formation	MM	Molecular mechanisms of synapse formation	23
06.11.2017	Synaptic Plasticity and Homeostasis	MM	How are synapses changing during learning and memory? How is synaptic strength maintained?	
13.11.2017	Neural Circuits of Behavior	AH	How can we use a simple NS to study the correlation between structure and function?	
20.11.2017	Adult neural stem cells	SJ	Contribution of stem cells in the adult NS, therapeutic potential of adult stem cells	25
27.11.2017	Neural Development & Sleep	RH	Importance of sleep during neural development, changes in sleep patterns during brain development	
04.12.2017	Neural Crest Cells	LS	Generation of the PNS, contribution of NC stem cells to neural development and function	22, 25
11.12.2017	Neurodevelopmental Disorders	ES	What are the consequences of aberrant neural development? Examples that will be discussed are autism, schizophrenia, intellectual disability	
18.12.2017	Neurodevelopmental Disorders	ES		

Note:

Papers and review articles on OLAT are part of the exam!



Proliferation

Differentiation

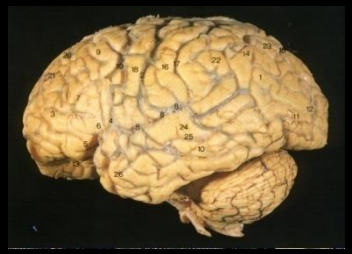
Cell migration

Connectivity

Axonal pathfinding
Synapse formation
Circuit formation

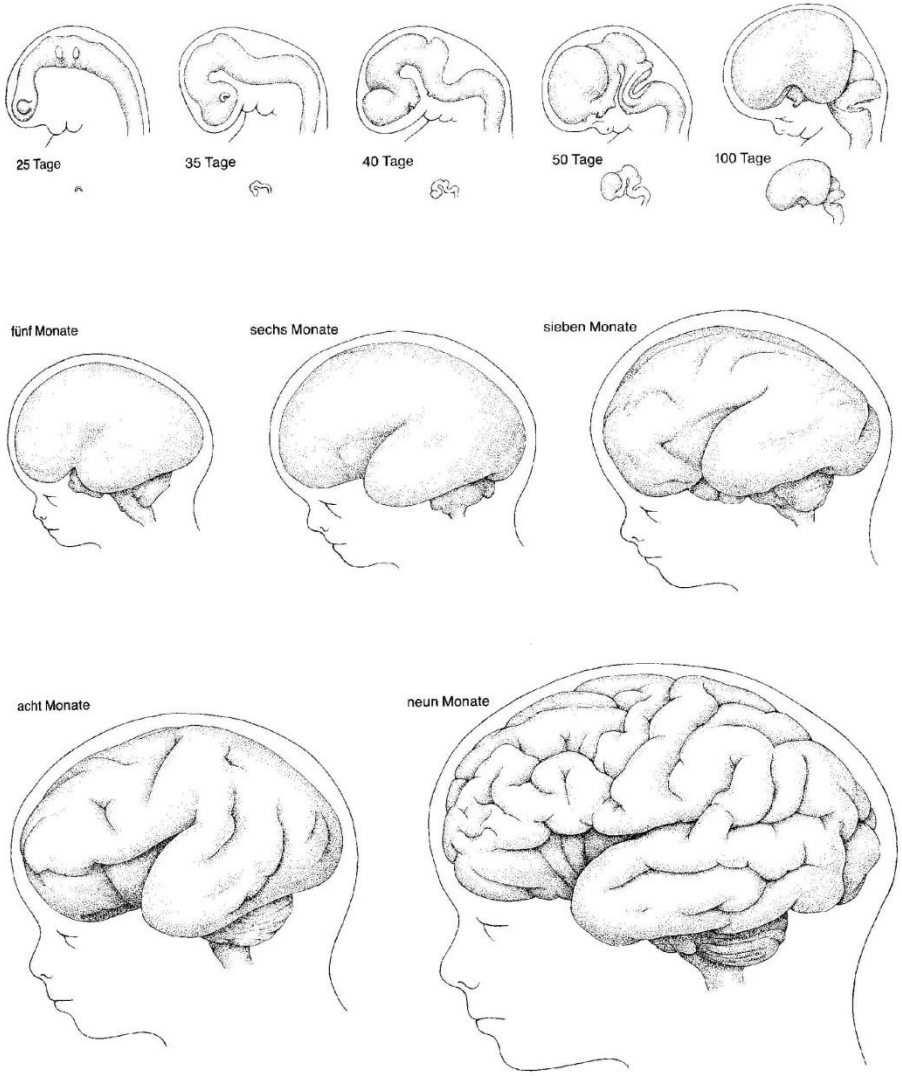
Maturation

Cell death
Pruning

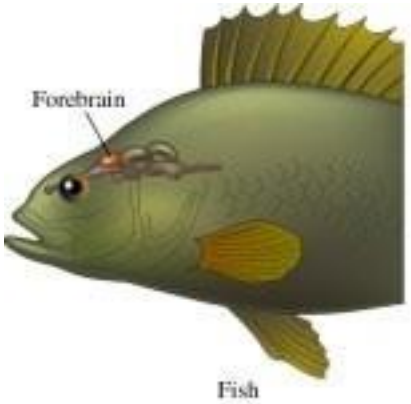


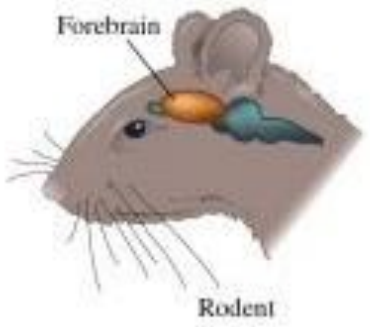
Aberrant development can lead to disease

Development means increase in size and increase in complexity !

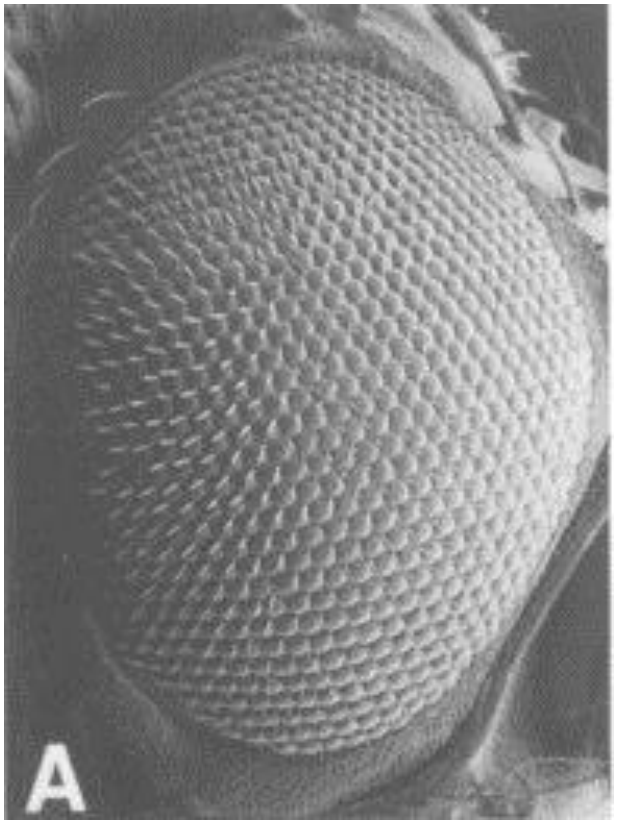


The size of the forebrain increased during evolution

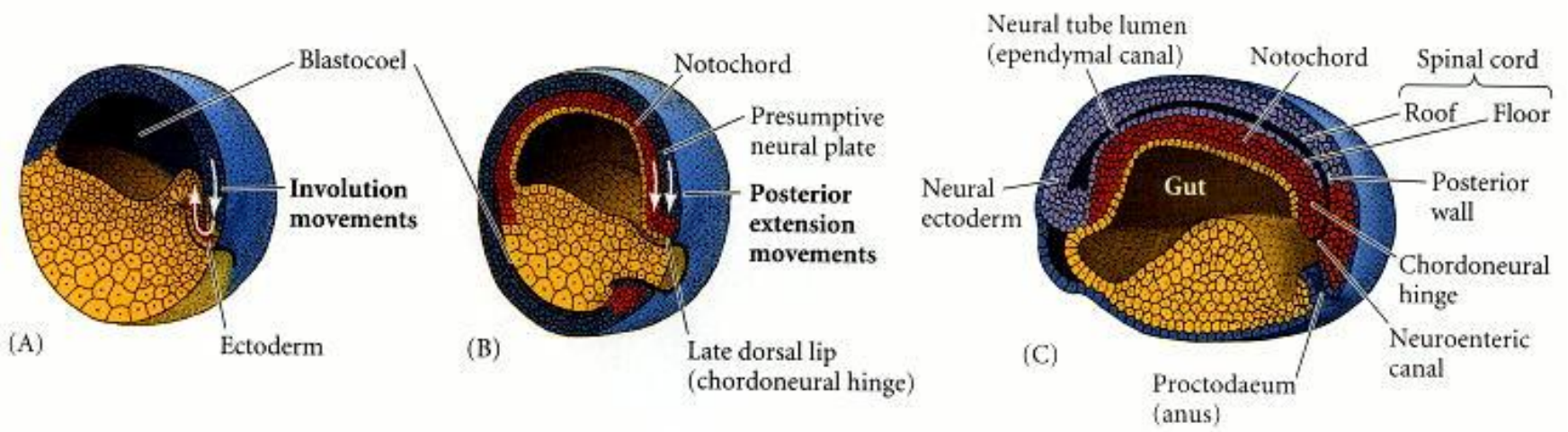




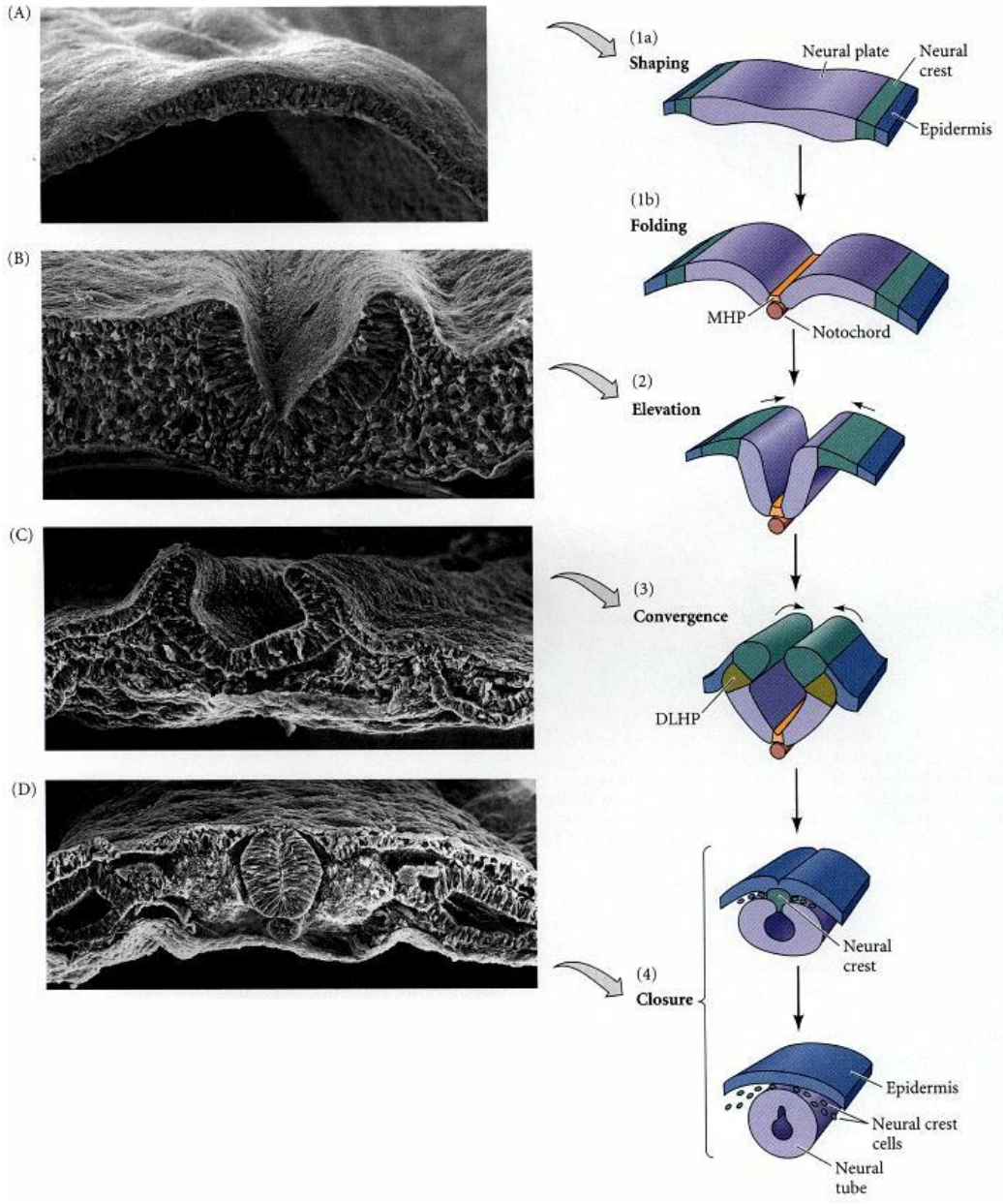
Structures may look very different in the adult organism but their development is very similar in invertebrates and vertebrates



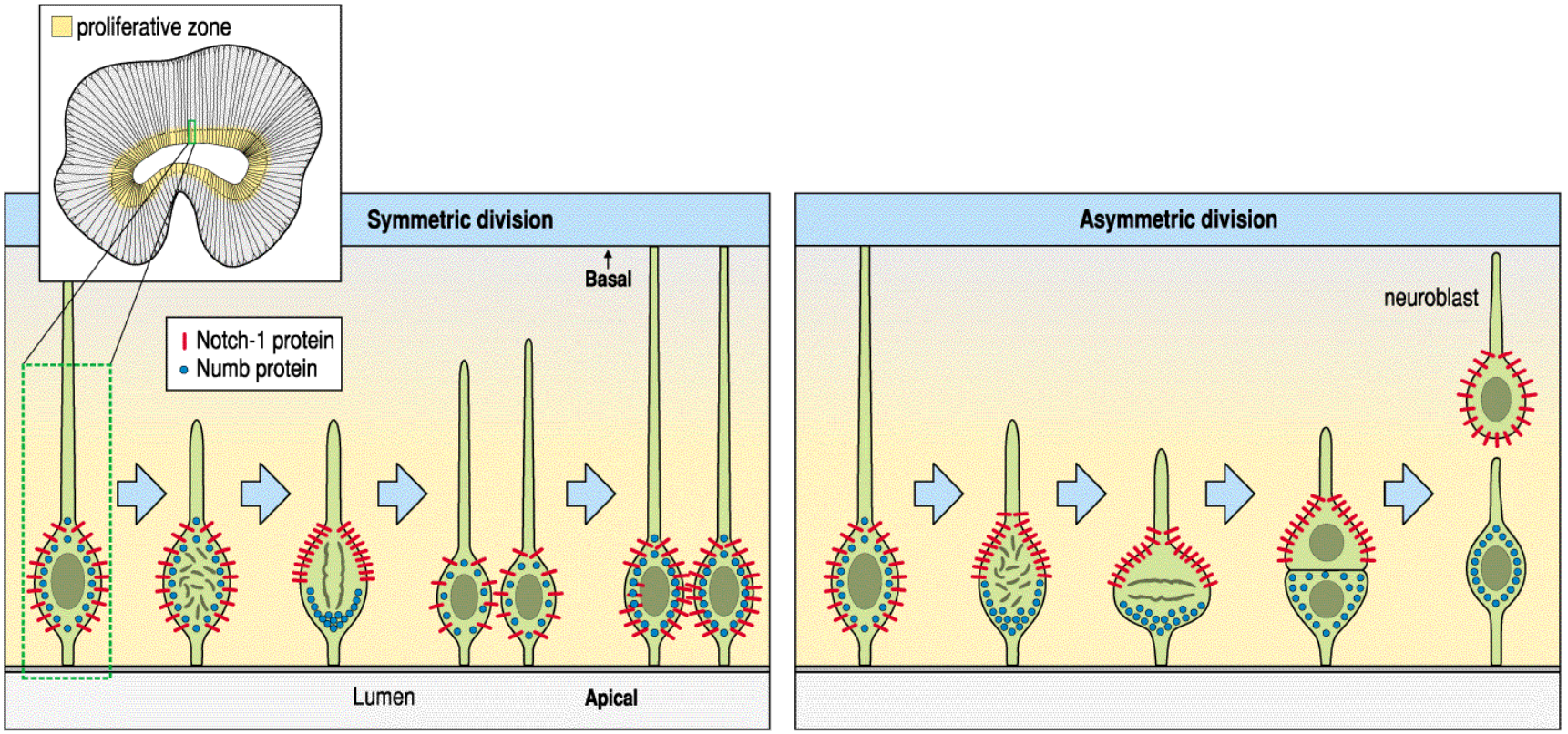
Gastrulation



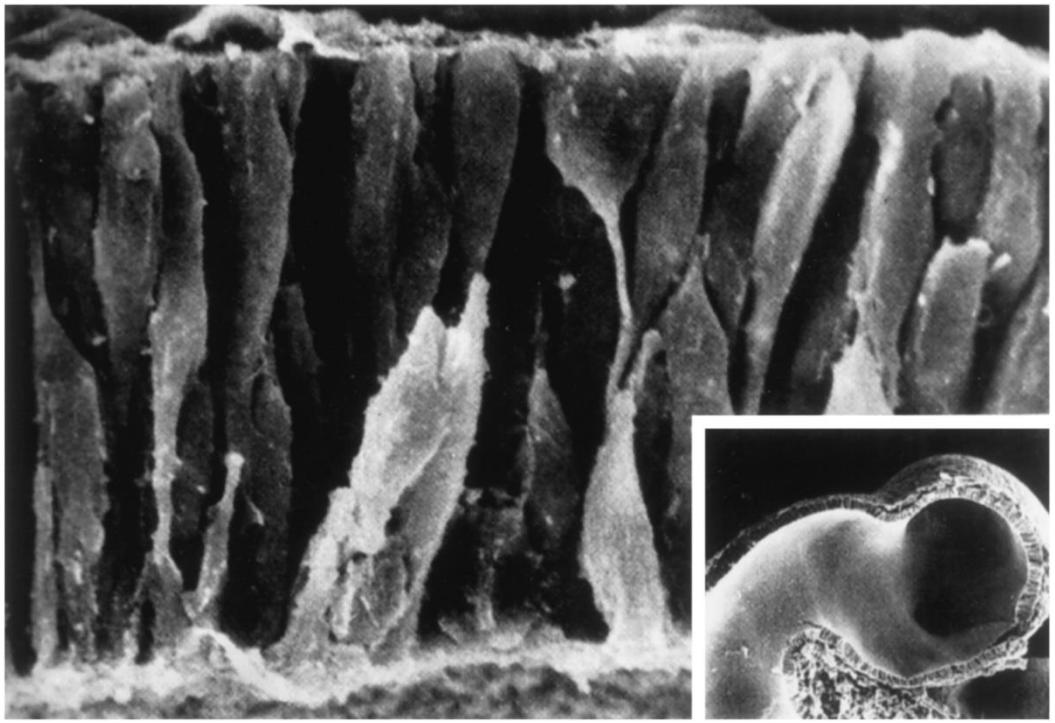
Neurulation



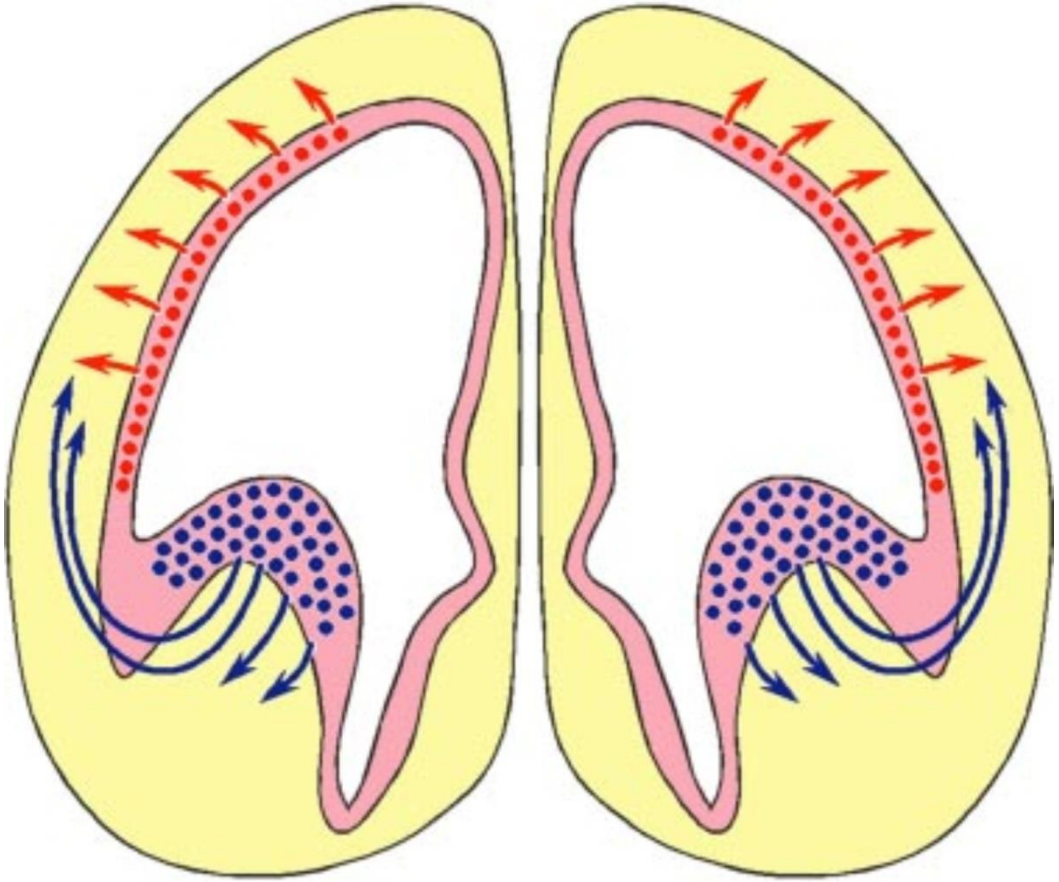
Proliferation

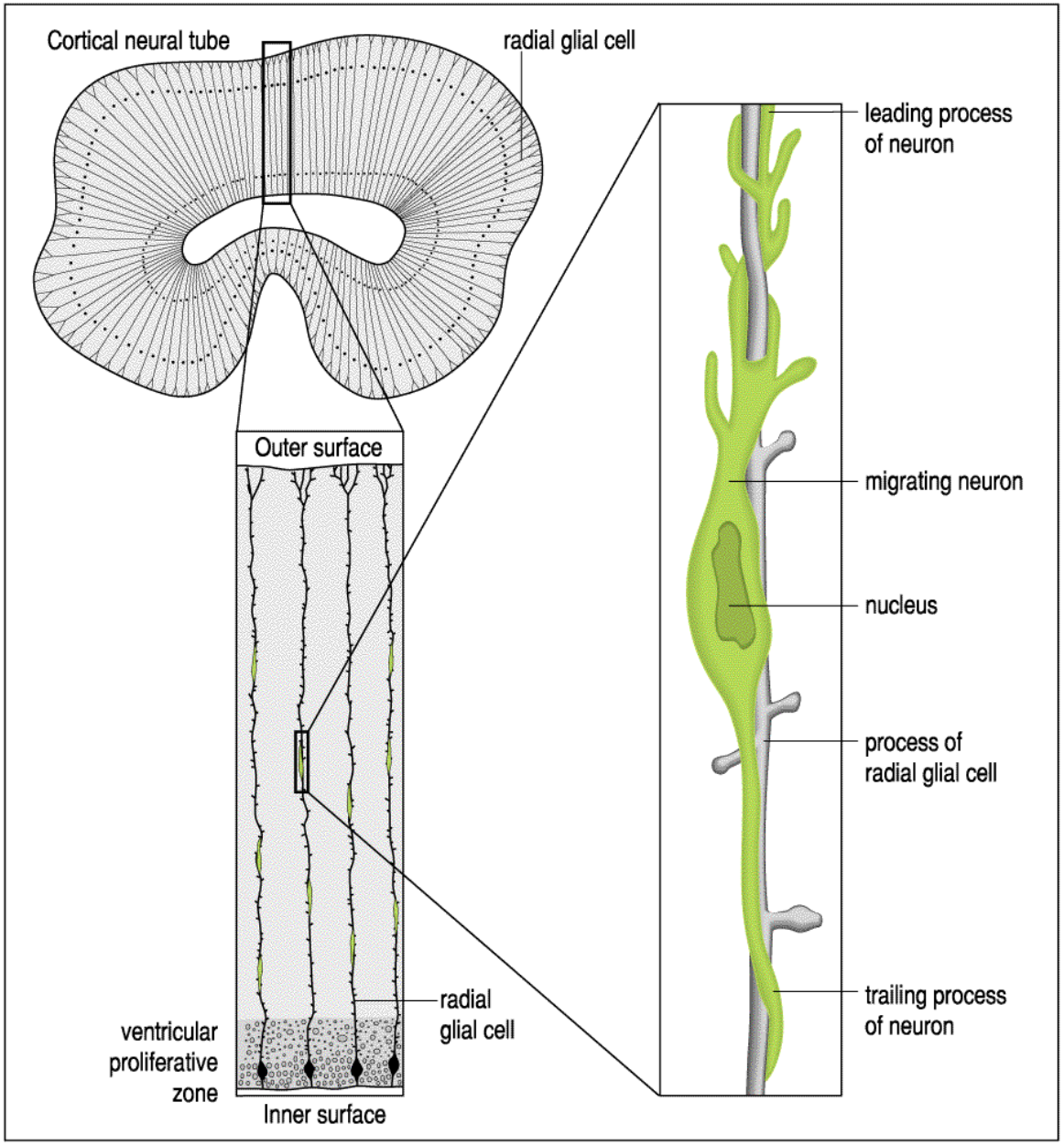


Cells proliferate in the ventricular zone of the neural tube



Radial and tangential migration



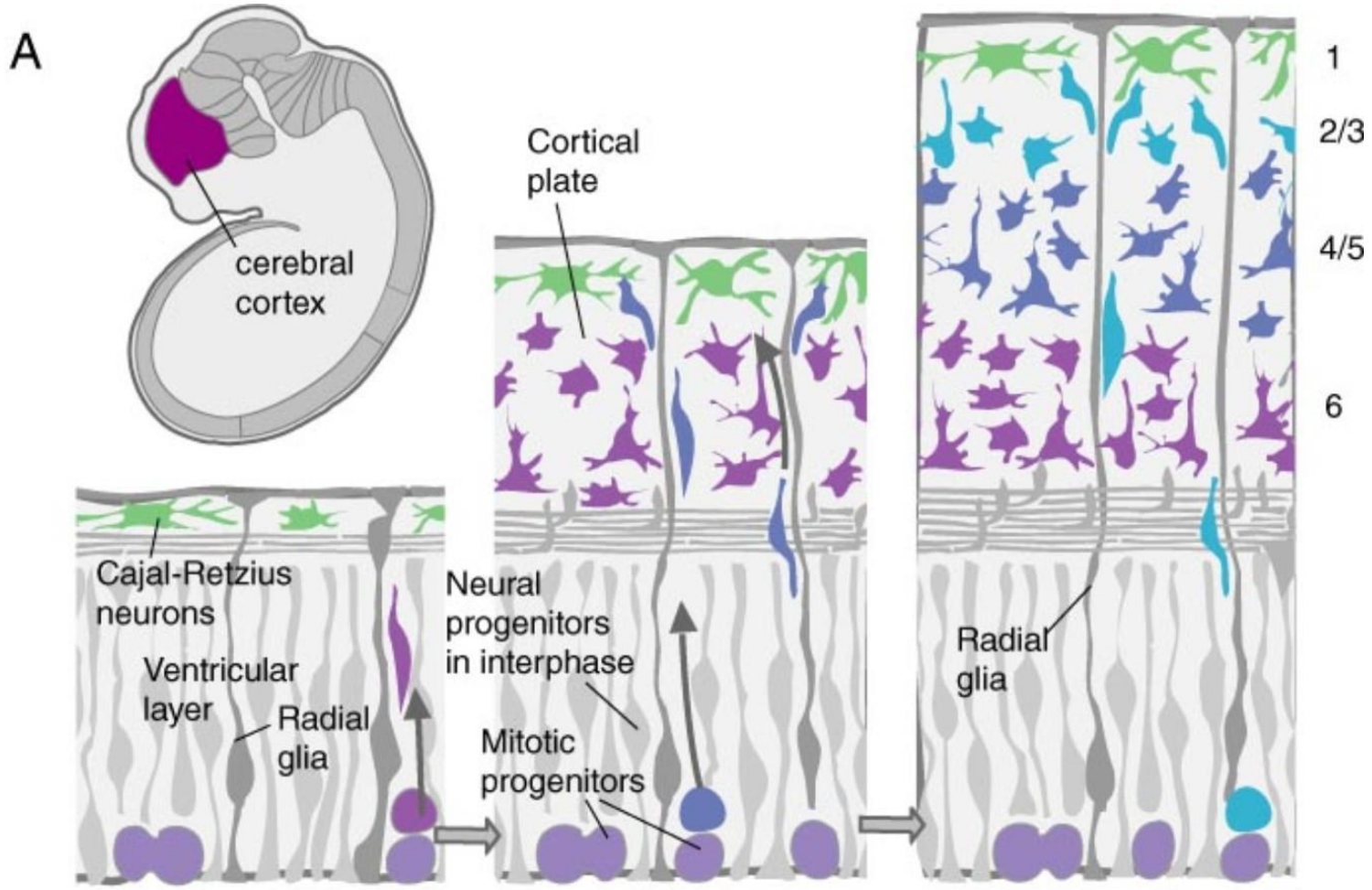

Cortical neural tube
radial glial cell
Outer surface
leading process
of neuron
migrating neuron
nucleus
process of
radial glial cell
trailing process
of neuron
radial
glial cell
ventricular
proliferative
zone
Inner surface

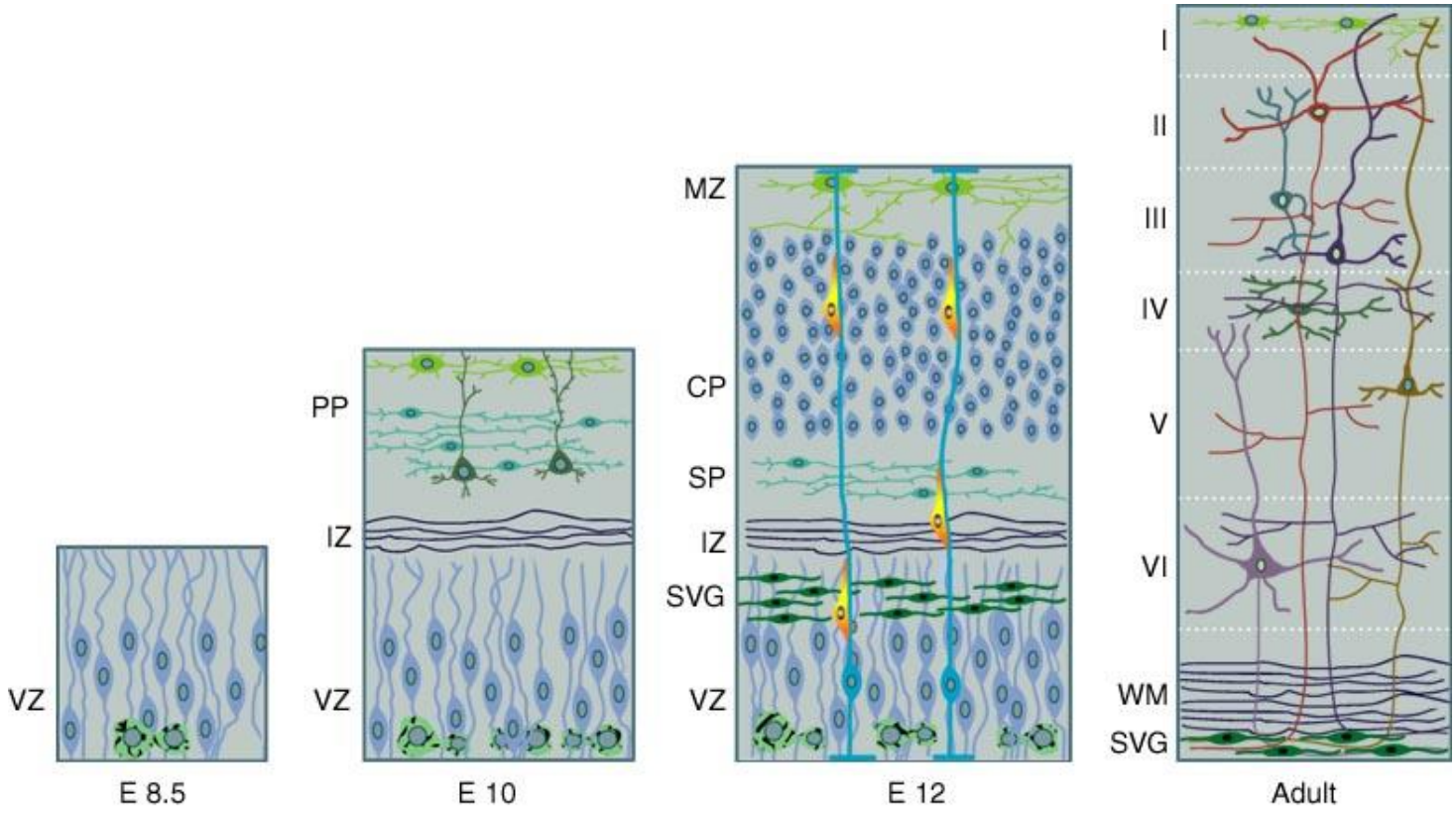
Radial glia can give
rise to neuronal precursors

Stem cells

(From Noctor et al., 2001.)

Radial migration is essential for cortical development





The peripheral nervous system of vertebrates is segmented

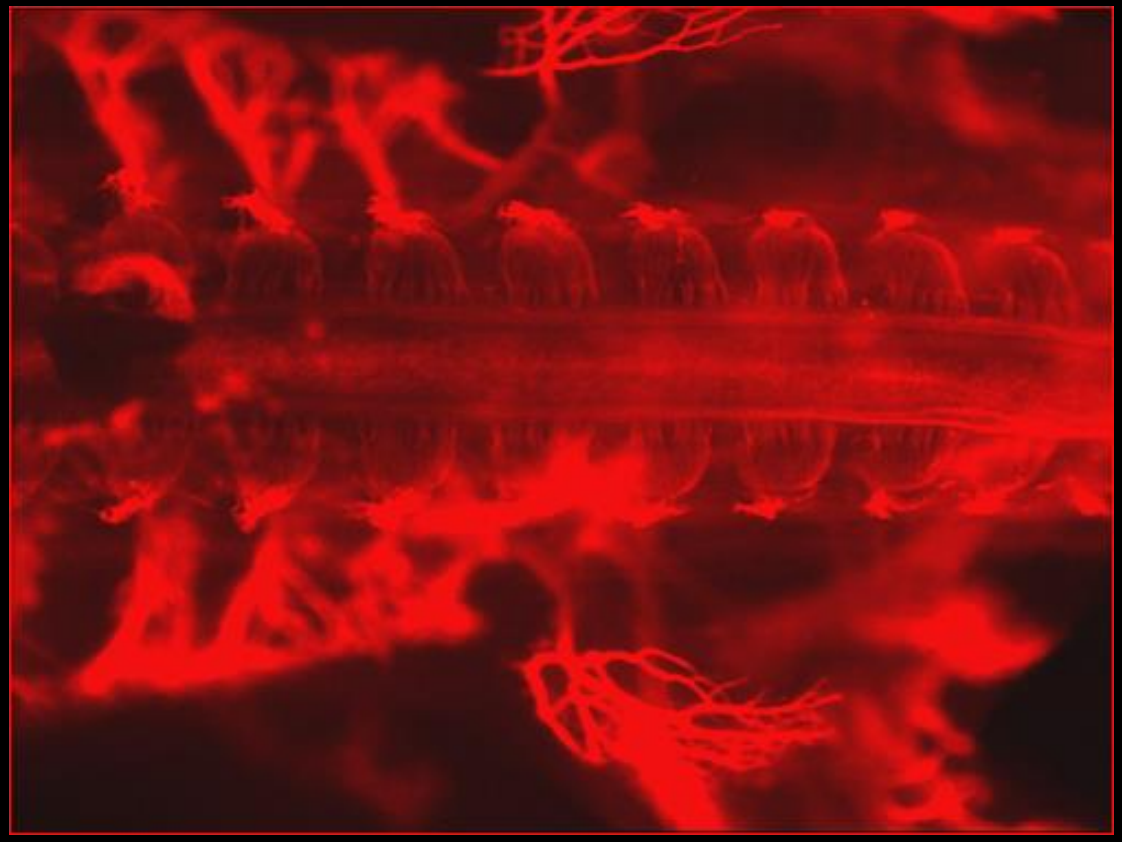
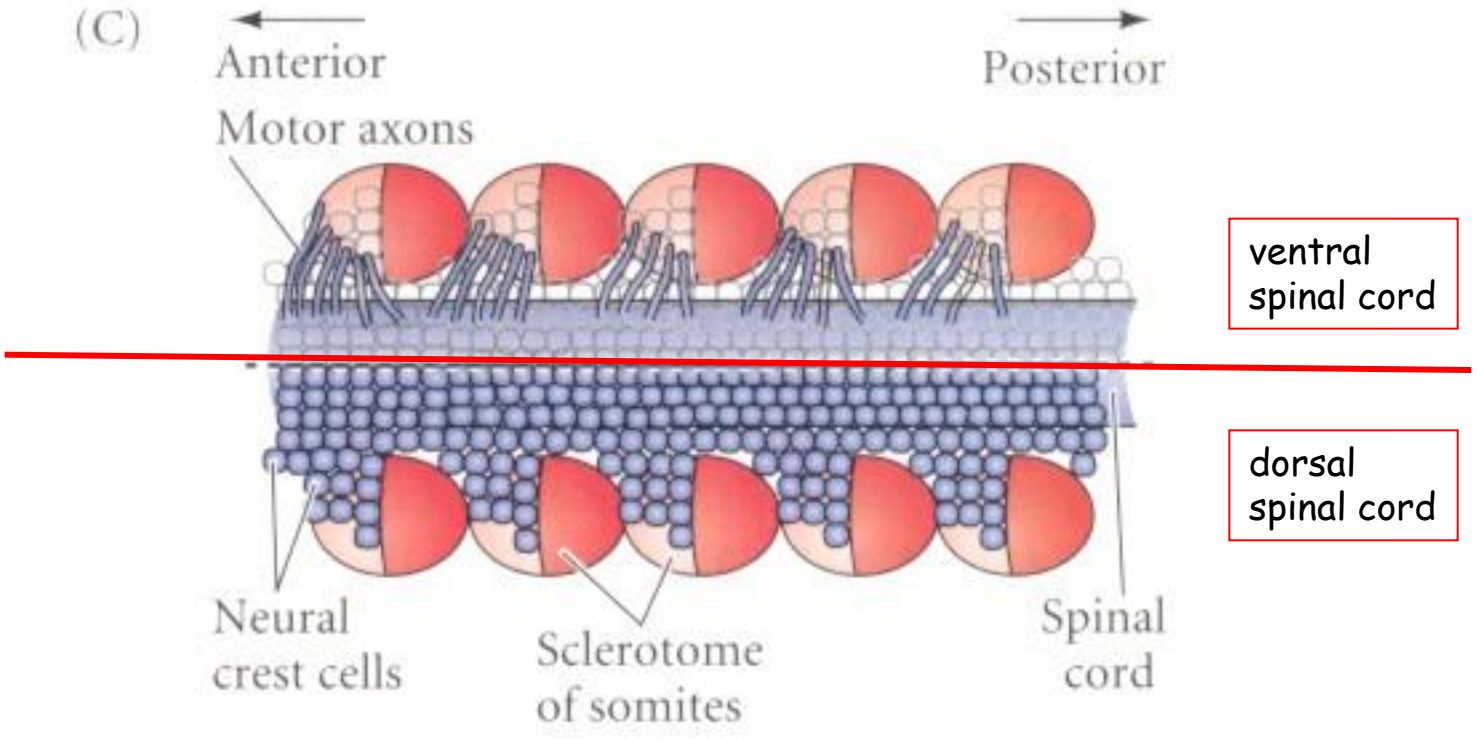


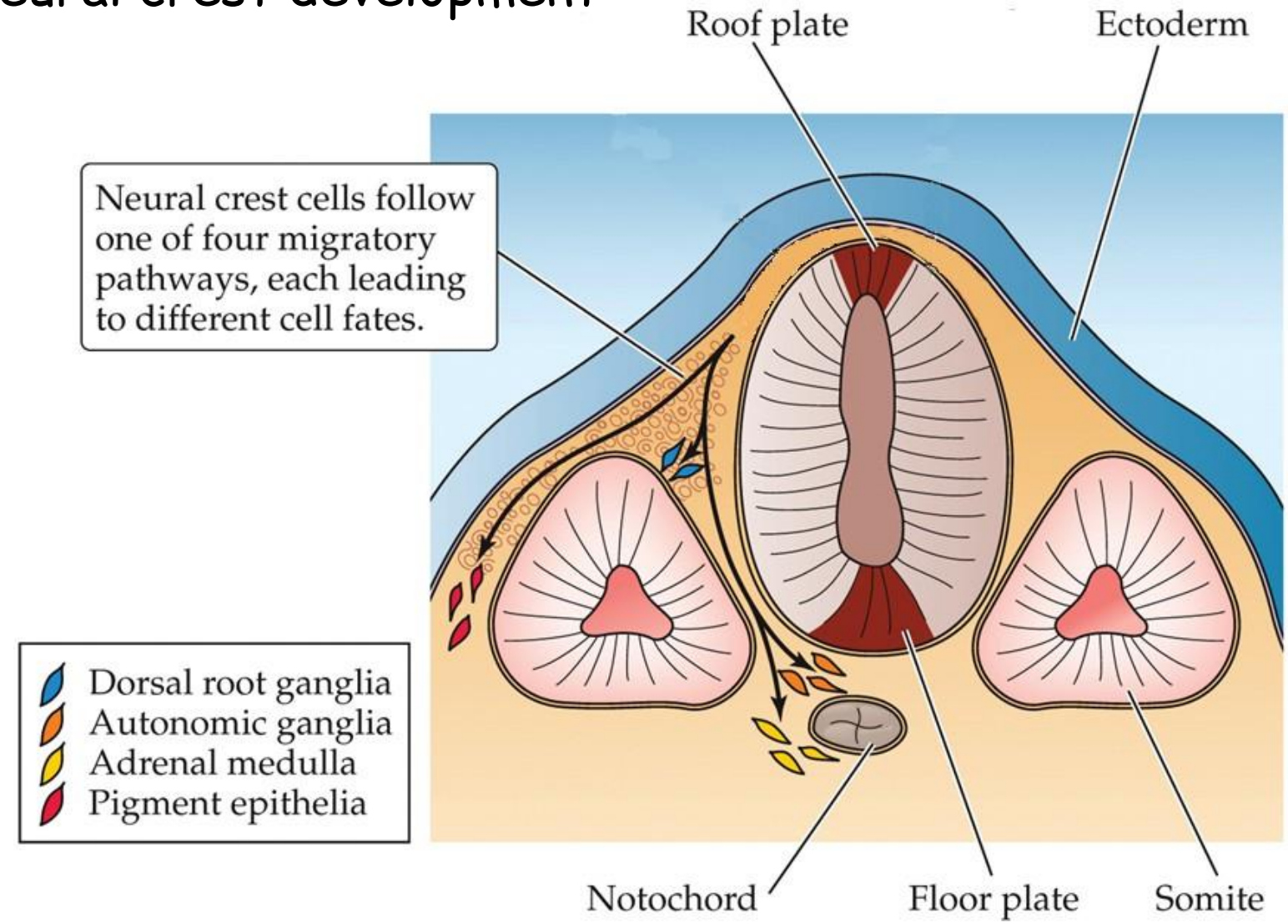
image: J. Strauss

Somites are essential for the segmentation of the peripheral nervous system



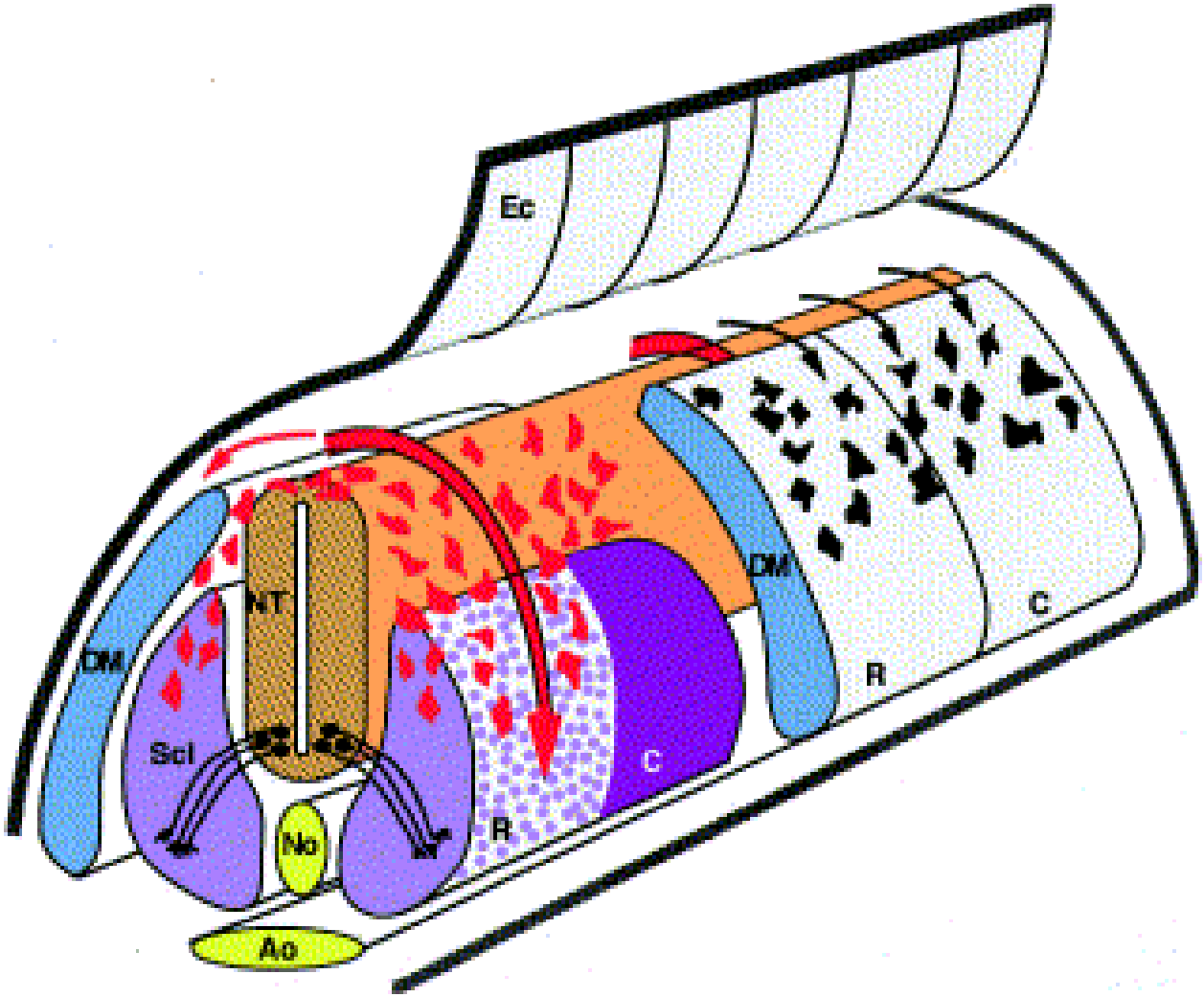
Gilbert, 2003

Migration and differentiation cannot be separated in neural crest development



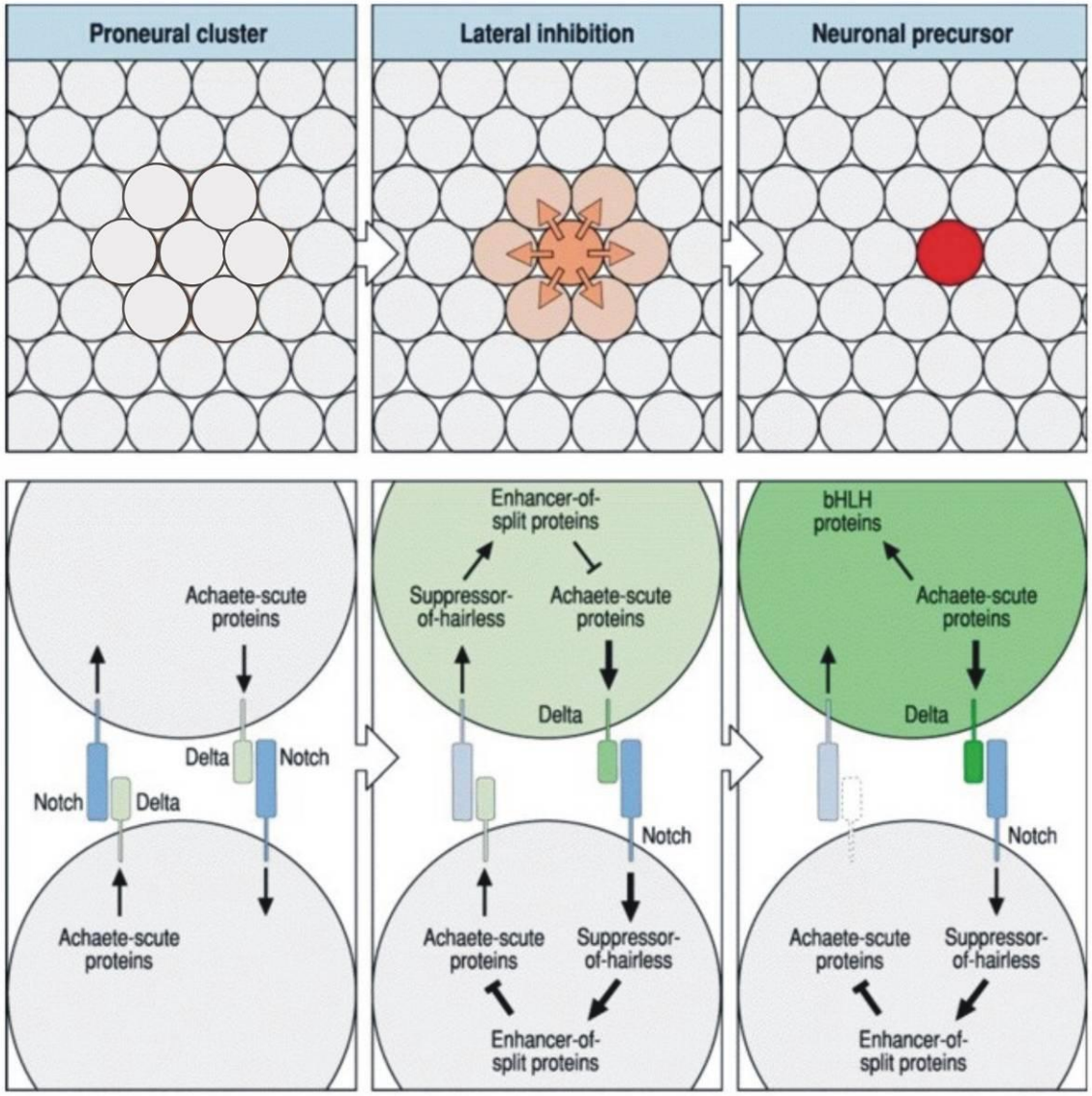
FOUNDATIONS OF NEURAL DEVELOPMENT 1e, Figure 3.19

The caudal part of the somite is inhibitory for neural crest cell migration

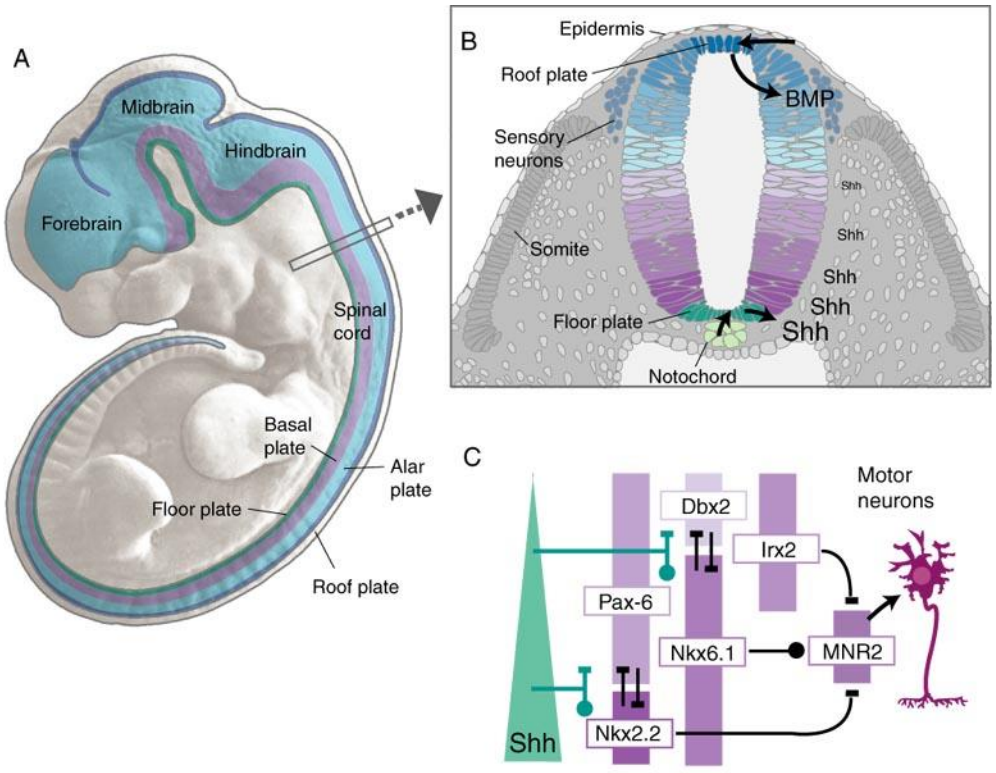


Differentiation and Patterning

Lateral Inhibition defines the number of neuronal cells

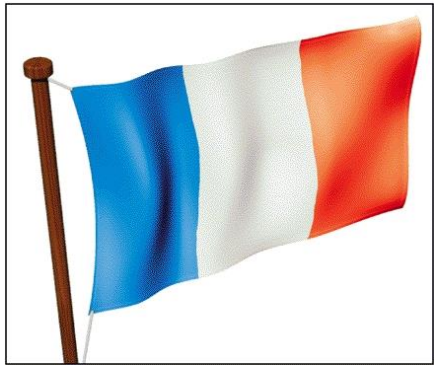


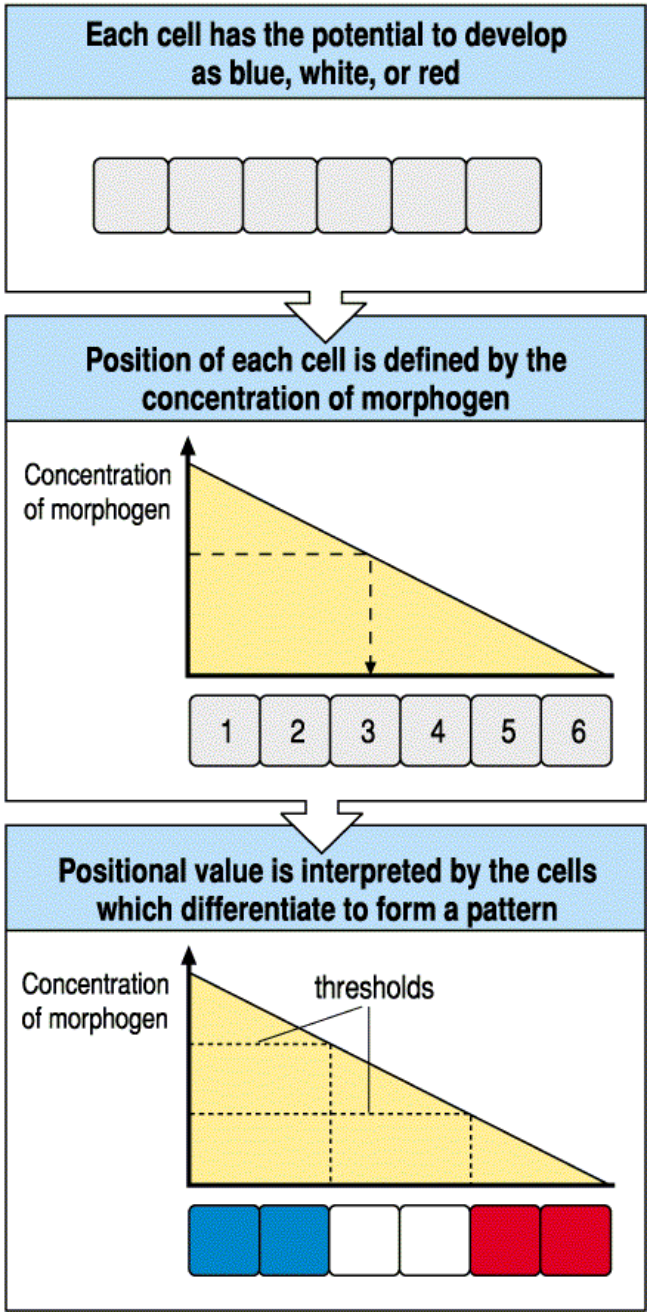
Wolpert, 2002

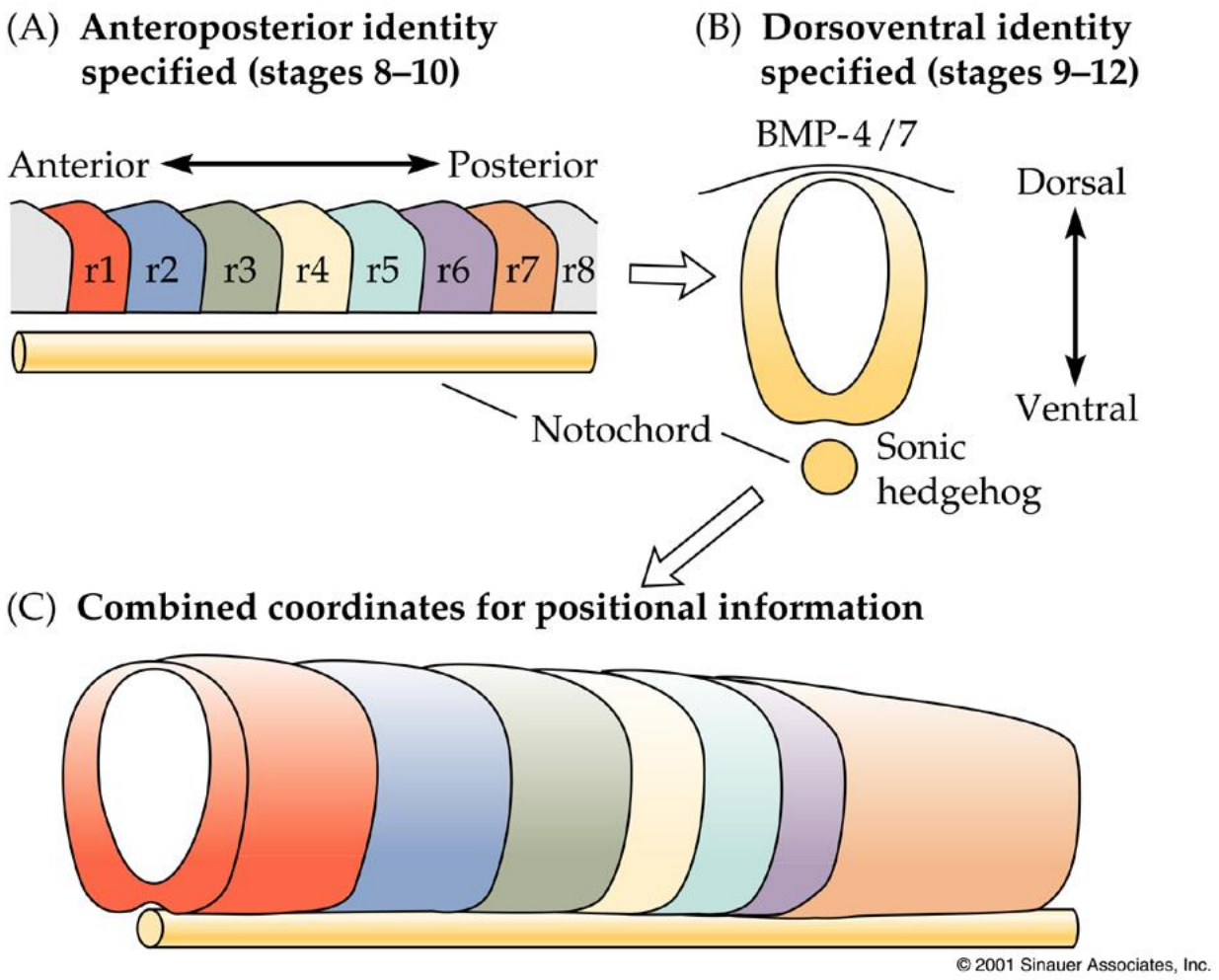

A
Midbrain
Hindbrain
Forebrain
Spinal cord
Basal plate
Alar plate
Floor plate
Roof plate
B
Epidermis
Roof plate
BMP
Sensory neurons
Shh
Shh
Somite
Shh
Shh
Floor plate
Shh
Notochord
C
Motor neurons
Dbx2
Irx2
Pax-6
Nkx6.1
MNR2
Nkx2.2
Shh

How do cells become different from each other ?

The French Flag Model



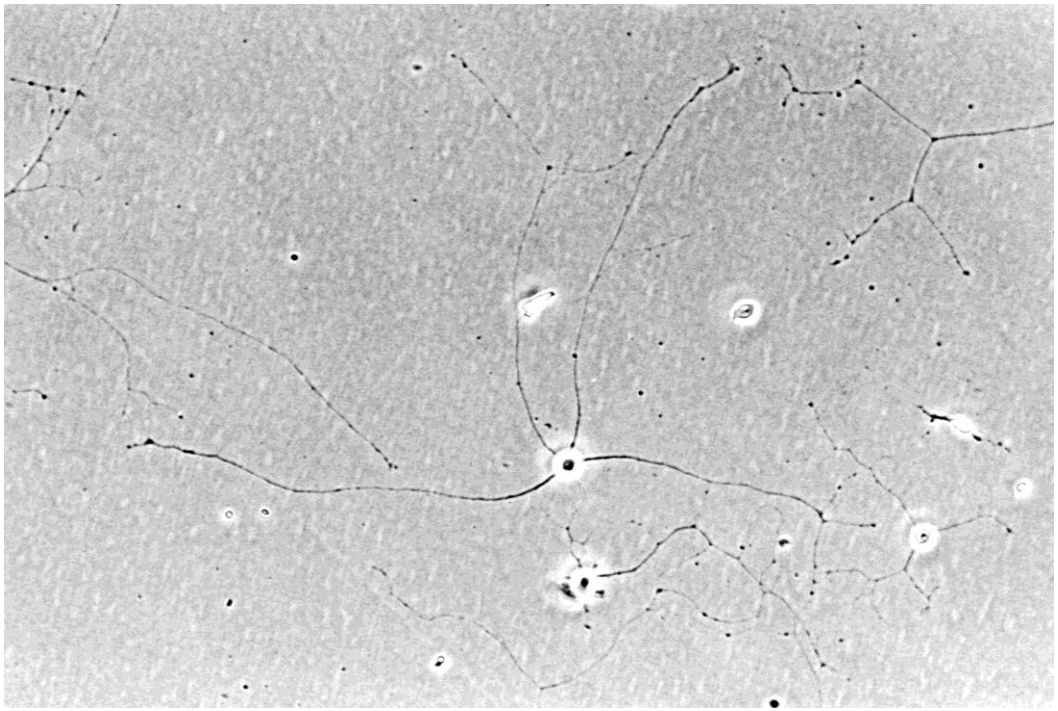




From Neuron to Brain, Nicholls et al., 4th ed.

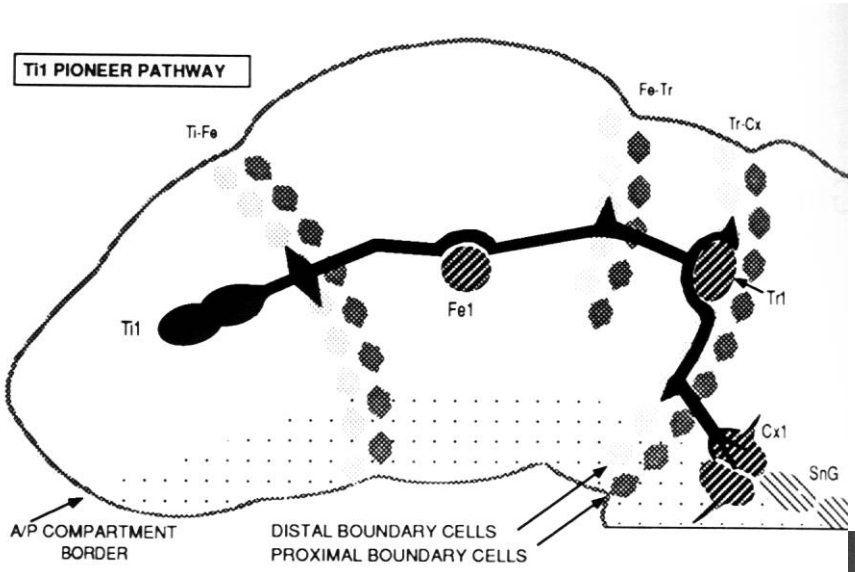
Neural connectivity
-
the basis of neural function

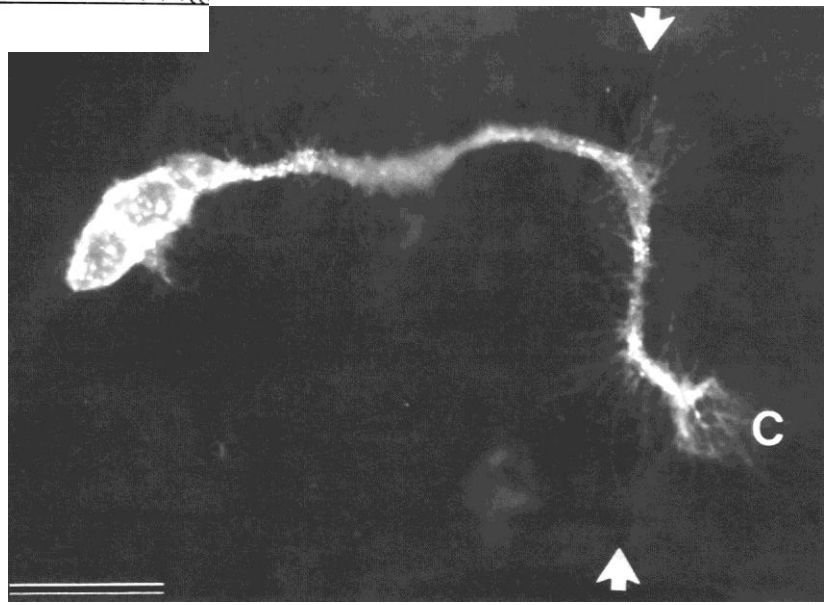
Neurons extend long processes to connect to their targets

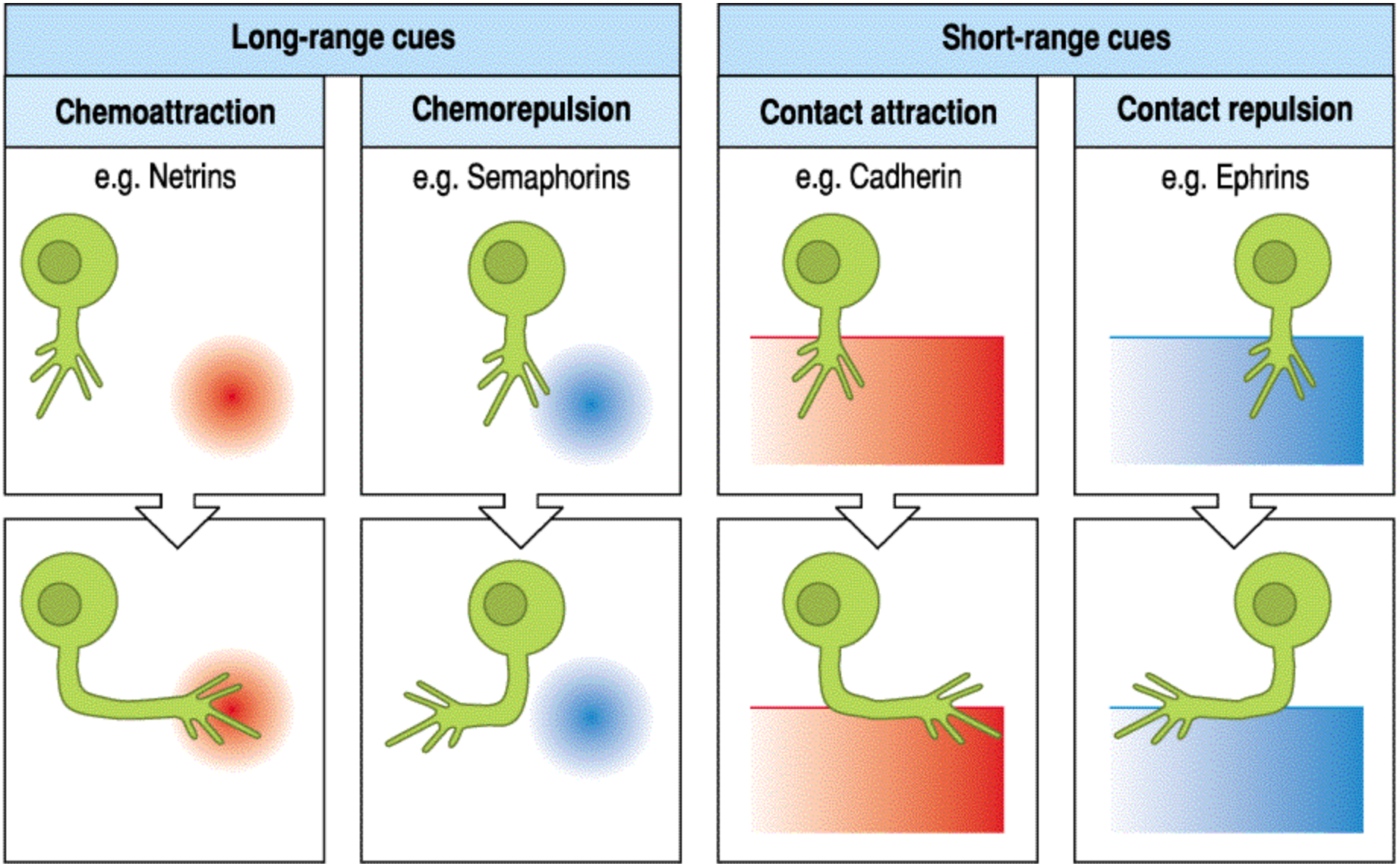


14 000 000 000 neurons are interconnected by fibers with a total length of 500 000 km

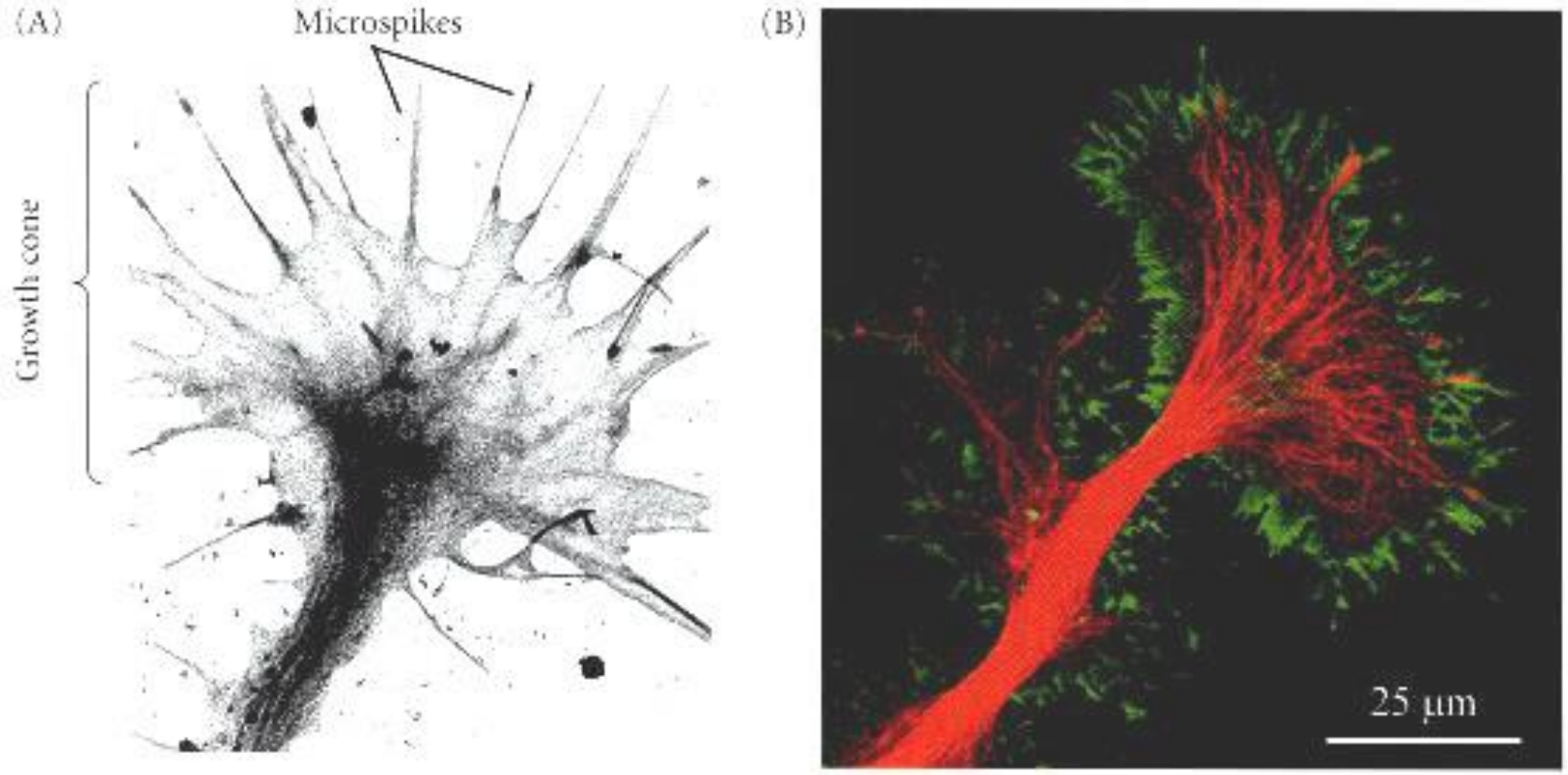
Axons use guidepost cells as intermediate targets





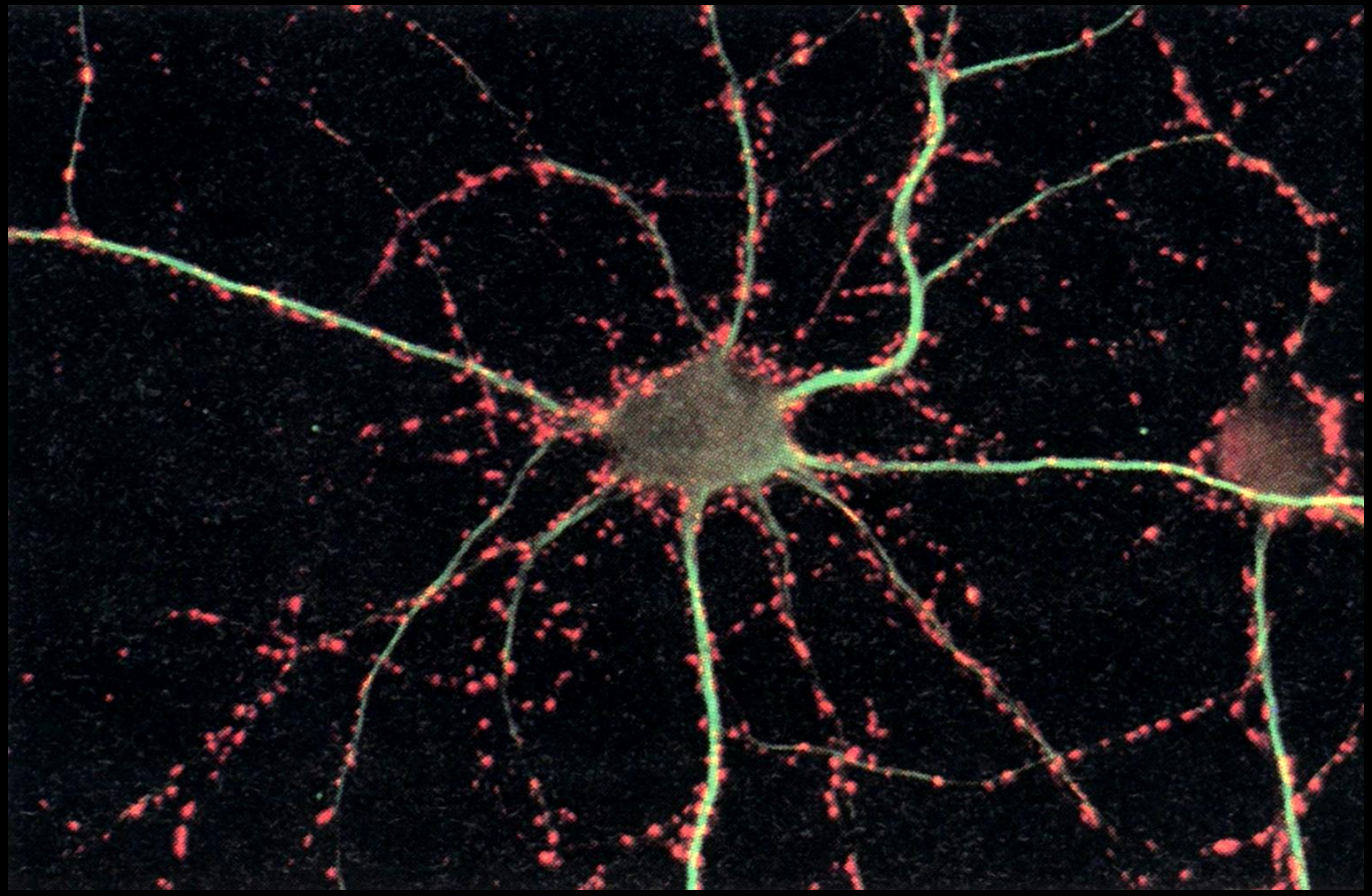

Long-range cues
Short-range cues
Chemoattraction
Chemorepulsion
Contact attraction
Contact repulsion
e.g. Netrins
e.g. Semaphorins
e.g. Cadherin
e.g. Ephrins

How is extracellular guidance information transmitted to intracellular signaling?

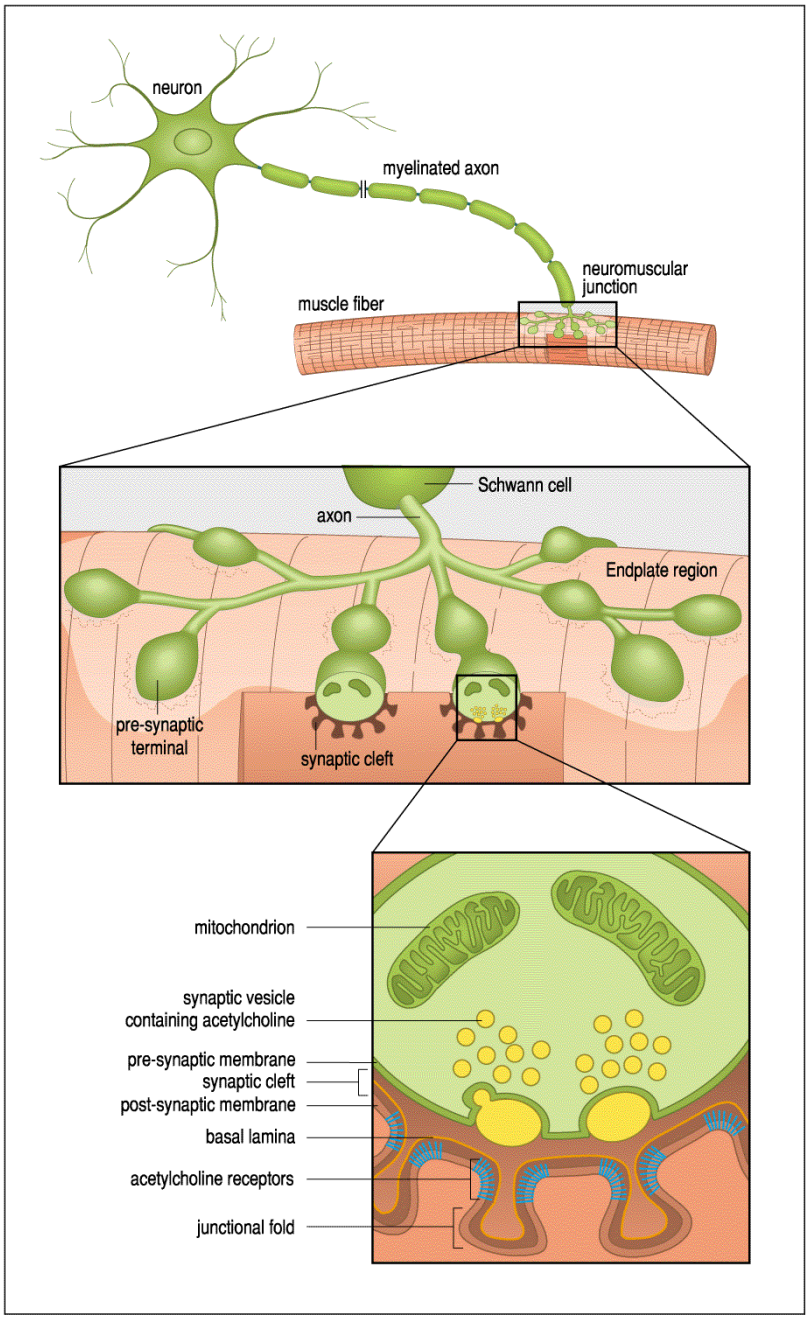

(A)
Microspikes
Growth cone
(B)
25 µm

Synapse Formation

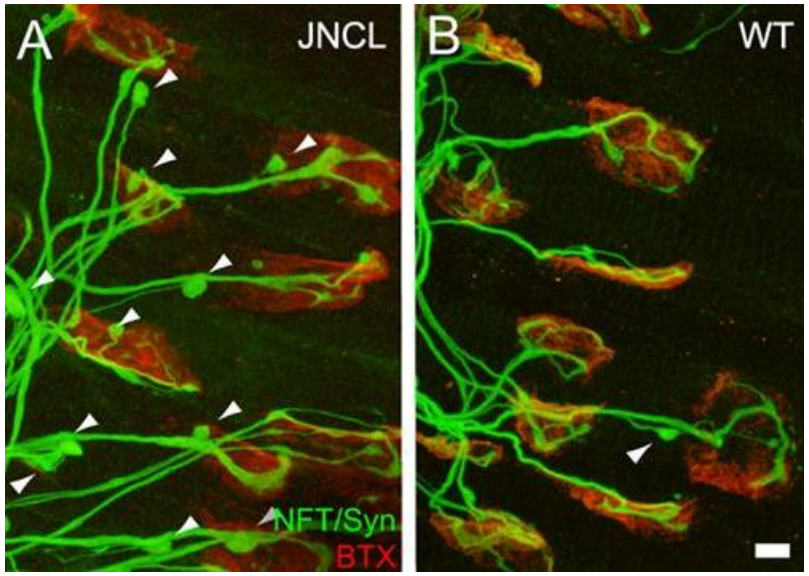
On average every neurons is connected to 1000 neurons

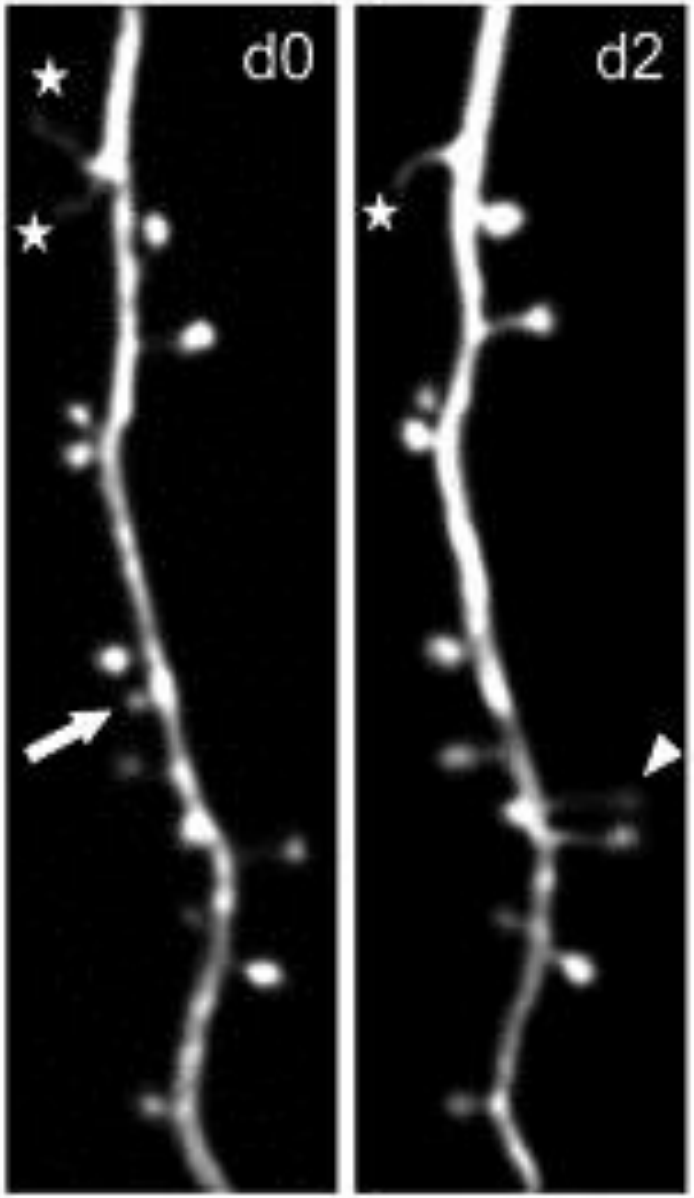


The neuromuscular junction is the best understood model for synapse formation



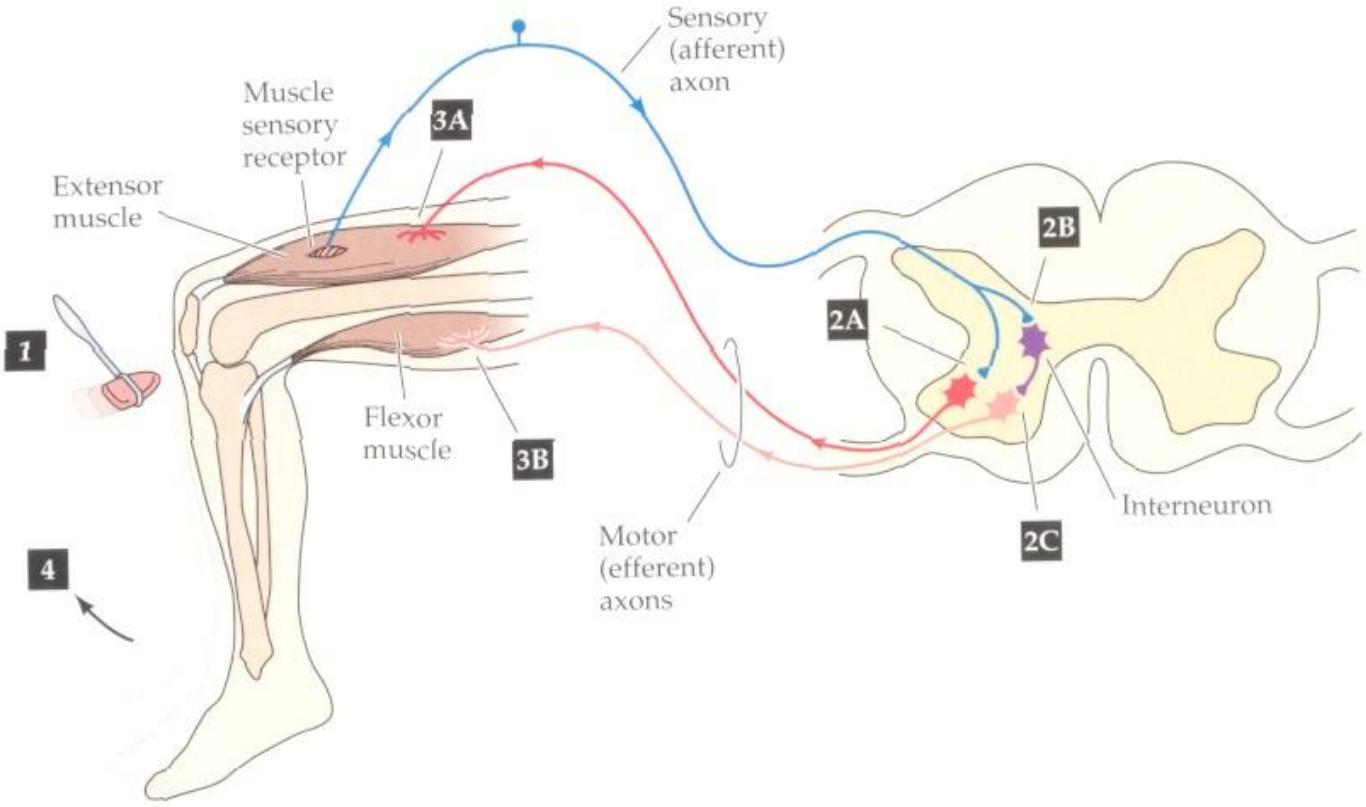
Both in the PNS and in the CNS synapses are eliminated during development and maturation

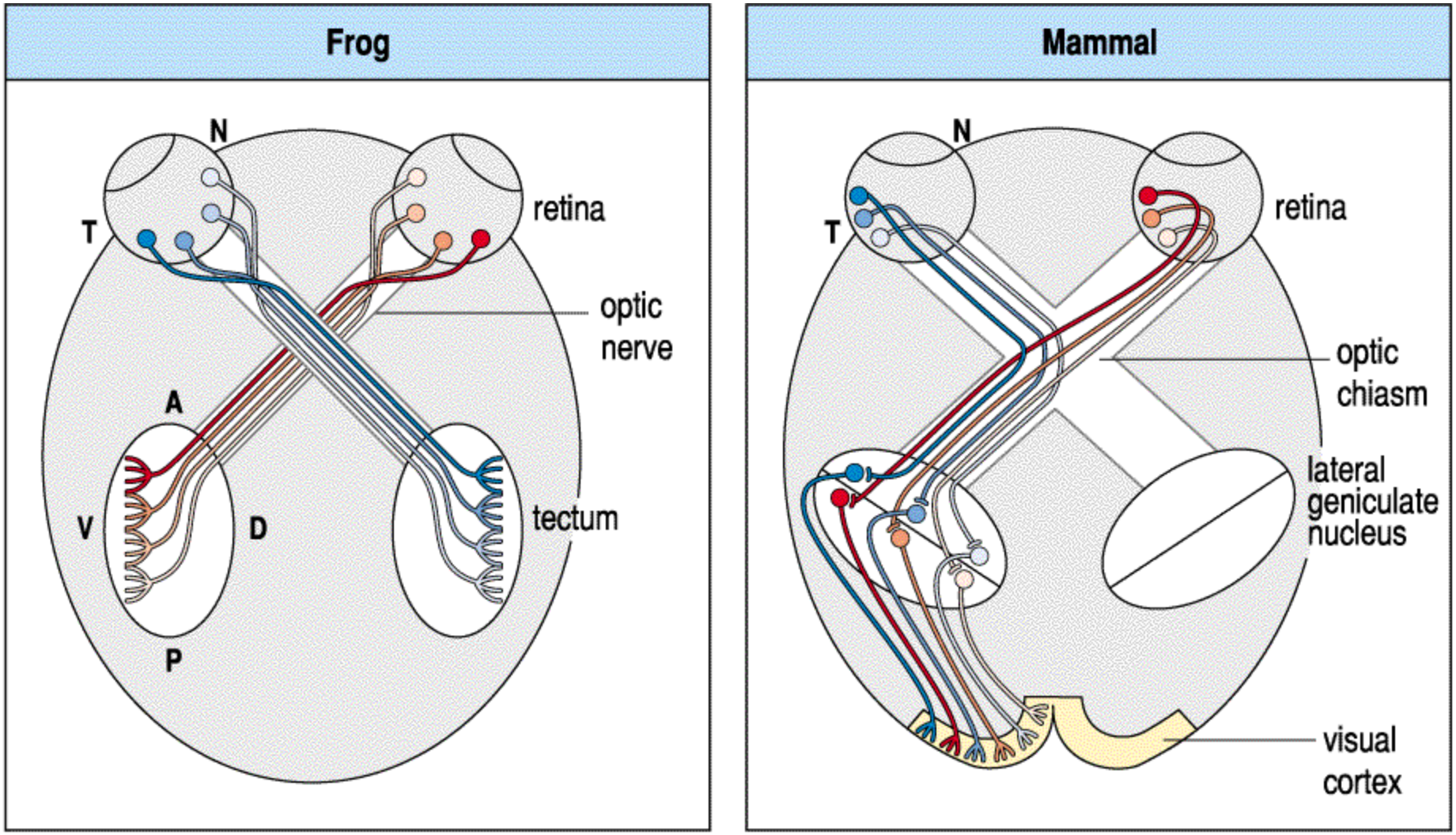




The formation of neural circuits

The stretch reflex




Frog
N
T
retina
optic
nerve
A
V
D
P
tectum
Mammal
N
T
retina
optic
chiasm
lateral
geniculate
nucleus
visual
cortex

From neural development to behavior

How simple nervous systems control behavior
or
what we can learn about the neural basis of behavior using simple model organisms

What happens when neural development goes wrong ?

Overview on developmental disorders and their molecular bases

mental retardation/intellectual disability
autism spectrum disorders
schizophrenia

You need to know:

Components of the Nervous System

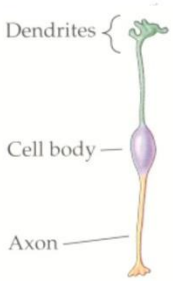
Central nervous system

neurons are arranged into nuclei or into layers
axons from tracts

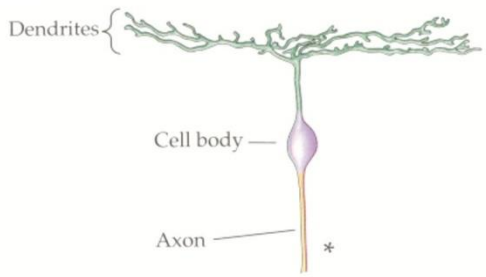
Peripheral nervous system

neurons are located in ganglia
axons form nerves

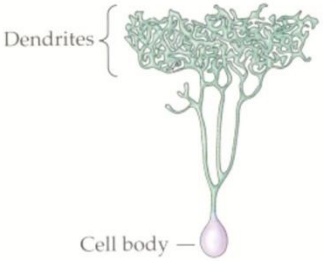
retinal bipolar cell

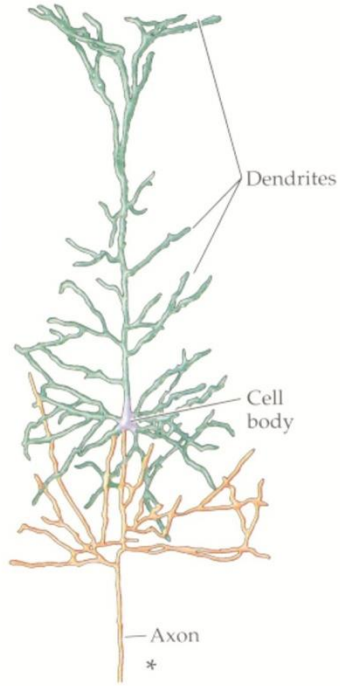


retinal ganglion cell

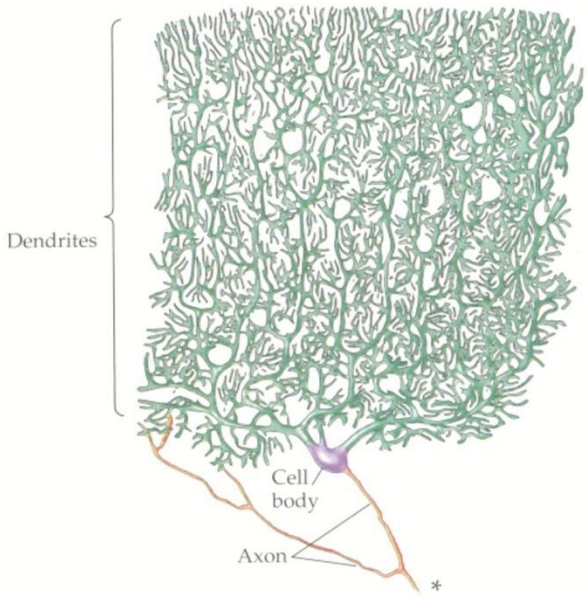


retinal amacrine cell



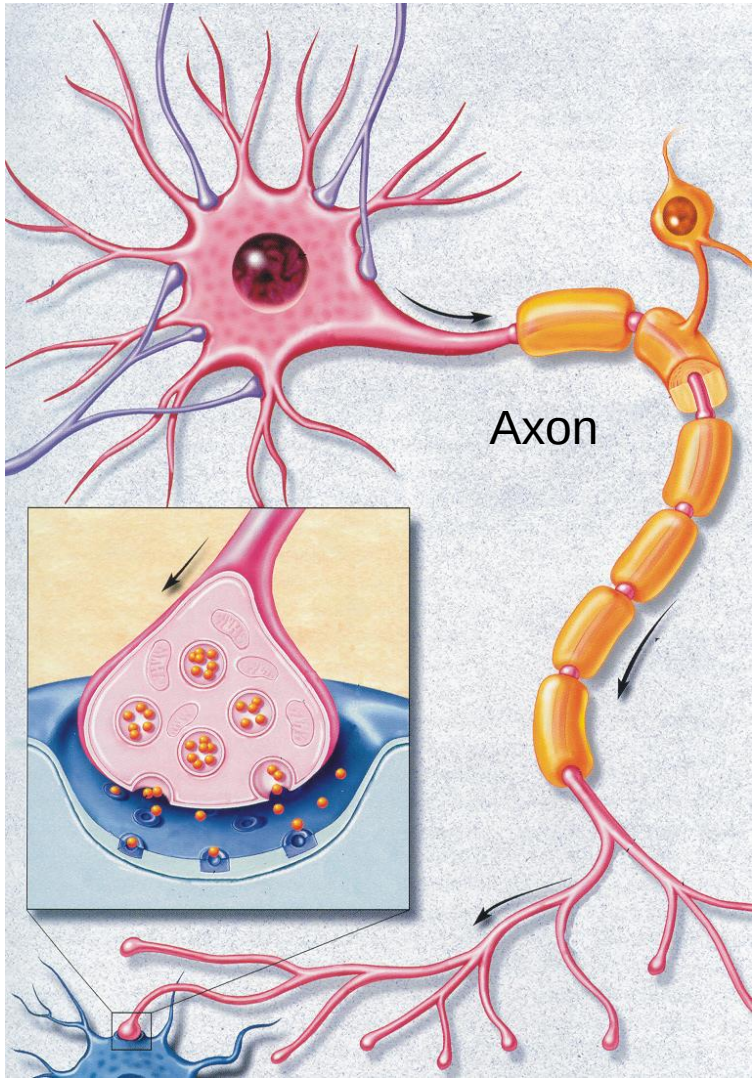


cortical pyramidal cell



cerebellar Purkinje cell

The neuron
is the basic cellular
element of the
nervous system



afferent neurons	neurons that carry information toward the CNS
interneurons	neurons participating in local aspects of a circuit
efferent neurons	neurons that carry information away from the CNS

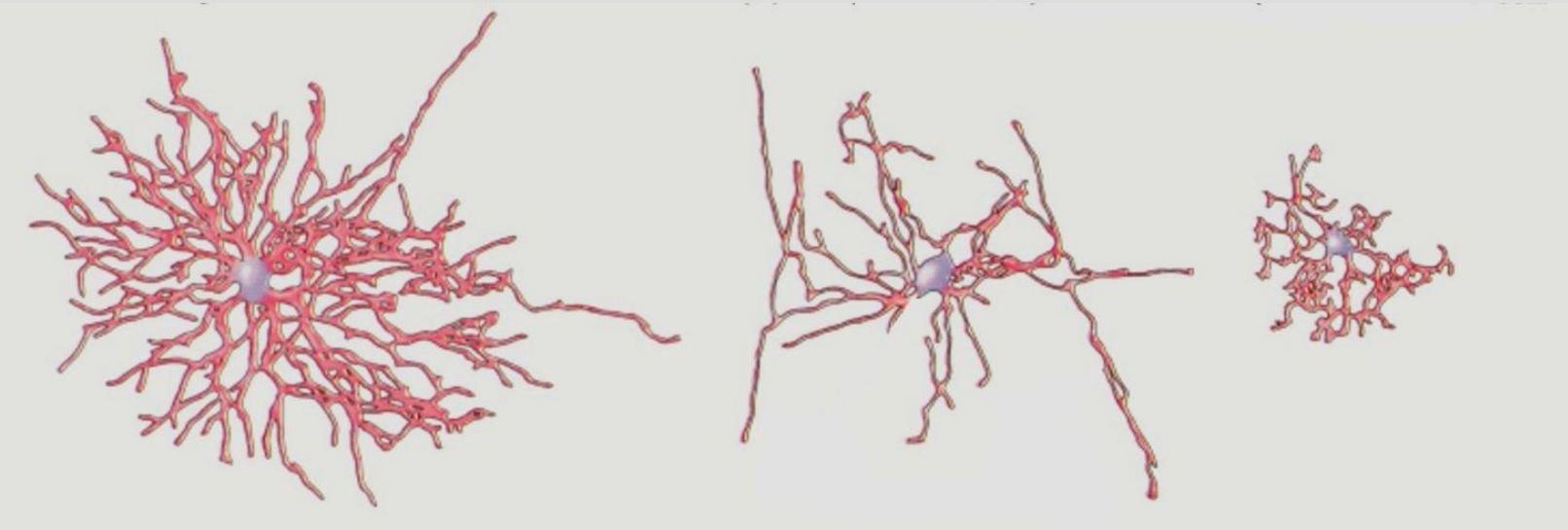
Glial cells

3 types of glial cells in the mature central nervous system:

astrocyte

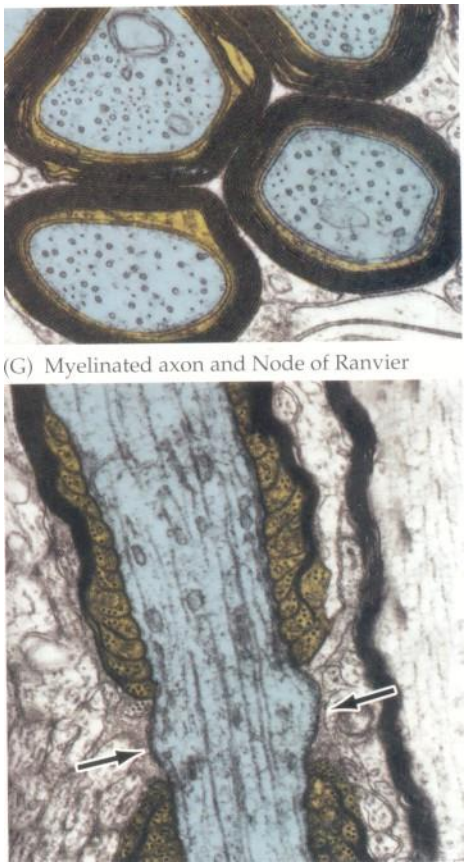
oligodendrocyte

microglial cell

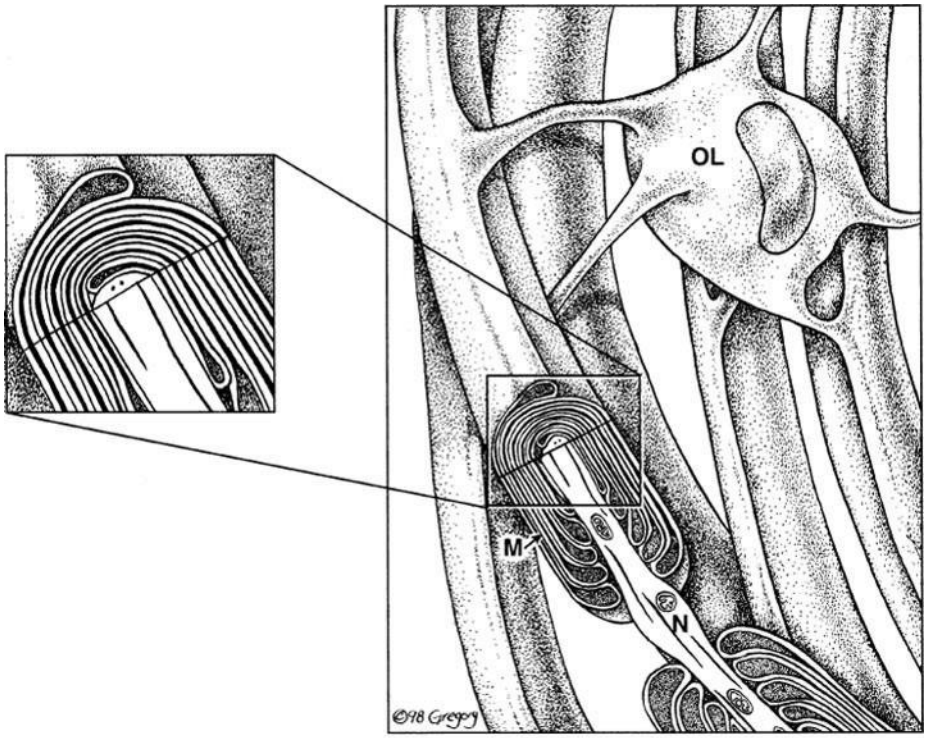


astrocytes	maintain chemical environment of neurons
oligodendrocytes (Schwann cells)	myelination
microglial cells	scavenger cells

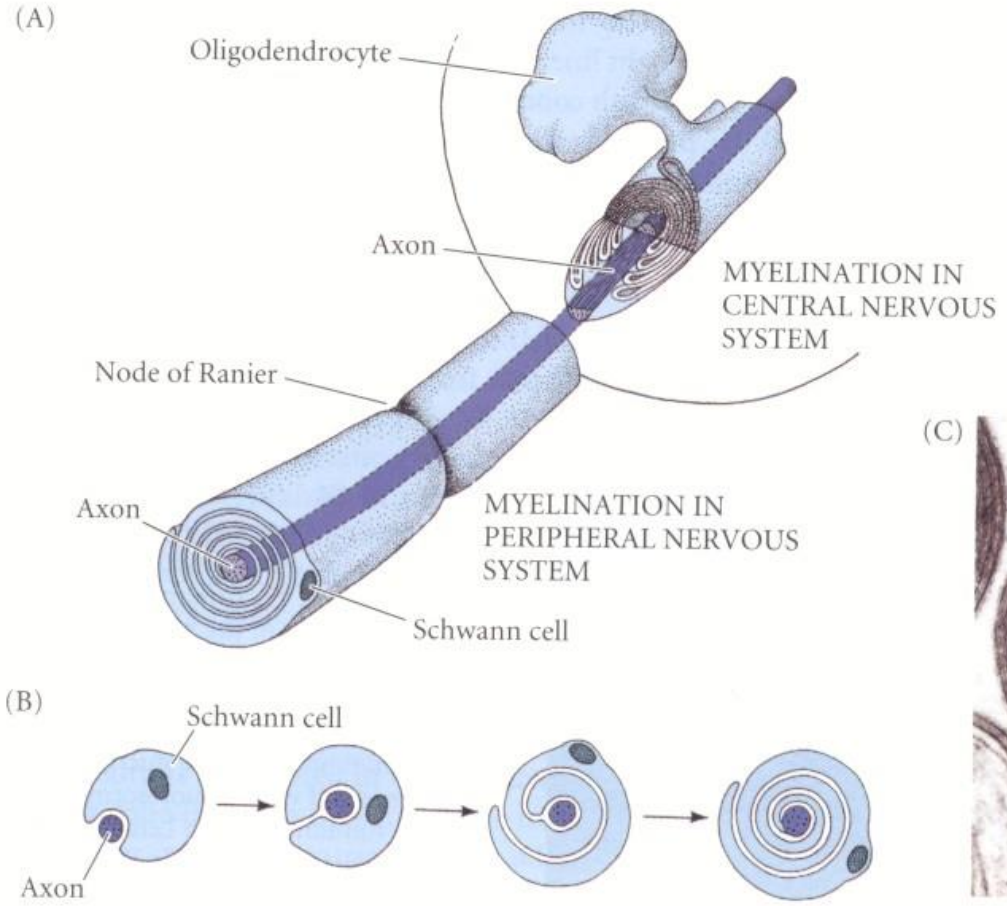
Myelination increases speed of action potential propagation

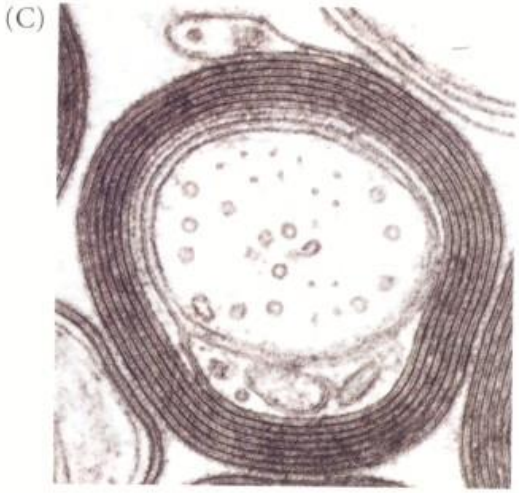


(G) Myelinated axon and Node of Ranvier



Similarities and differences of myelination in PNS and CNS





next week:

Neurogenesis