

# Review for Midterm

Dr. Johnson will hold a review for the upcoming exam on

**Sunday, 26 Jan 2020**

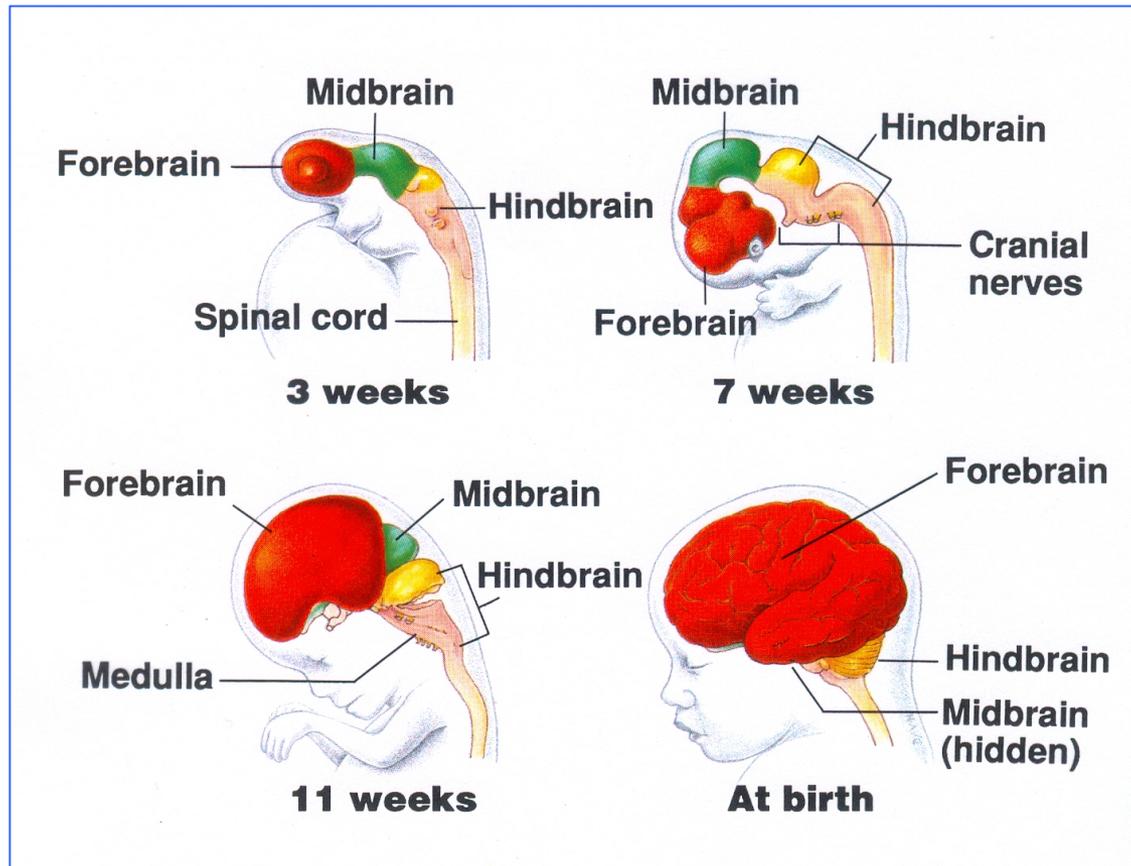
**3-4:20 pm**

**Peterson 110**

Bring your questions!

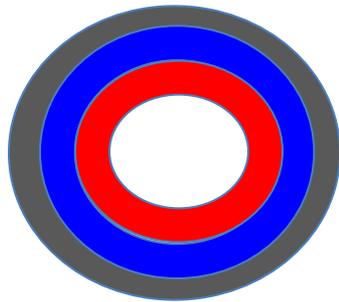
Lecture 3

# Development



# Embryonic Development

Initially, the embryo has 3 distinct layers of cells

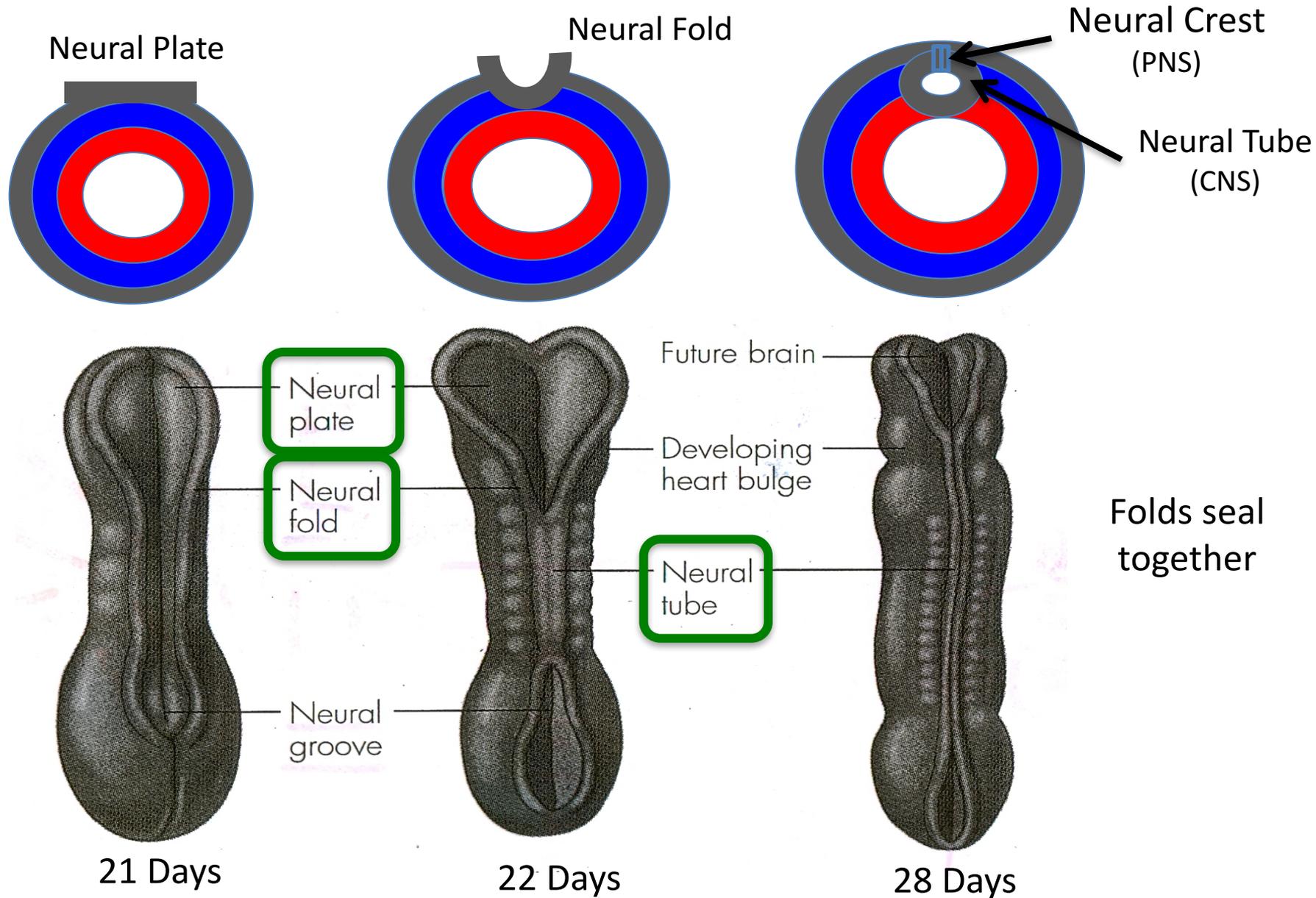


**Ectoderm** >> Nervous System & Skin

**Mesoderm** >> **Muscles, Bone**

**Endoderm** >> **Organs**

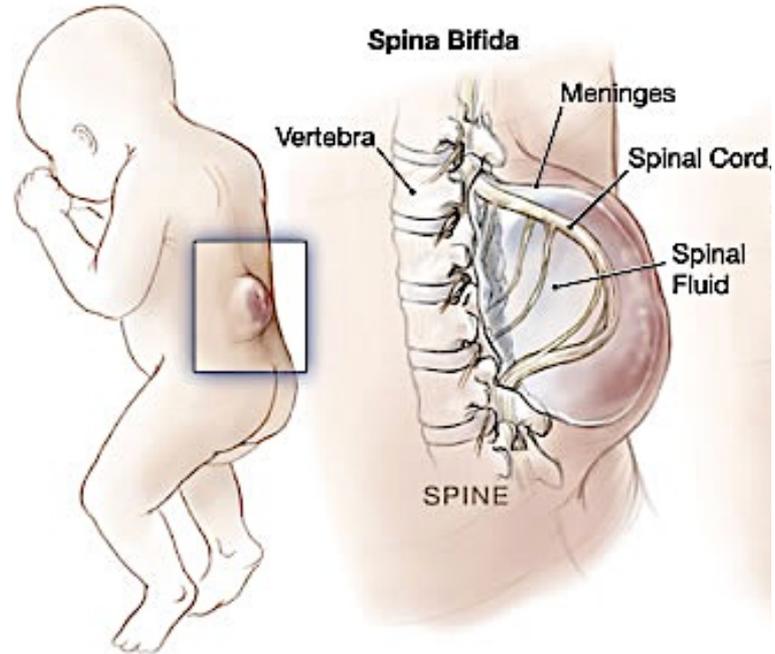
# Embryonic Development



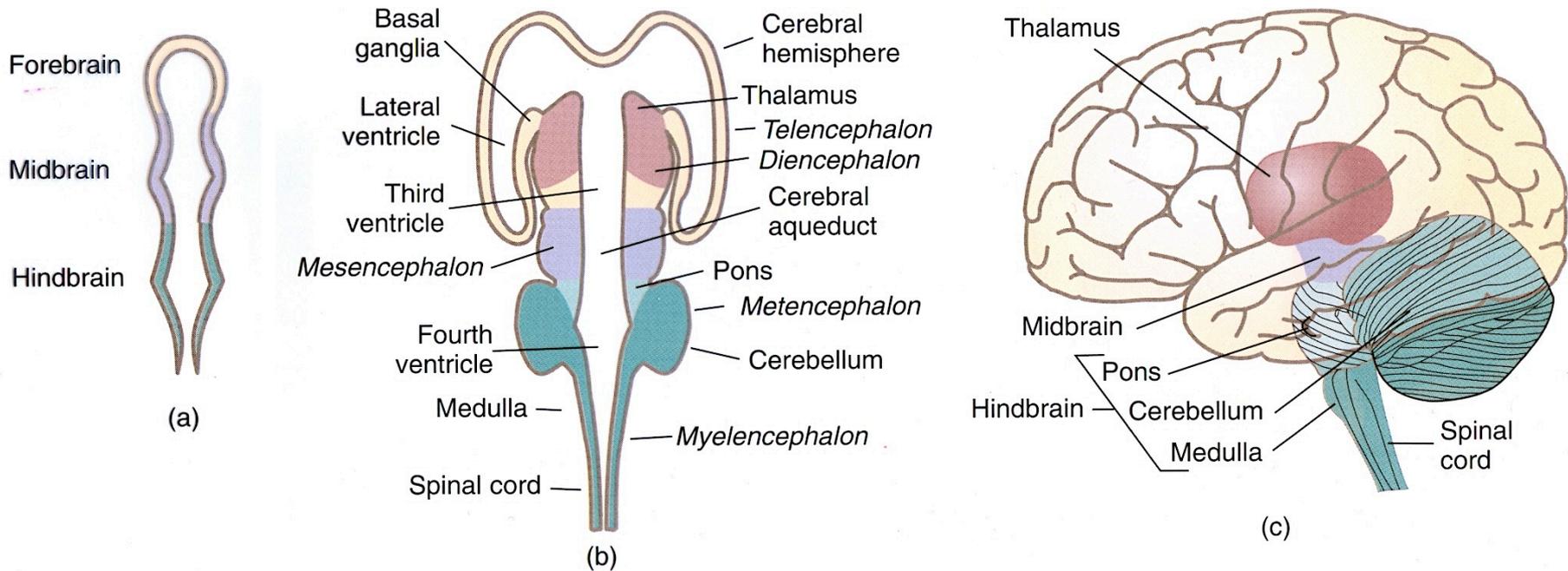
# Spina Bifida



**Neural Folds  
fail to join**



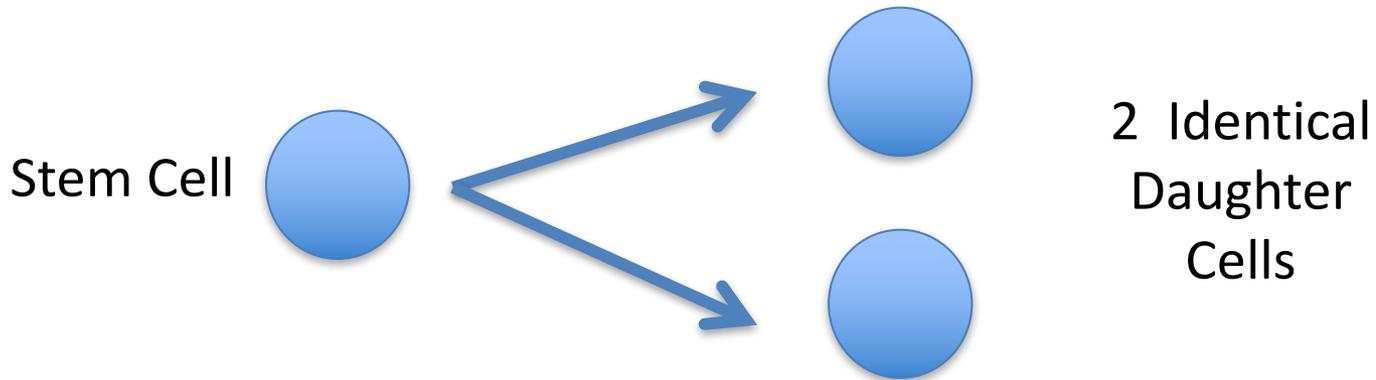
# Neural Tube develops into Forebrain, Midbrain & Hindbrain



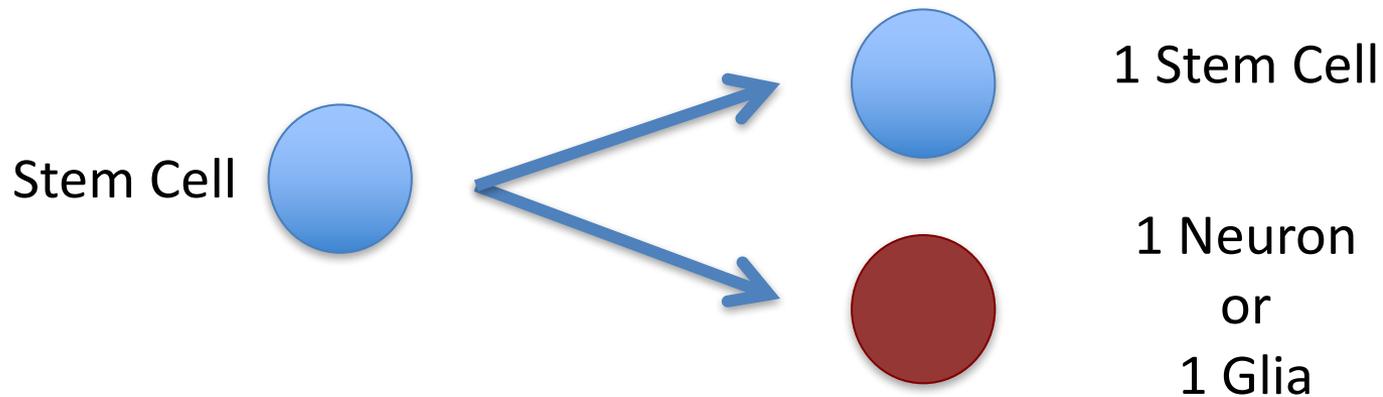
Hollow center becomes  
**Ventricles and Central Canal**

# Proliferation of cells

First 7 weeks: **SYMMETRICAL DIVISION**



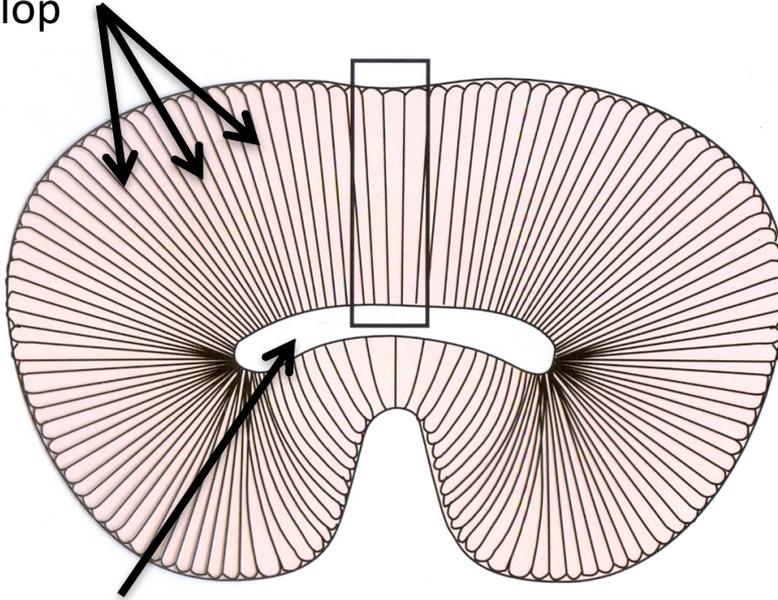
Then switch to **ASSYMMETRICAL DIVISION**



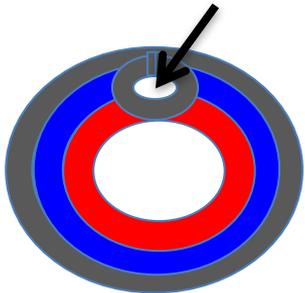
# Migration

## Radial Glia

One of the first types of Glia cells to develop



Ventricular Zone

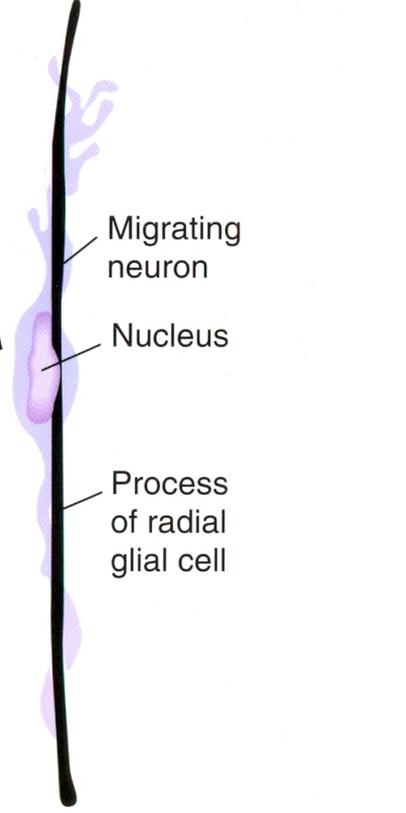
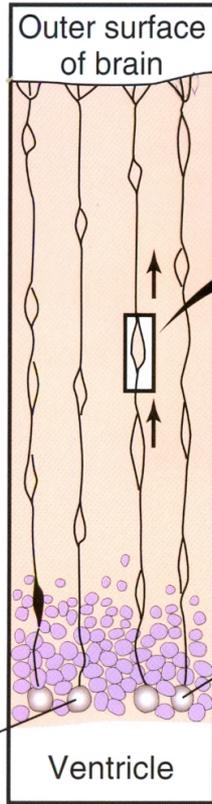
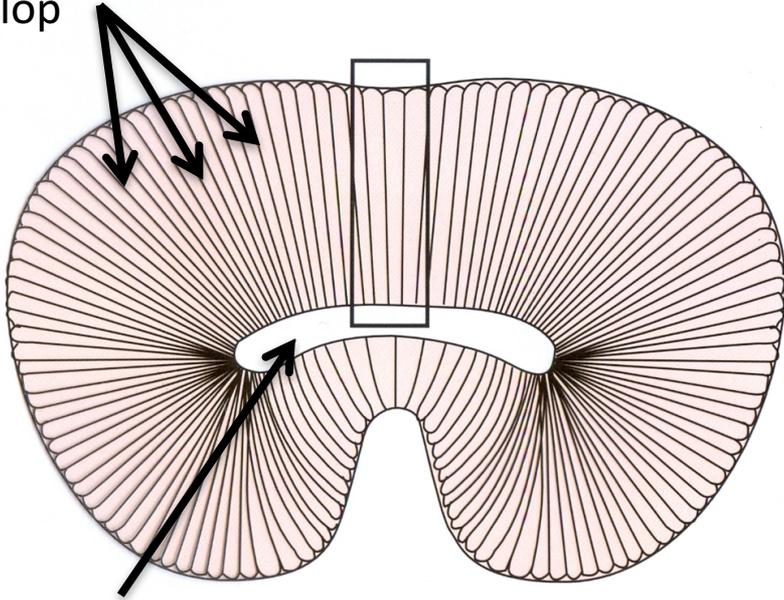


# Migration

## Radial Glia

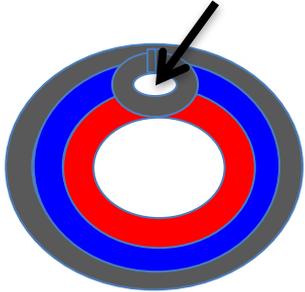
One of the first types of Glia cells to develop

As new cells accumulate in Ventricular Zone, the Neurons start to Migrate



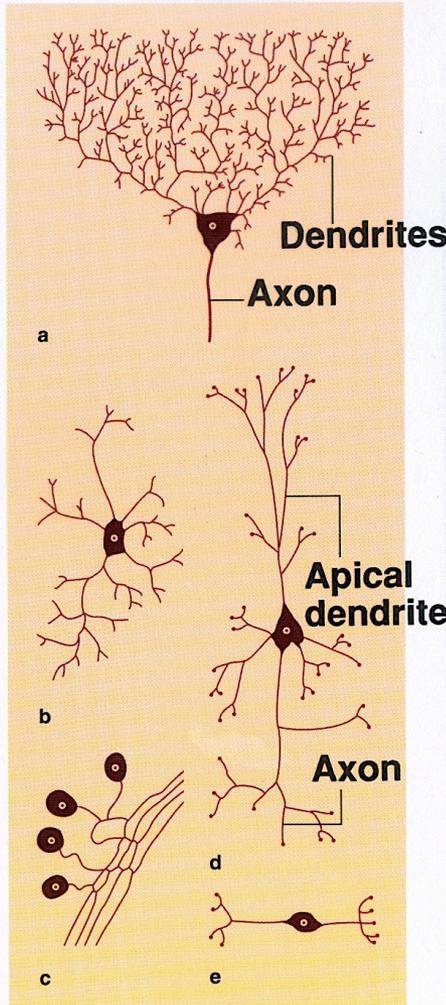
Newborn Neurons "crawl" along Radial Glia

## Ventricular Zone



Cells around wall of ventricle divide and give rise to neurons

# Differentiation

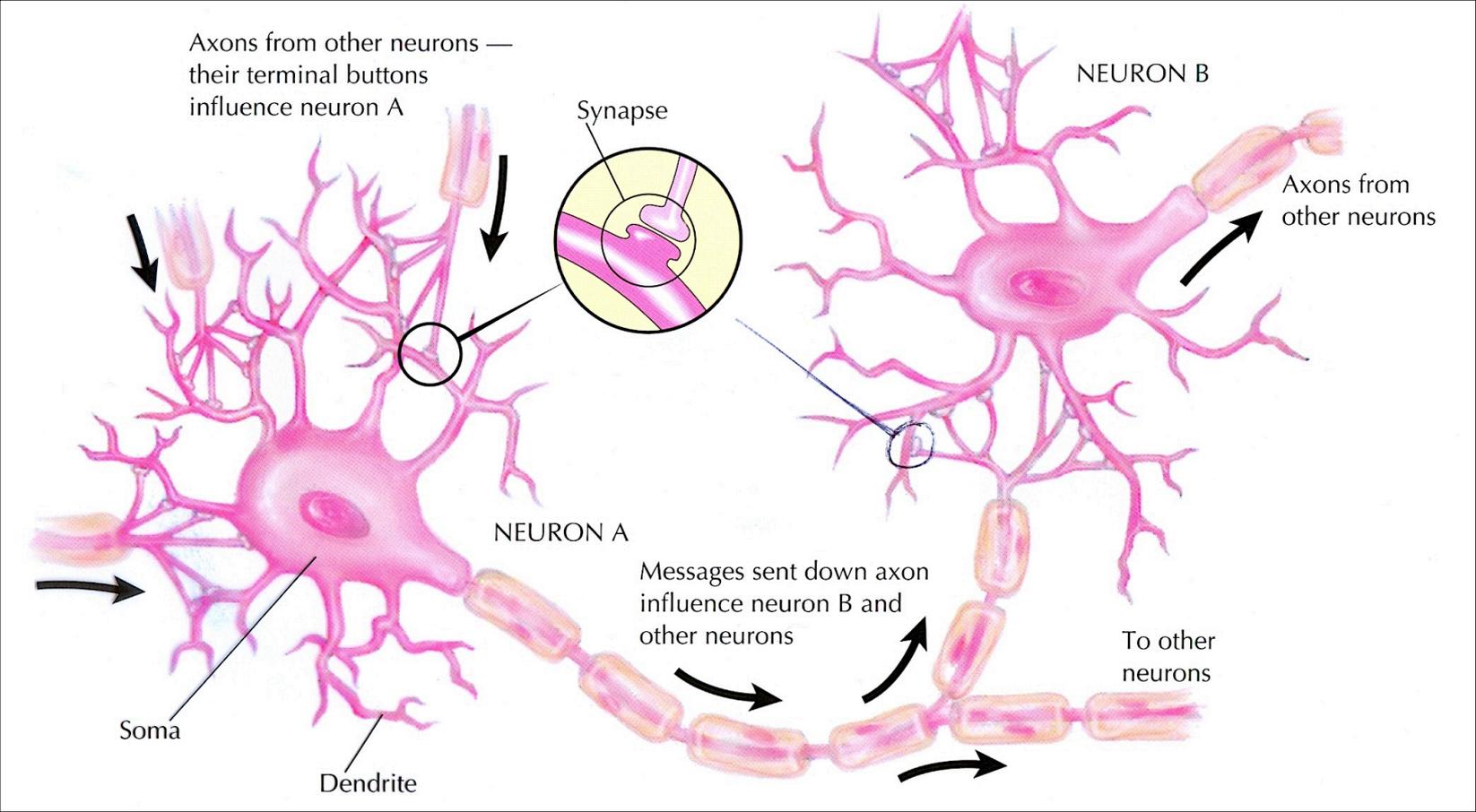


Once in place,  
Neurons begin to  
differentiate  
into a wide variety  
of cell types

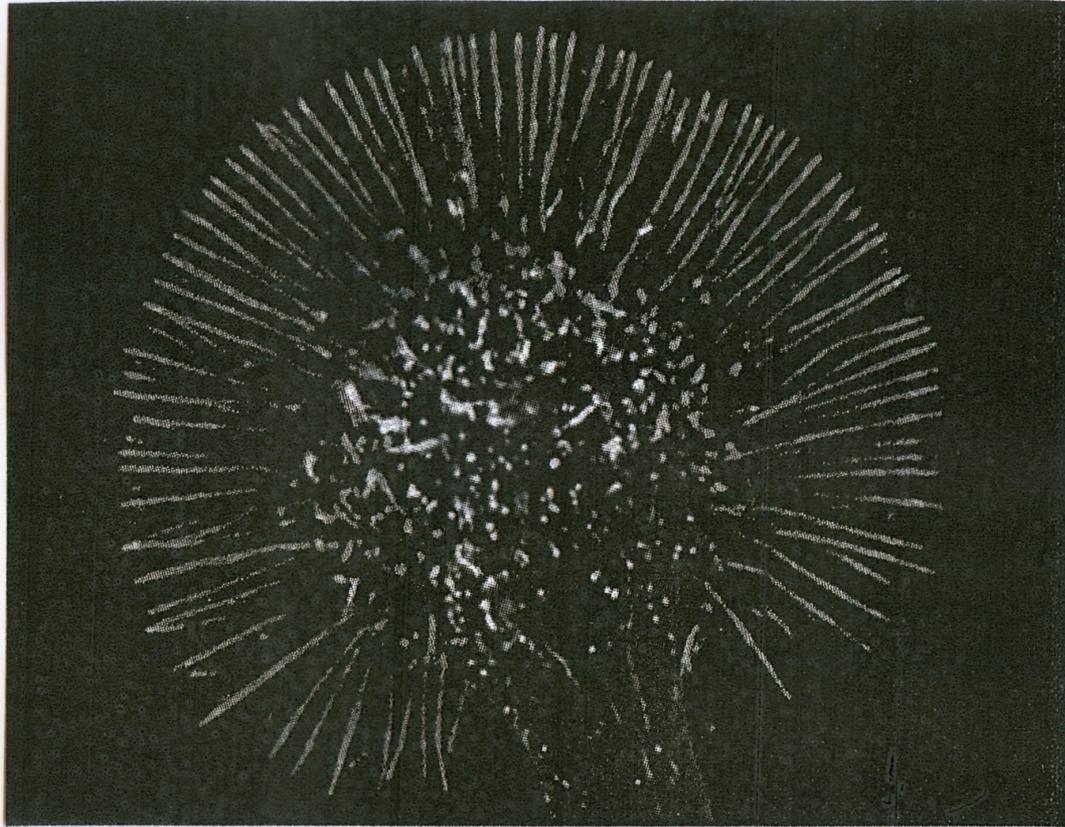
Influenced by  
**Cell Autonomous**  
(genetic) and  
**Induction**  
(environmental)  
factors

# Synaptogenesis

Forming the critical CONNECTIONS between neurons



# Synaptogenesis



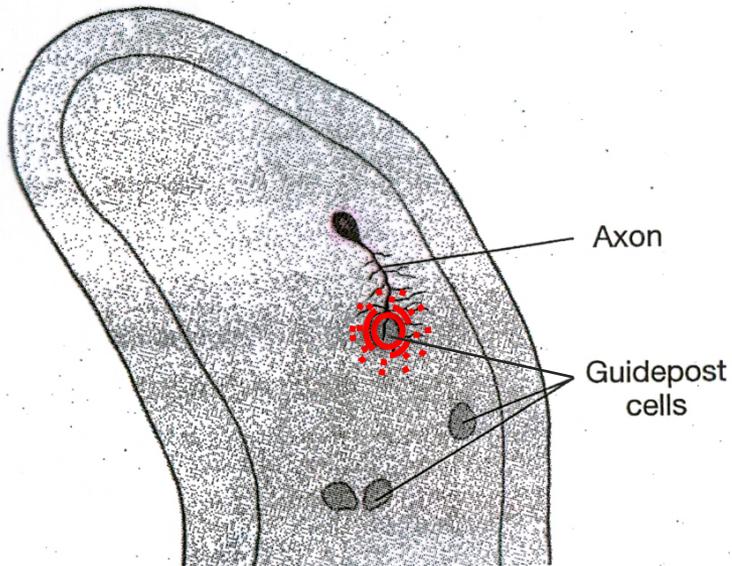
**Figure 3.10 The growth cone.** This micrograph, a photograph taken by an electron microscope at extremely high magnification, shows the growth cone of a developing neuron with its many filopodia.

At this stage,  
the terminal of the axon  
is a ciliated  
**Growth Cone**

Its cilia are called  
**Filopodia**

# Synaptogenesis

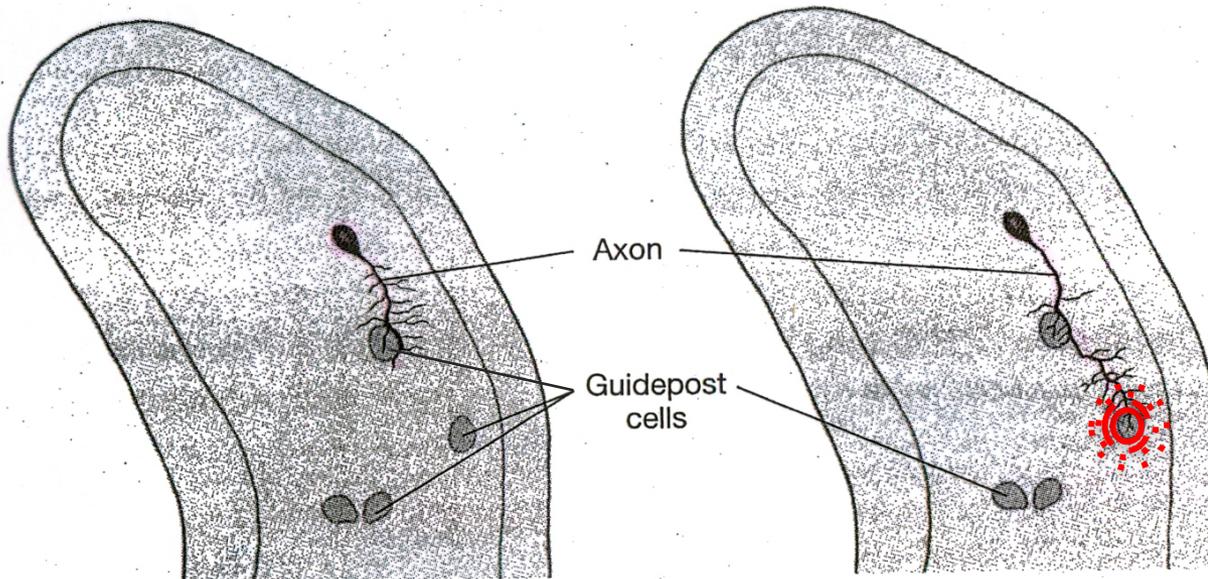
Glia cells, called "**Guidepost Cells**",  
ooze neurotrophins that  
attract/repel axon Growth Cones



Time 1

# Synaptogenesis

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ooze neurotrophins that  
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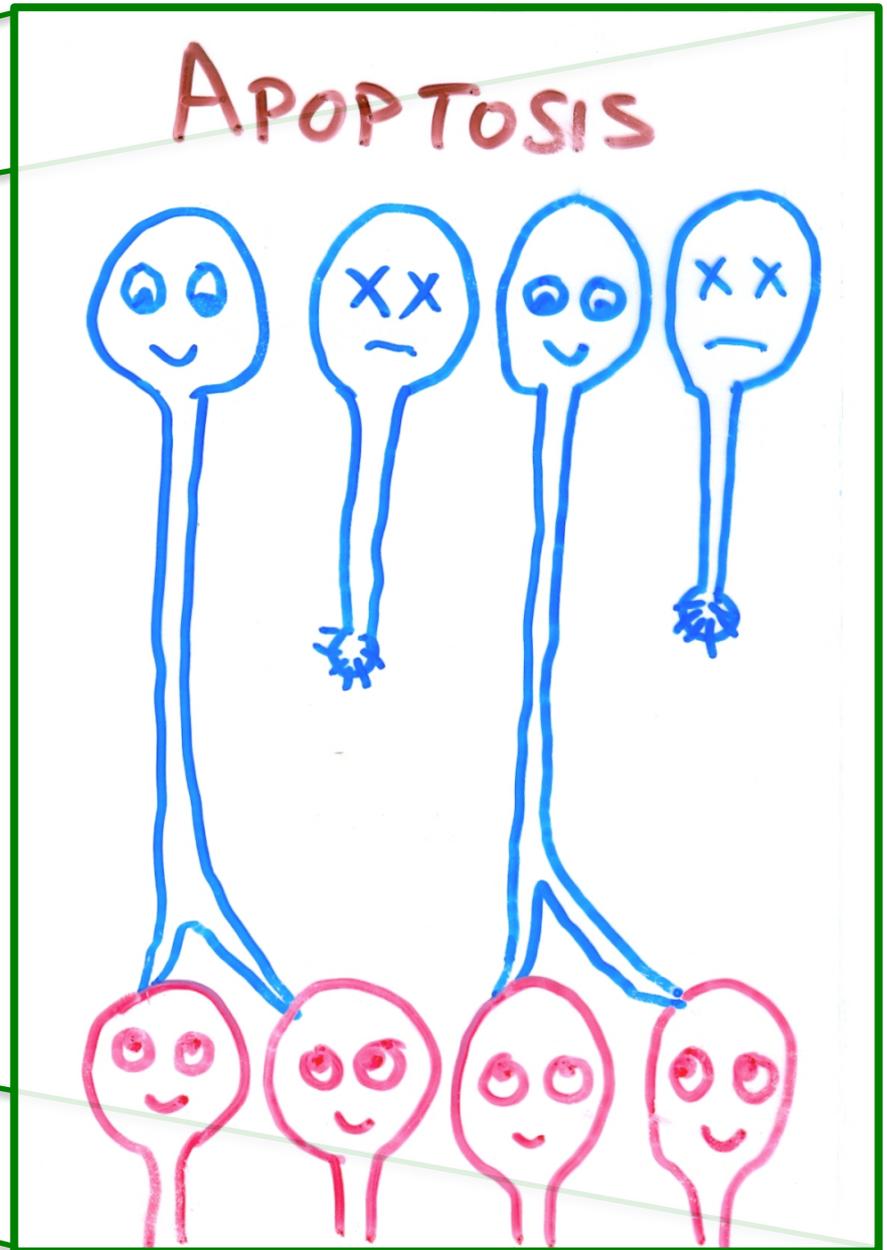
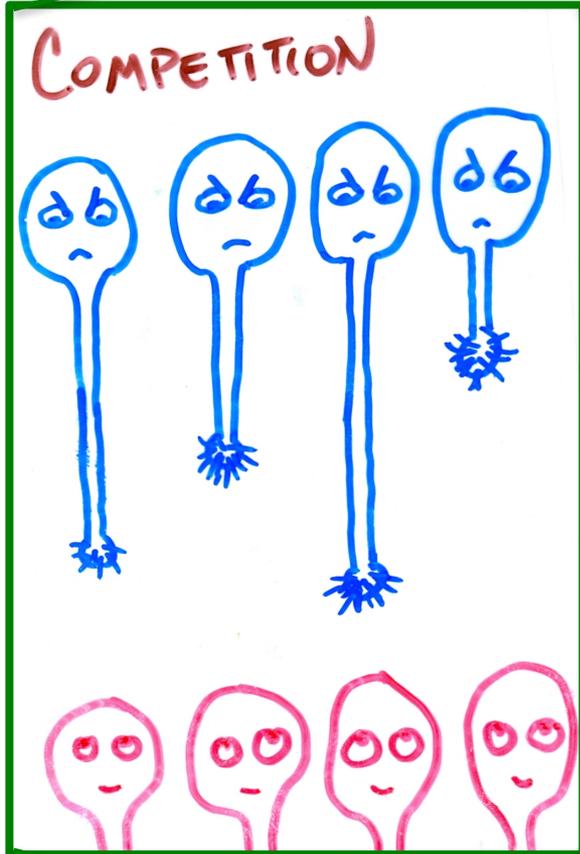
Time 1

Time 2



# Synaptogenesis

A competitive process



--- Time ---

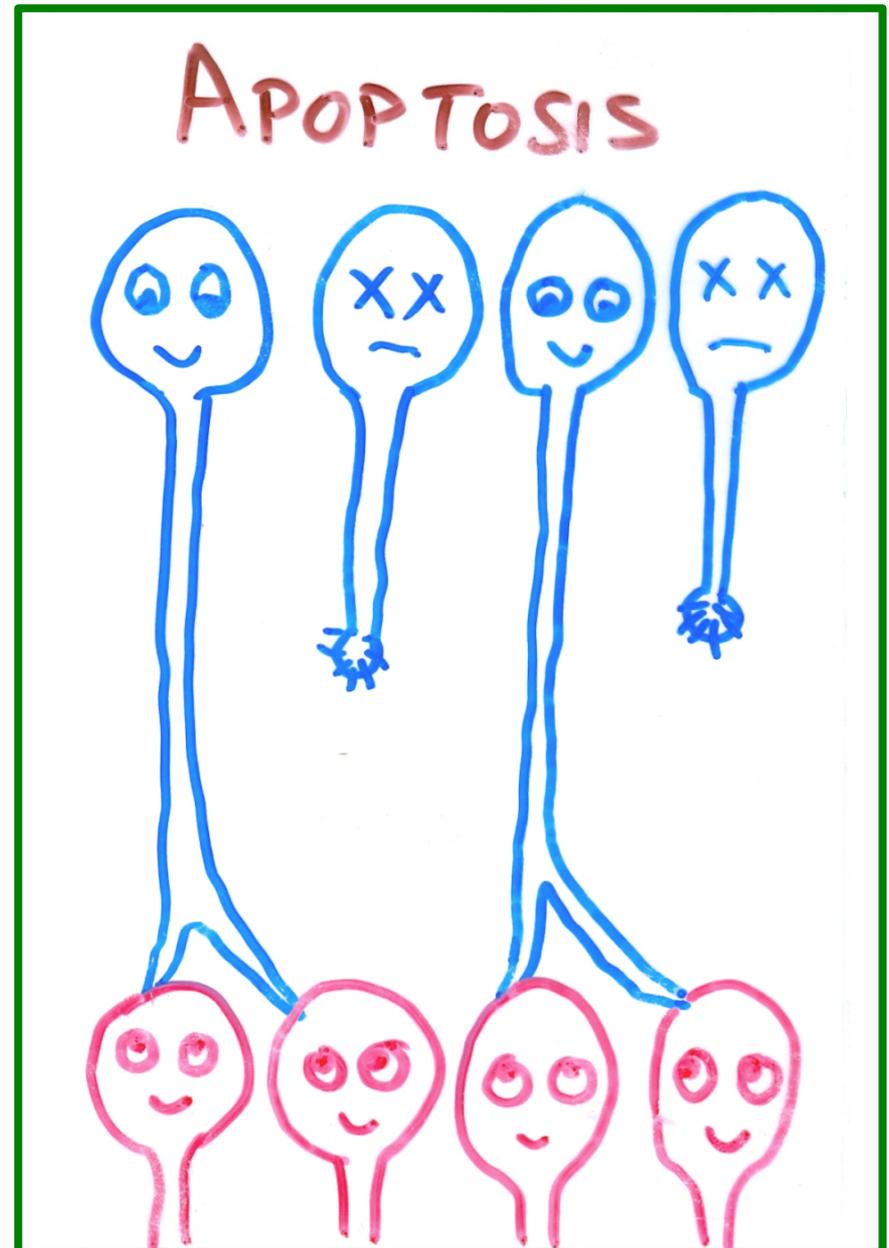
# Synaptogenesis

## Apoptosis

Cell Suicide

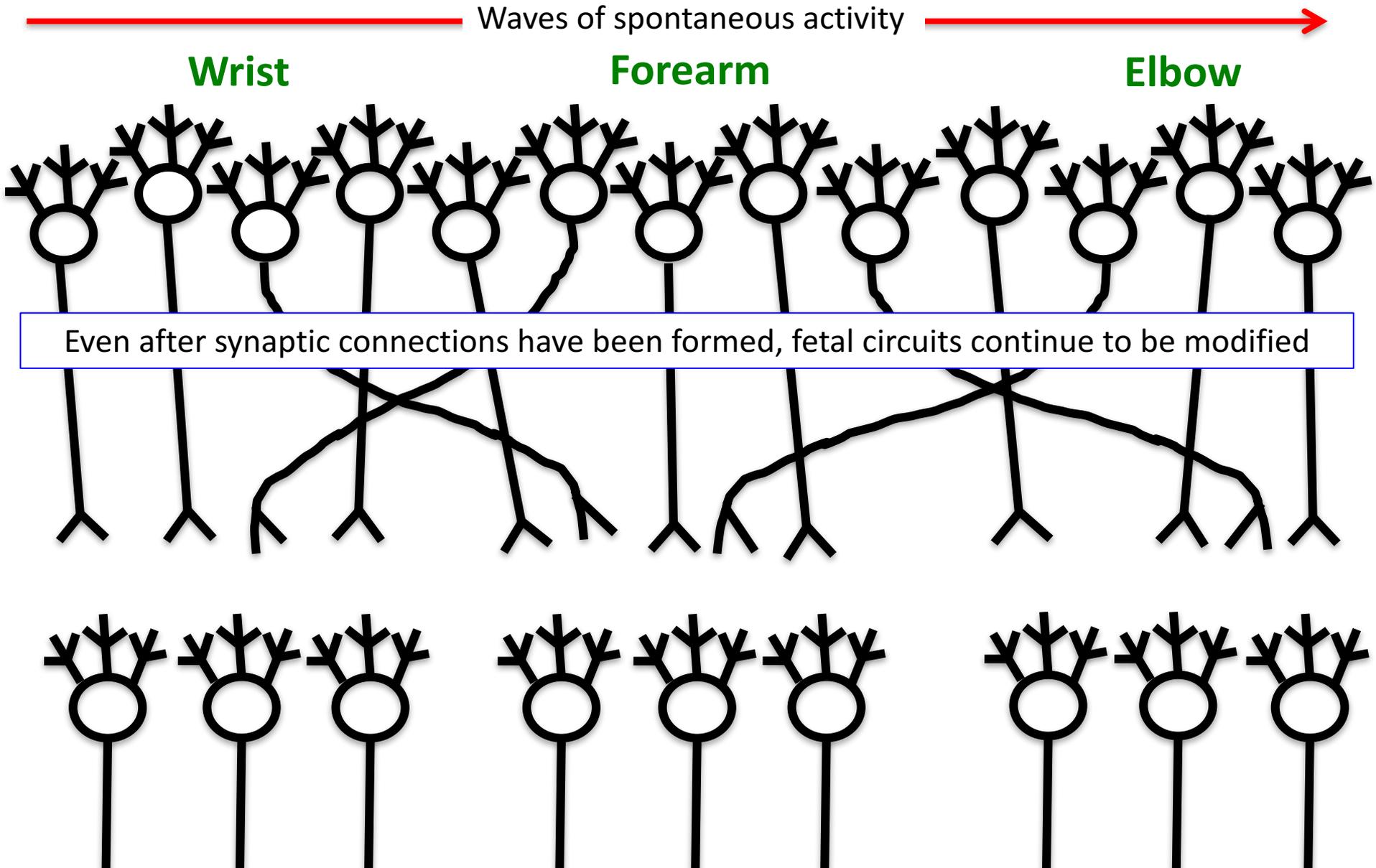
Neurons are massively OVER-produced  
in the fetal brain  
(50% more than present at birth!)  
and then selectively die off

The less fit, less well-connected cells  
are culled,  
so only the most fit, best-connected persist

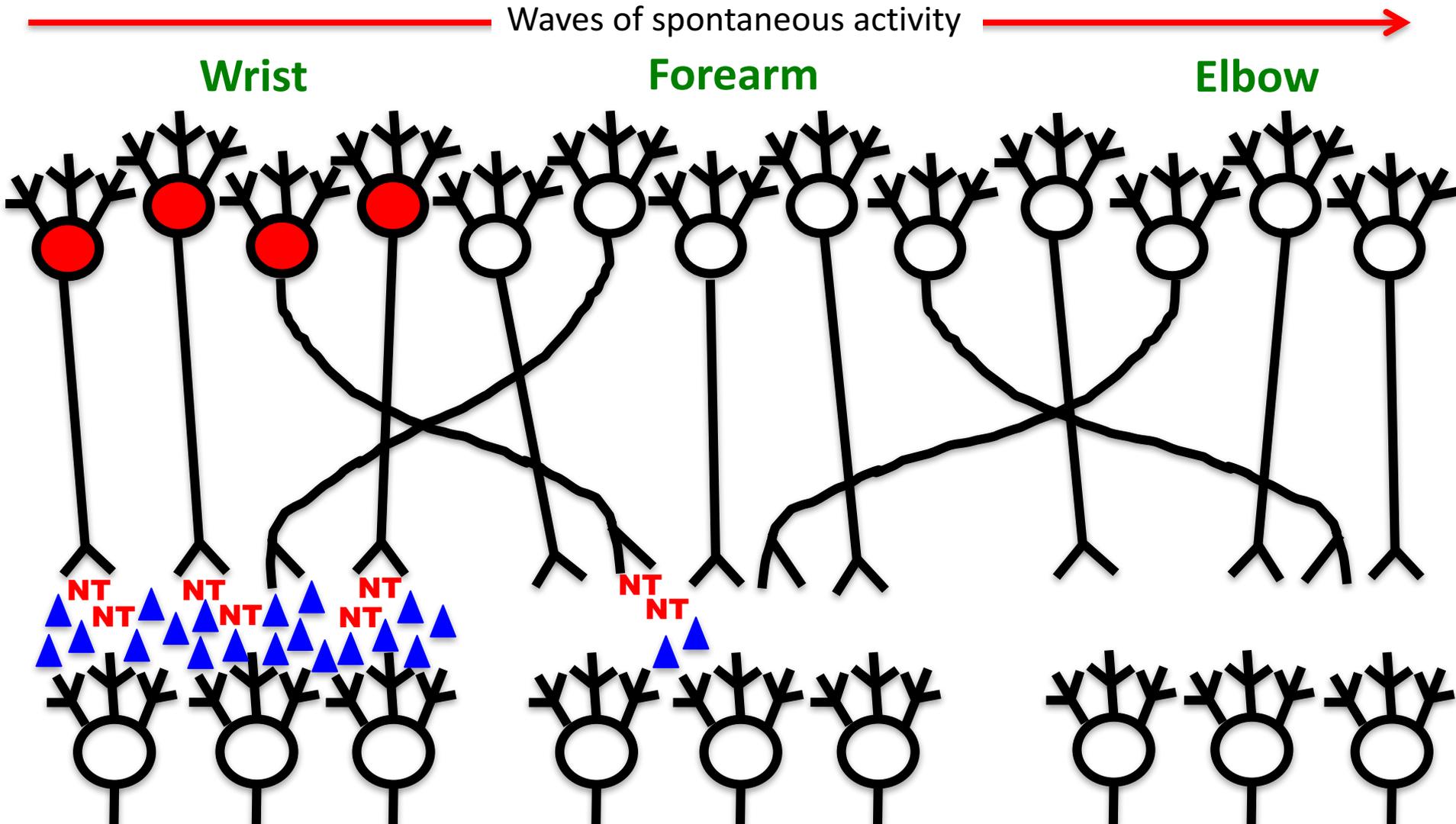


# Cells that Fire Together, Wire Together

# Cells that Fire Together, Wire Together

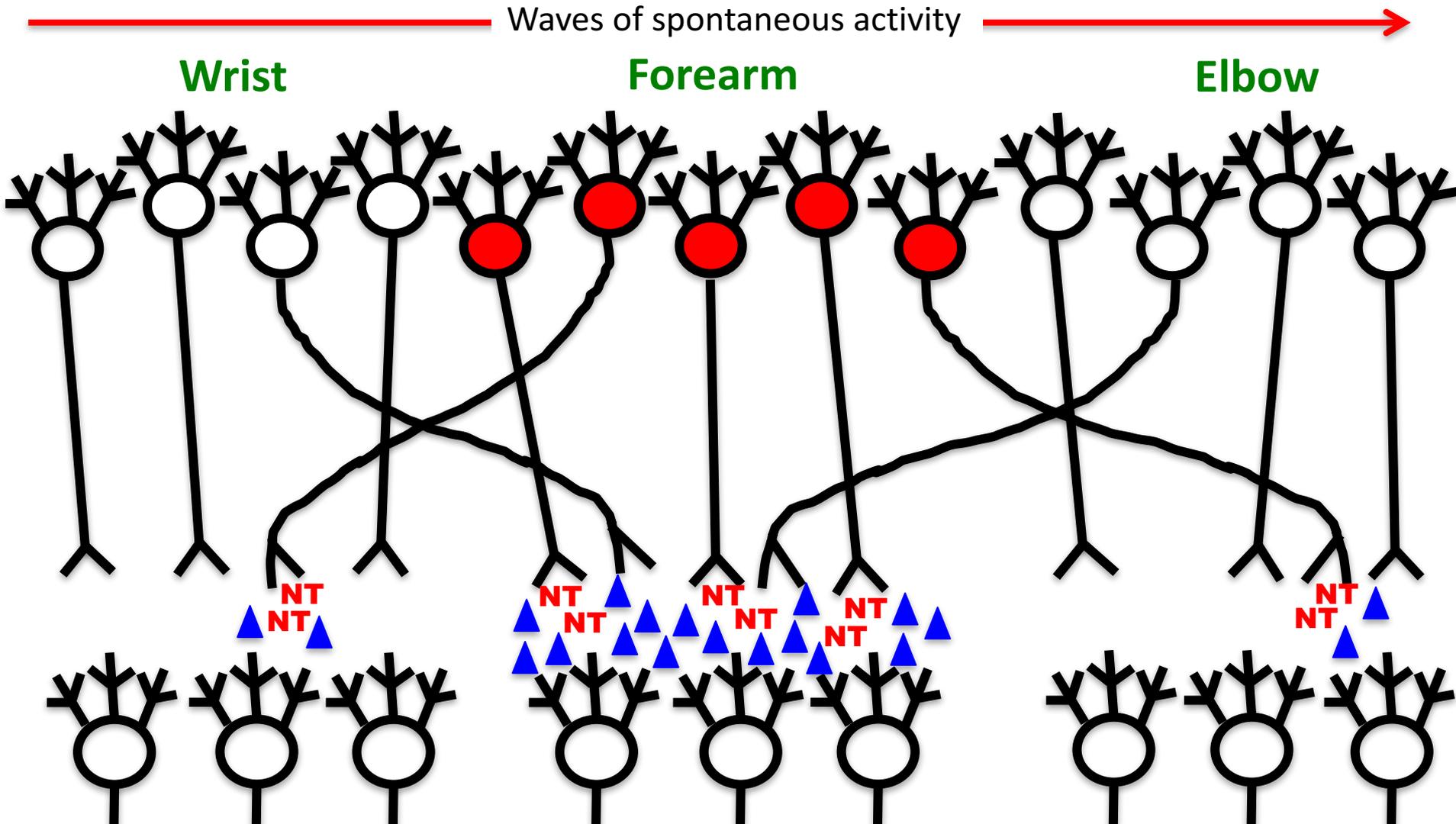


# Cells that Fire Together, Wire Together



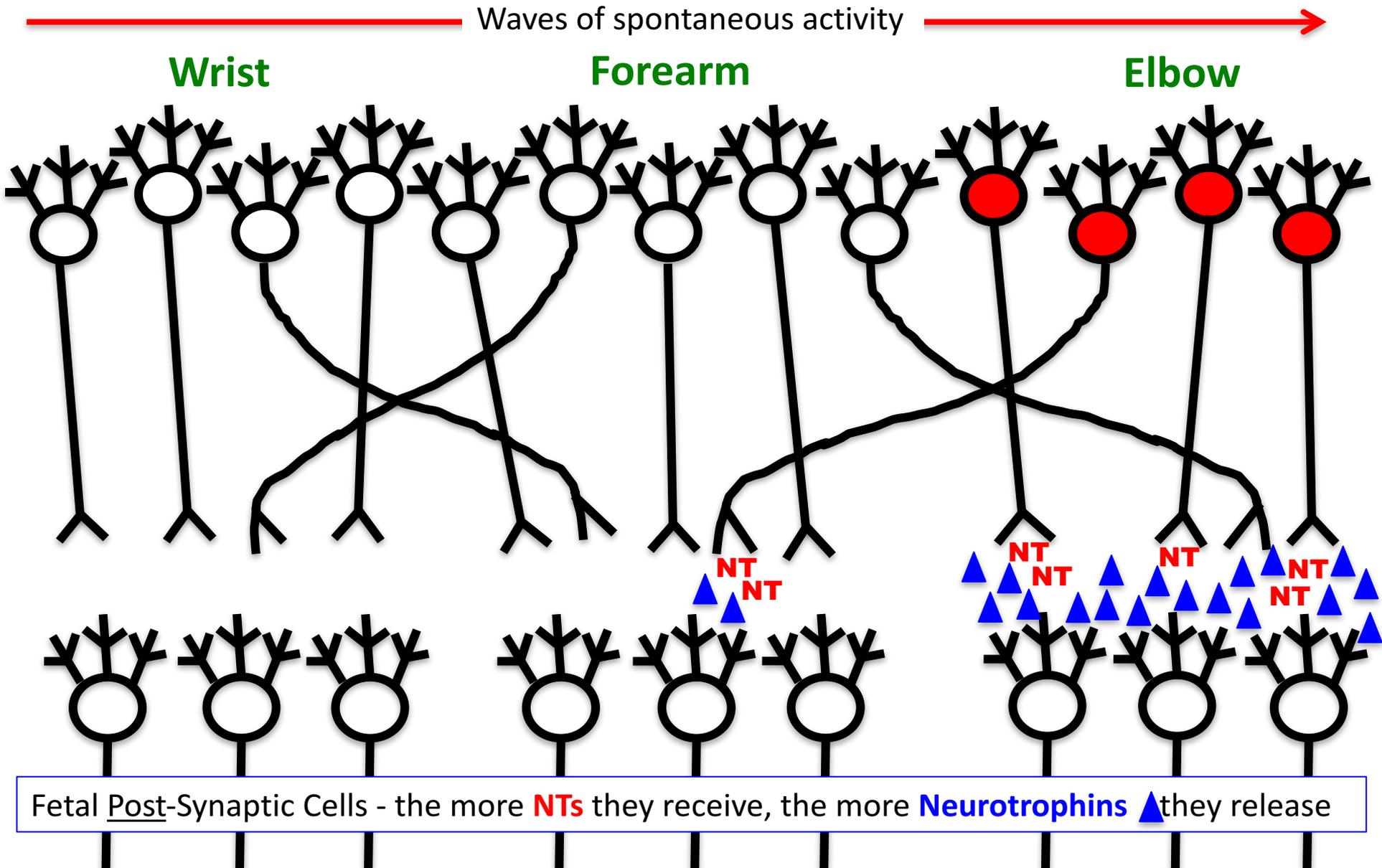
Fetal Post-Synaptic Cells - The more **NTs** they receive, the more **Neurotrophins** ▲ they release

# Cells that Fire Together, Wire Together



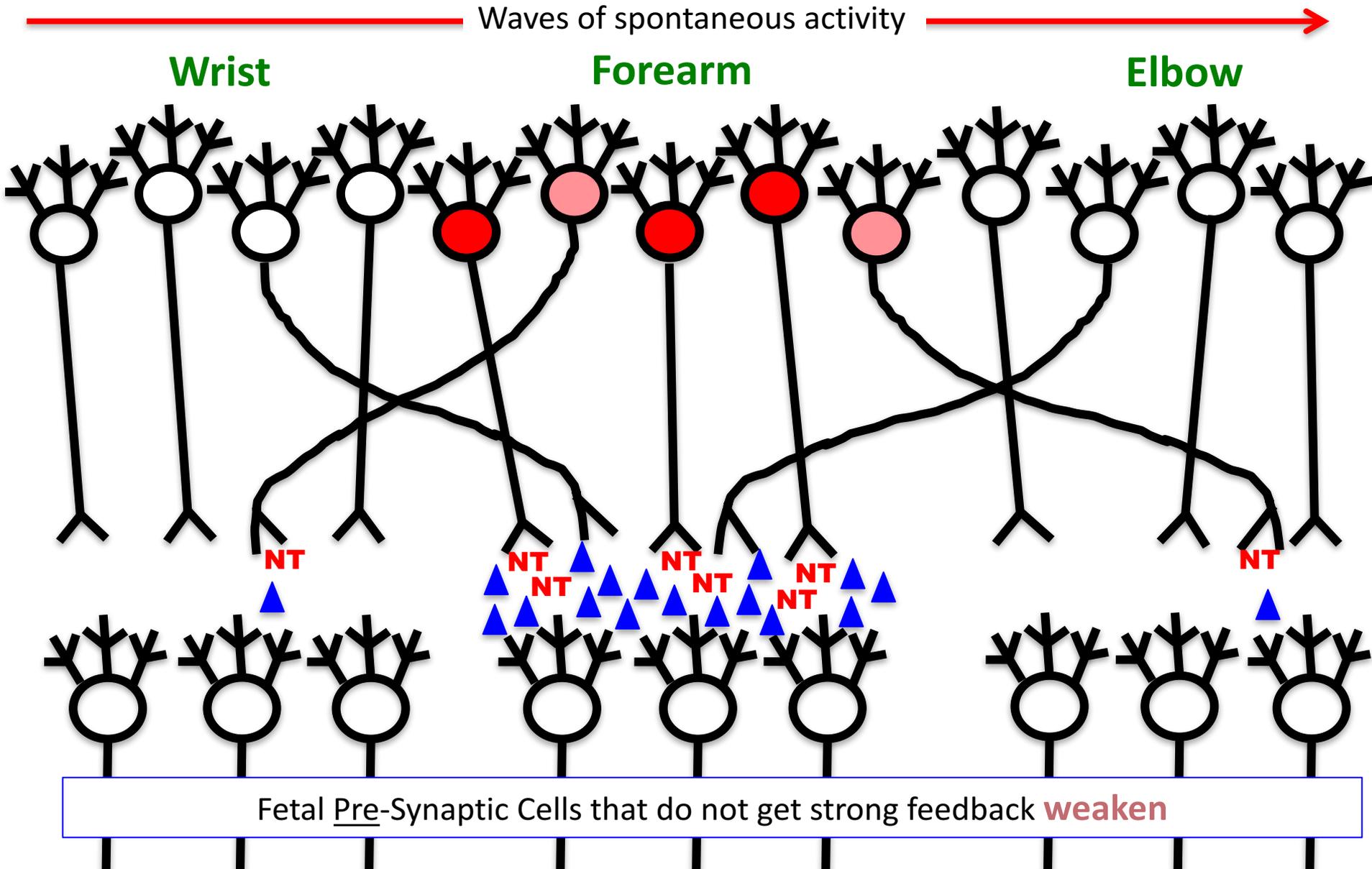
Fetal Post-Synaptic Cells - the more **NTs** they receive, the more **Neurotrophins** ▲ they release

# Cells that Fire Together, Wire Together

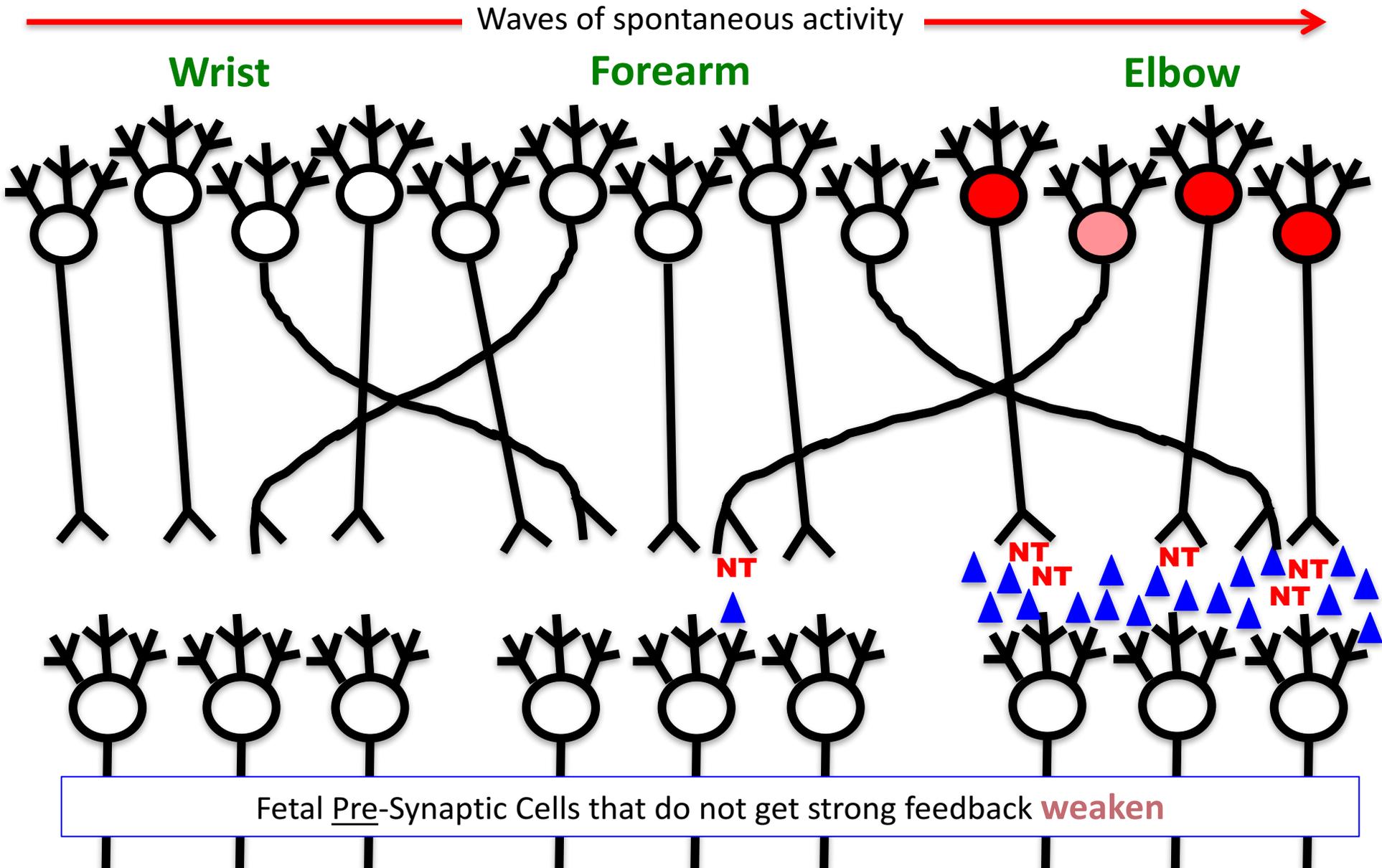




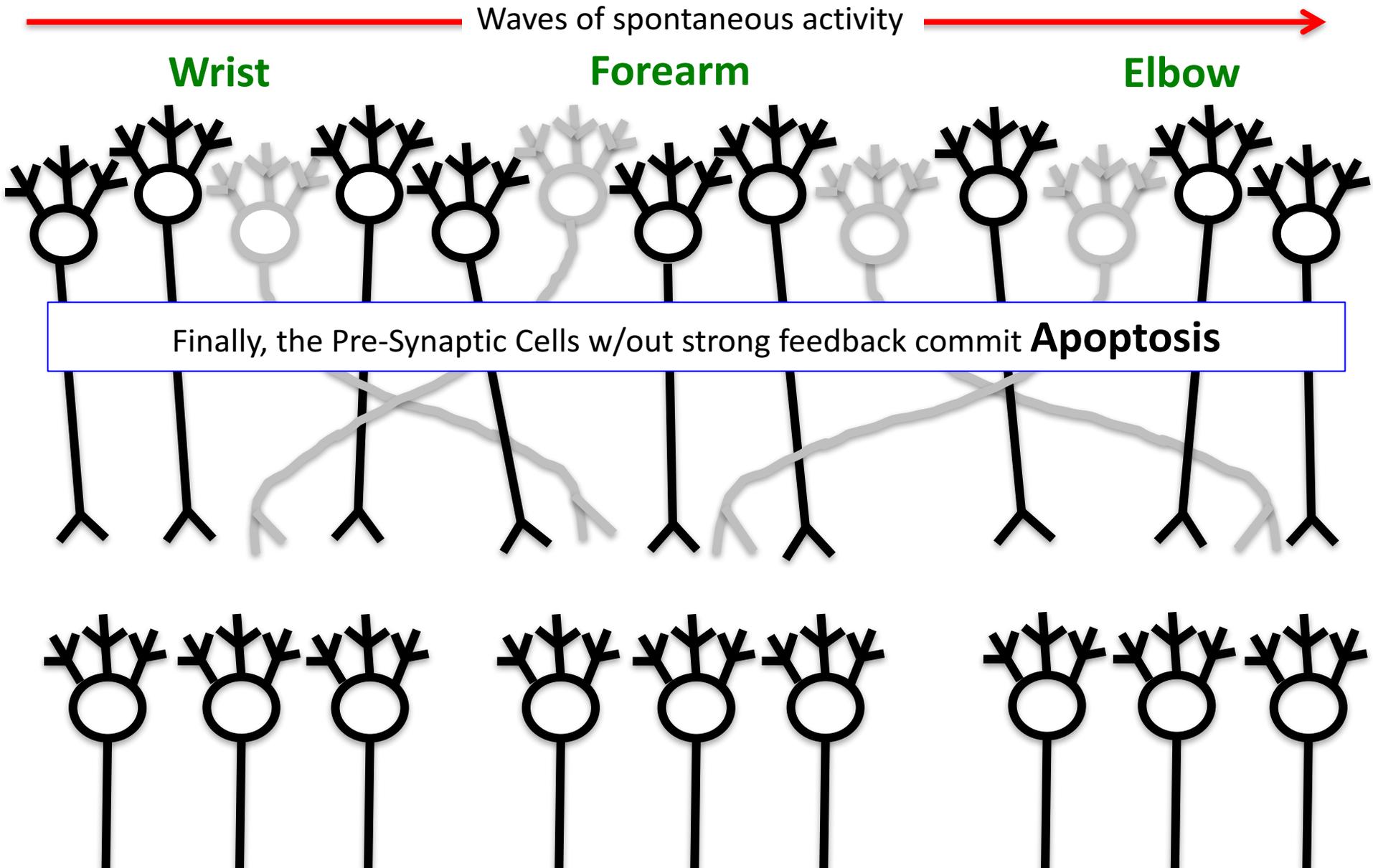
# Cells that Fire Together, Wire Together



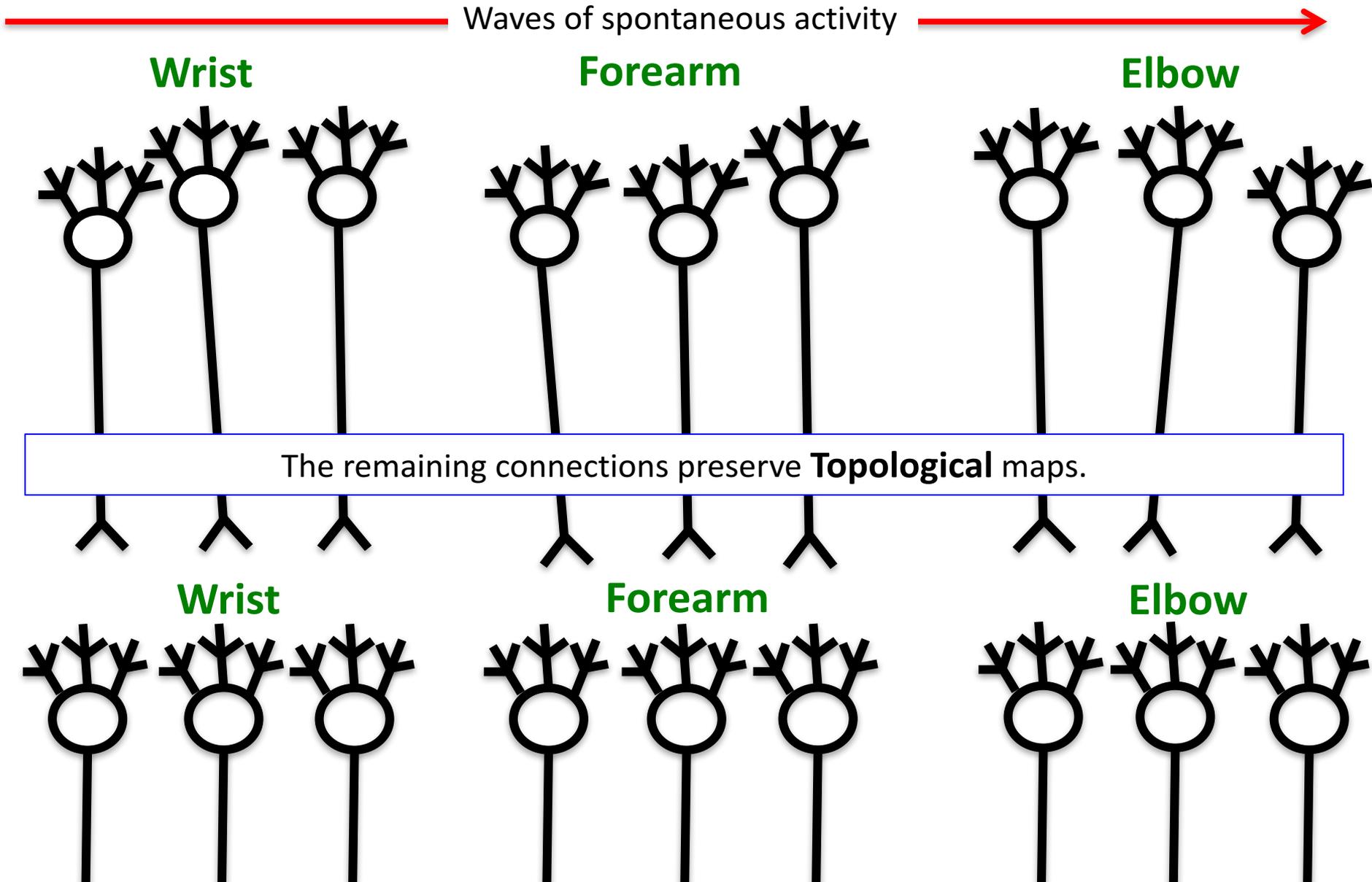
# Cells that Fire Together, Wire Together



# Cells that Fire Together, Wire Together



# Cells that Fire Together, Wire Together



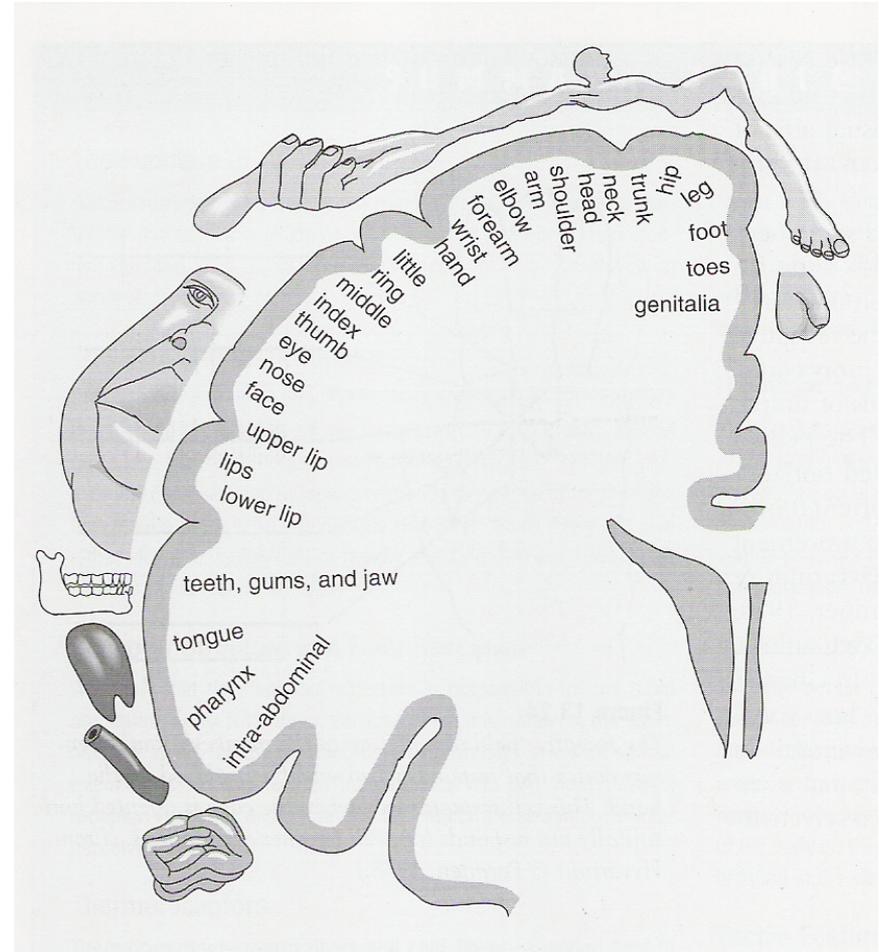
# Topological Maps

## The Penfield Map

in Somatosensory Cortex

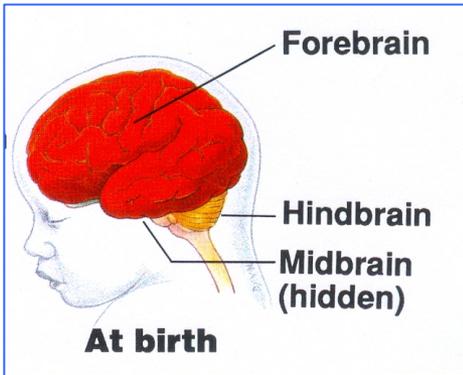
### A "Topological" Map

preserves the spatial relationships  
of the (in this case Sensory) surface  
that it represents

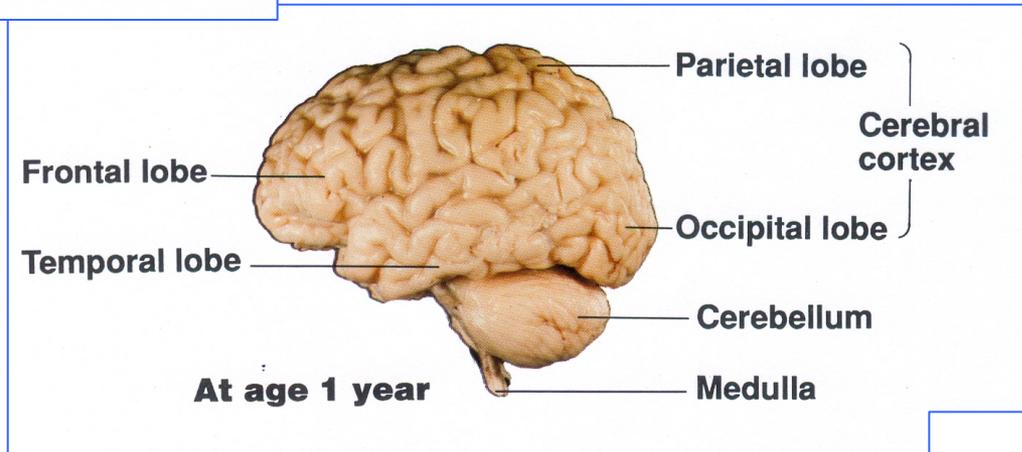


## Further Developments After Birth



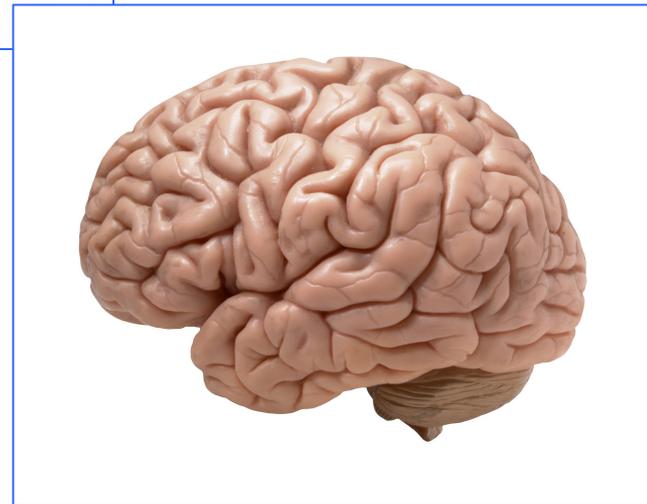


At birth,  
~350 g



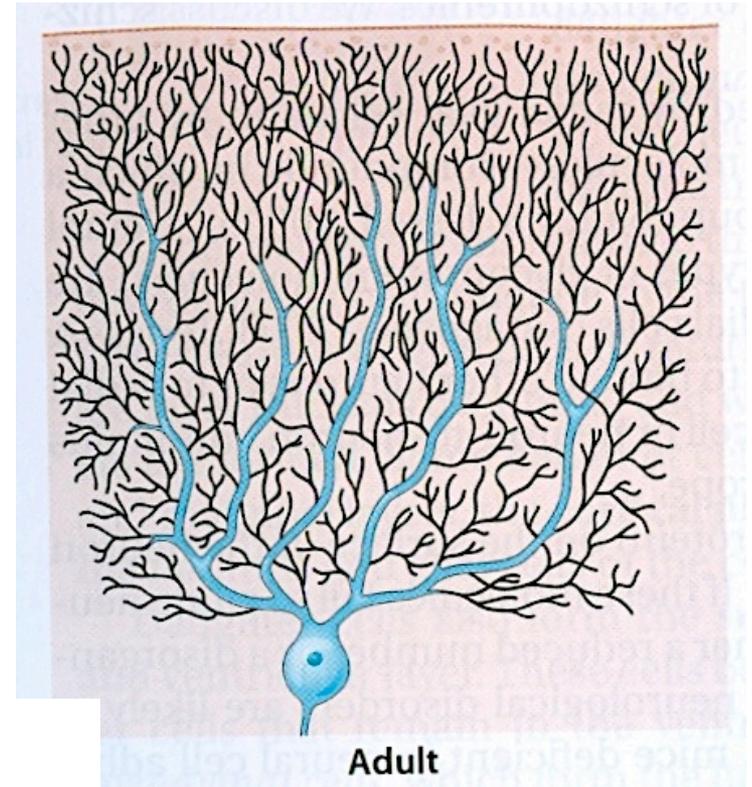
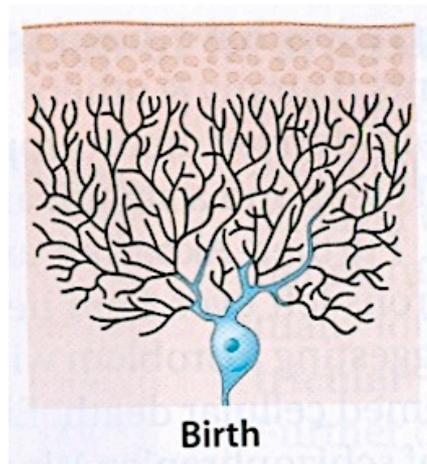
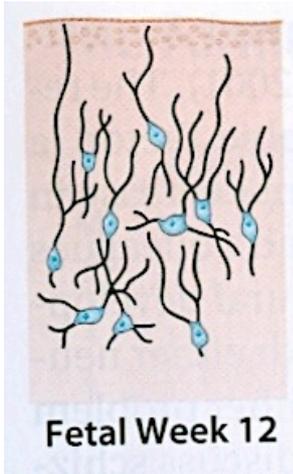
At 1 year,  
800-1000 g

Adult,  
1200-1400 g



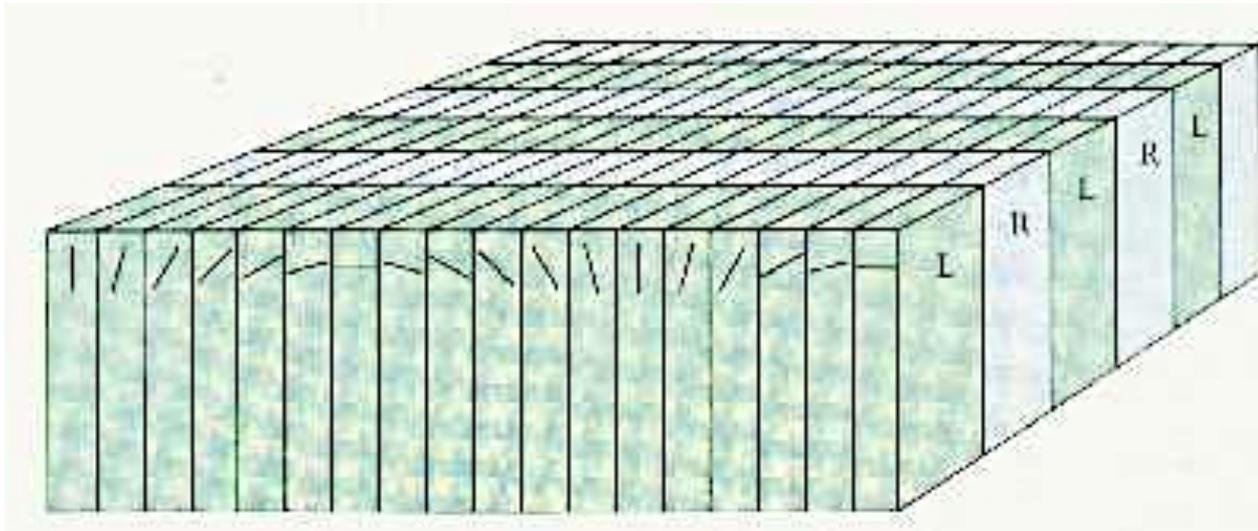
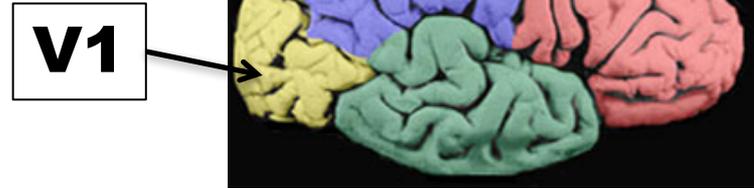
# Most "brain growth" after birth = **Dendritization**

(i.e NOT new cells!)



# Effects of Experience

Maps in V1 include columns of cells that preferentially respond to Horizontal, Vertical or Diagonal lines



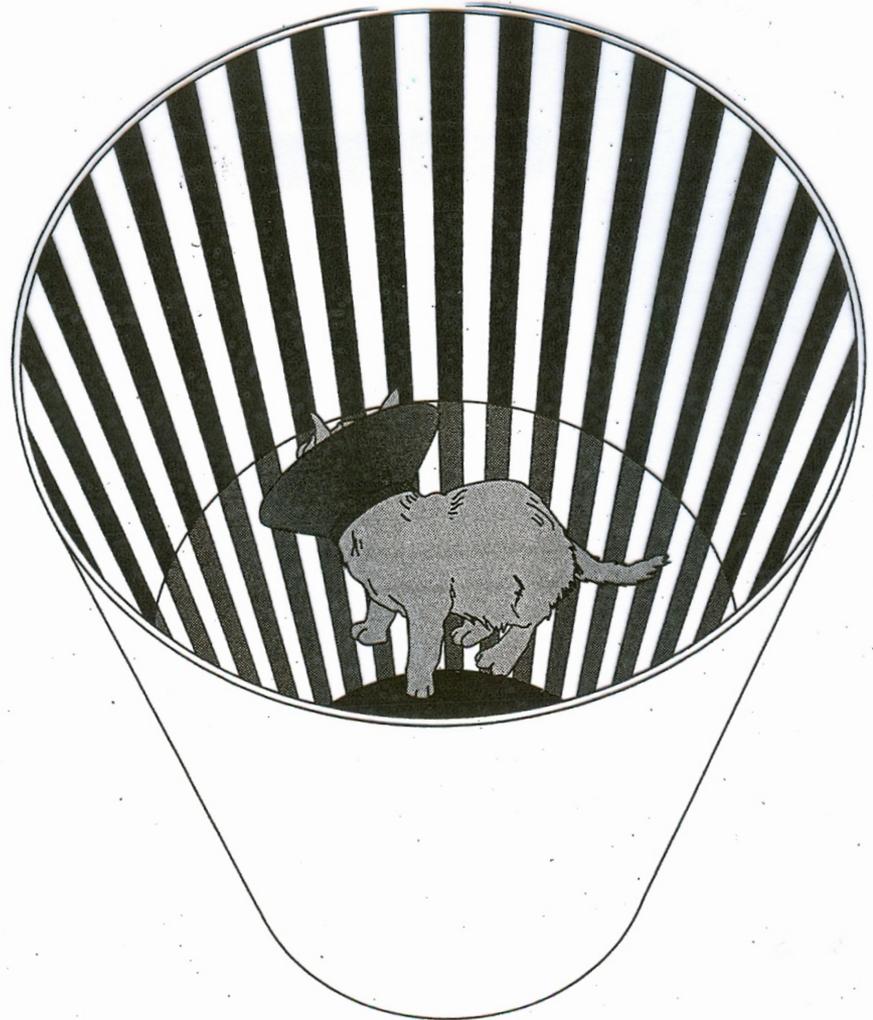
While these maps are largely laid down during Fetal development, they are also shaped by experience

# Effects of Experience

Kittens, exposed to ONLY  
Vertical lines,  
during critical period for  
post-natal Synaptogenesis  
in area V1

Cells, which would otherwise respond  
to Horizontal lines,  
are taken over by connections  
activated by  
Vertical lines

Afterward, these cats will  
NEVER be able to detect  
Horizontal lines in environment



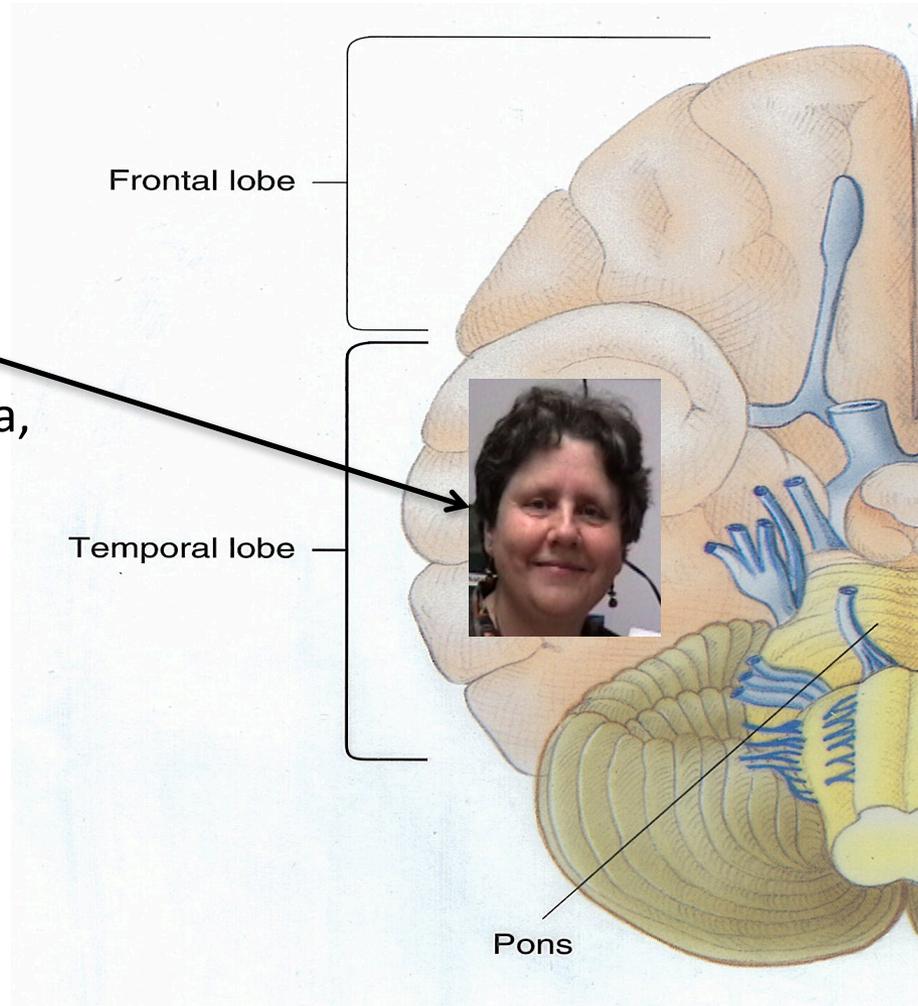
# Effects of Experience

But NOTE:

Other areas of visual cortex  
continue to be modified  
throughout life

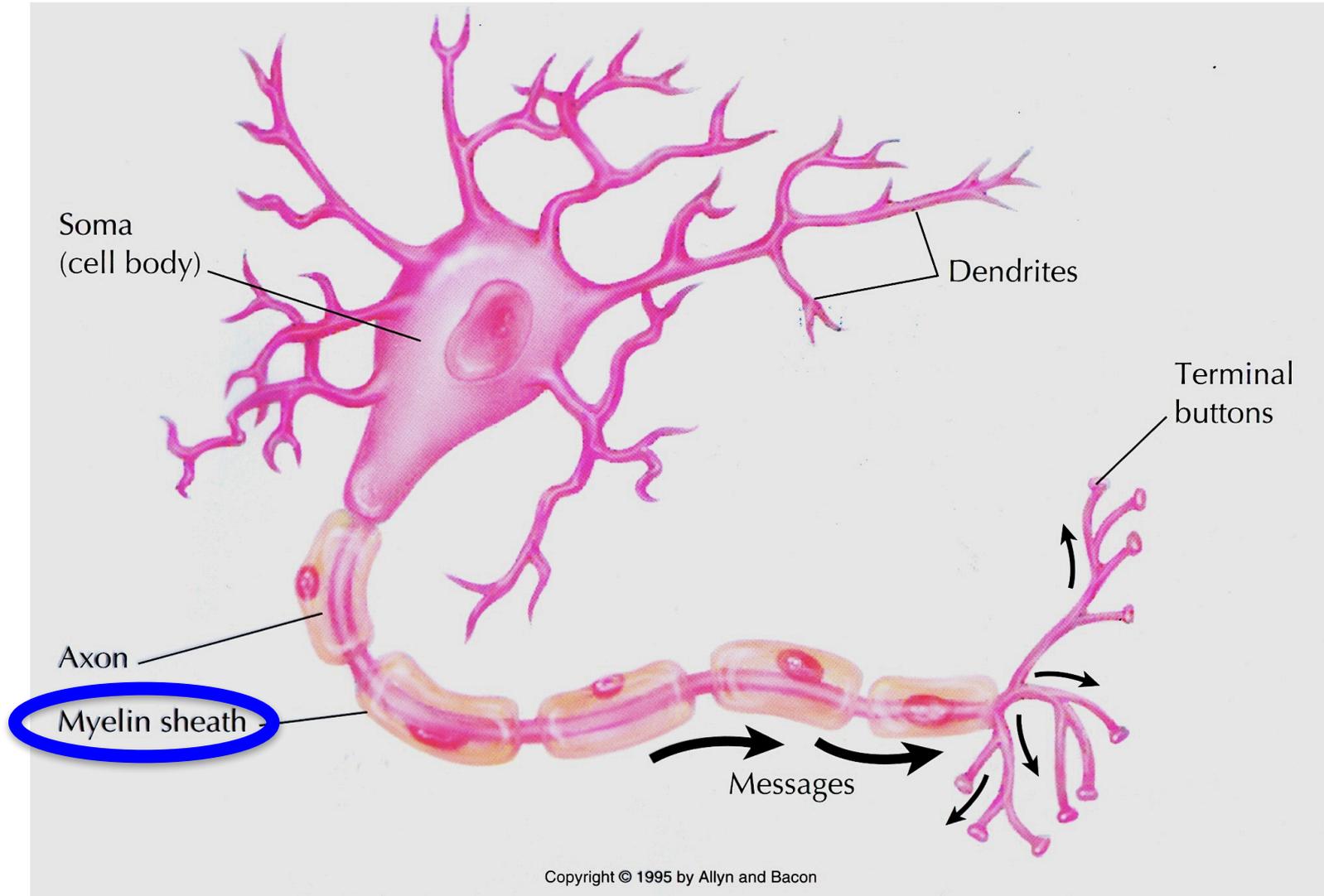
e.g. **Fusiform Gyrus**  
of the Inferior Temporal (IT) area,  
end of "Ventral Pathway"

Circuitry changes  
every time you learn to  
recognize a new face...



# Myelinization

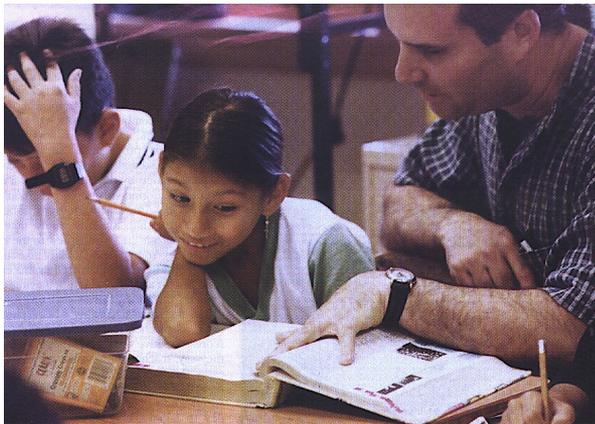
Myelinization of axons continues into adulthood (until ~20 years old)



# Learning



The brain is VERY plastic!  
Continues to change  
- make new connections –  
throughout life!



More on this to come...!

# LINKS

<http://www.youtube.com/watch?v=JD8DNuAMEDM&feature=related>

Google “tutortom10 neural growth and regulation”

Short Free Tutorials: [www.khanacademy.org/](http://www.khanacademy.org/)