Brain System Development

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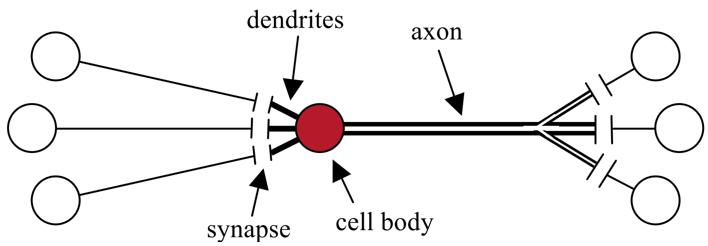
Understanding neurological operation

A typical brain cell, called a neuron, is composed of several parts; the cell body, dendrites that extend from the cell body and receive incoming messages from other cells and neurons, the axon that transfers an electro-chemical signal (called an "action potential") away from the cell body to trigger other cells in the network, and the junctions with other cells, called synapses, which are small gaps between cells.



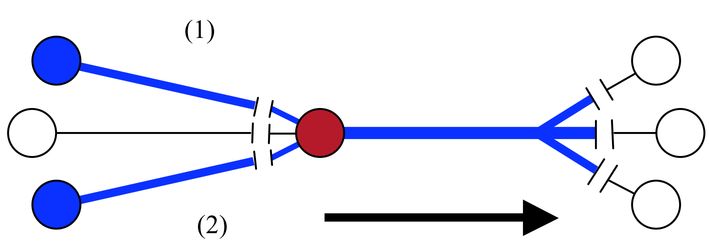
When a sufficient number of incoming dendrites are stimulated by other cells, an electrical impulse, called an "action potential," travels down the axon to signal other neurons in the network.

The sensitivity of cells to input varies.

- For some cells, a single stimulated dendrite triggers an action potential, other cells require that multiple incoming dendrites be stimulated before triggering an action potential.
- In addition, other types of neurons can inhibit the triggering of an action potential by releasing a neurotransmitter called gaba.

An oversimplified, but basically accurate, example:

- Say a cell requires two activated dendrites in order to trigger an action potential that travels down the axon to communicate with other cells in the network. This means that any two activations of dendrites by incoming neurons will trigger an action potential.



Two activated dendrites trigger an action potential that travels down the axon to other neurons in the network

The Fundamental Principle of Neurological System Development:

How Brain Systems Grow and Develop

We Build What We Use:

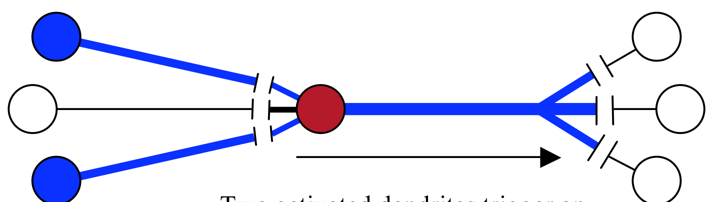
Brain cells and brain systems grow and develop through **use-dependent** neurological processes that can be described as **"we build what we use".**

Several use dependent growth processes have been identified, and more are likely to be identified as the scientific understanding of brain development and underlying neurological processes increases.

1) Long-term potentiation

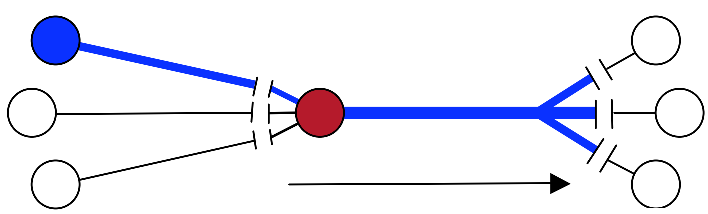
When an action potential is triggered in a neuron (or throughout a neurological network), chemical and structural changes take place in the neuron (or throughout the network) that make it more likely for that neuron (or for activated neurons within the network) to fire the next time the neuron receives input.

For example, prior to long-term potentiation a cell might require two inputs in order to trigger an action potential:



Two activated dendrites trigger an action potential that travels down the axon to other neurons in the network

After long-term potentiation, the same cell might require only one input to trigger an action potential:

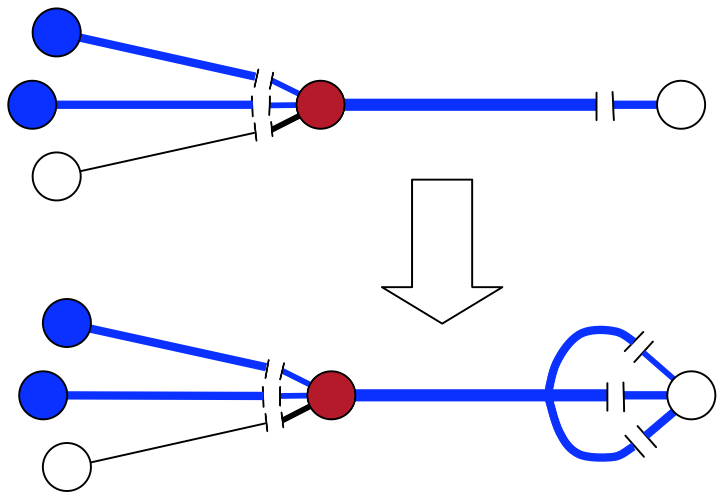


Long-term potentiation increases the likelihood that a neuron (or network) will activate

From long-term potentiation, the system becomes more sensitive.

2) Synaptogenesis

When an action potential is triggered in a neuron (or throughout a neurological network), the activated neuron (or network) will tend to grow more synaptic connections to other cells in the used network of cells.

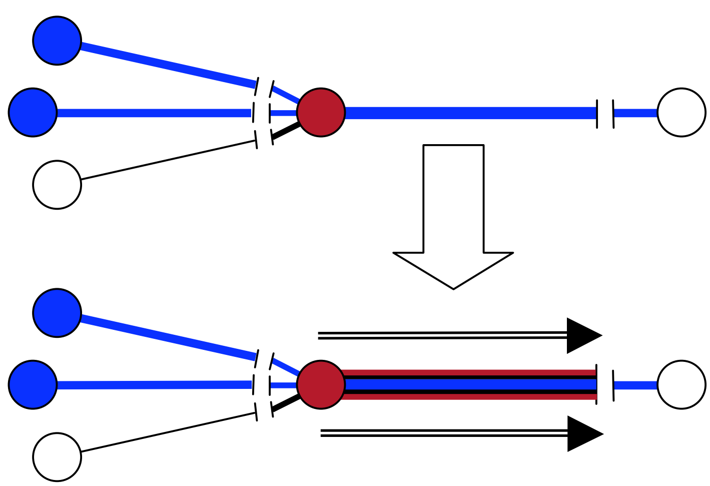


A neuron that is repeatedly activated will tend to grow increased synaptic connection along the used pathway.

From synaptogenesis, the system becomes stronger.

3) Use-dependent mylenation

Mylen is a fatty covering that grows along the axon and increases the speed of the action potential along the length of the axon. A mylen coating makes the exchange of information within the network faster and more efficient.



When a brain cell (or network) is activated, it increases the rate at which mylenation takes place, which will increase the speed of the action potential down the axon so that networks process information more quickly and efficiently

From use-dependent mylenation, the system becomes more efficient.

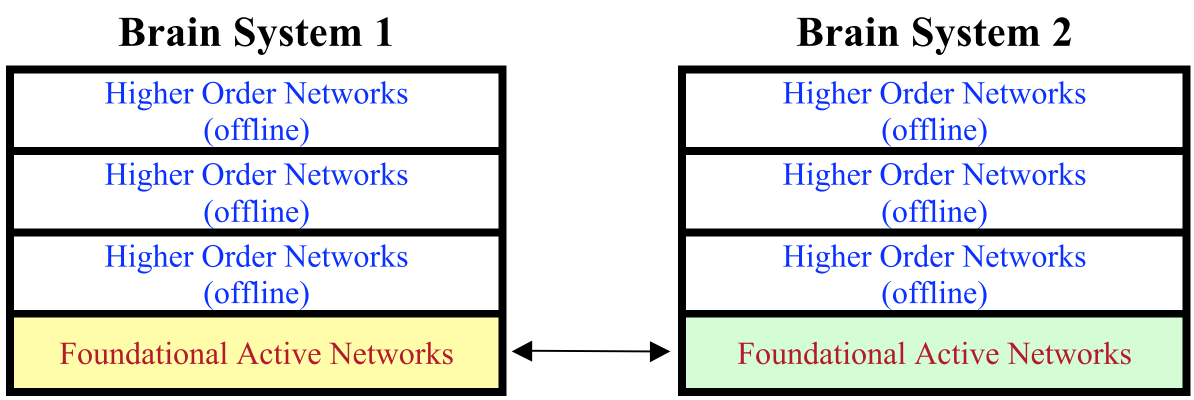
The Role of Developmental Immaturity

Immaturity is **NOT** a mistake

That the brain employs use-dependent growth processes has important implications for how the brain creates the "wiring" connections involved in complex neural networks.

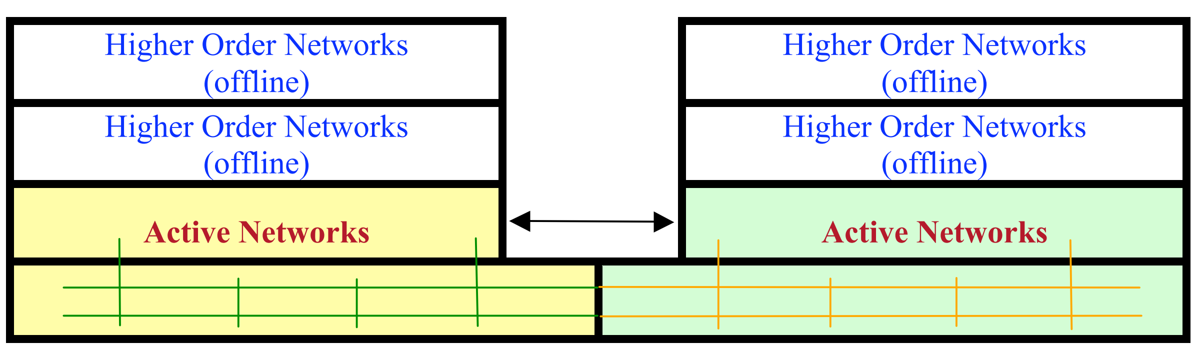
Phase I: Establishing Foundational Integration of Systems

Because the brain employs use-dependent processes to build neural networks, the developing nervous system starts by activating only the simplest elements of various brain systems in order to allow these fundamental elements of each system to be used together, and thereby "wire-up" (through experiential use-dependent processes of long-term potentiation, synaptogenesis, and use-dependent mylenation) the foundational interconnections.



Phase II: Integrating More Complex Elements of Systems

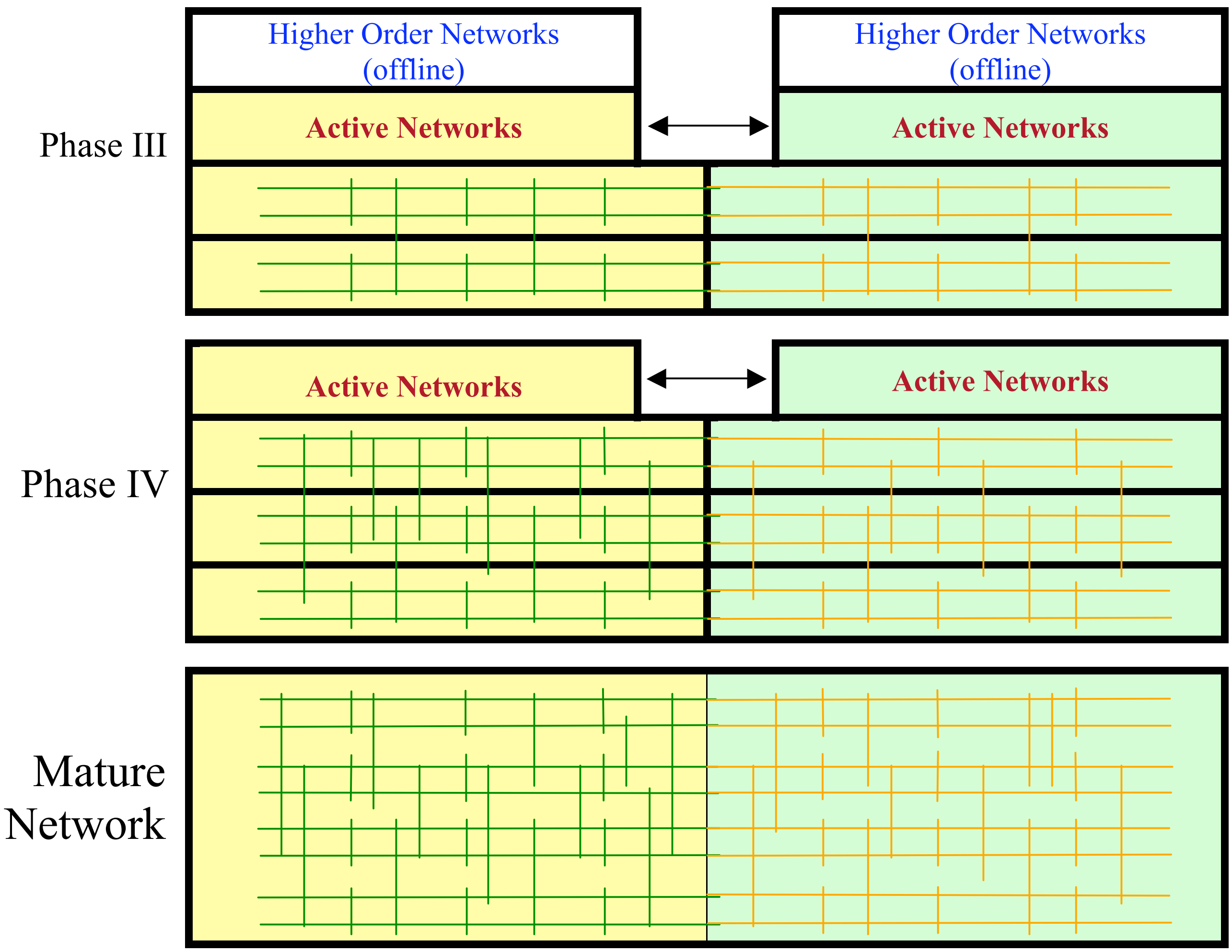
Then, after a sufficient amount of time has elapsed for the foundational elements of each system to be used together and so develop the basic levels of interconnections, then the brain activates more advanced elements of each system in order to allow these more advanced elements to be used together (and to thereby "wire-up" their interconnections through use-dependent processes) and also to allow these more advanced elements to be used with the foundational level that was previously established in order to "wire-up" a more complexly integrated system.



Phase III, IV, etc: Integrating Increasingly More Complex Elements of Systems

The timing systems of the brain allow each level of system sophistication an amount of time to be used together with other brain systems and with the previously "wired-up" integration of the systems, to provide for a phased, use-dependent integration of increasingly complex organization. When a set amount of time has passed, the brain then operationally activates a more advanced level for different systems.

In this way the maturational timing systems of the brain control the development of organizational wiring for a complexly integrated and flexible system of brain networks. This "self-organization" is based on the principle of use-dependent growth processes (i.e., long-term potentiation, synaptogenesis, and use-dependent mylenation) and the phased activation of increasingly complex elements of brain systems.



Experiences, particularly mutually interactive regulatory experiences involving primary interpersonal relationships, interact with genetically hardwired predispositions in system organization to create the flexible "wiring" networks necessary for complex social, communicative, emotional, and psychological-structure regulatory networks.

Immaturity is not a mistake or a problem to be fixed. Phased periods of immaturity are necessary and vital components in the development of organized neural system complexity.