

Efficiency in Communication: The Nervous System and The Pony Express

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Rule to build by:

To optimize efficiency of communication connect multiple routes of signal transportation to one decision center.

What:

Biological: In the body, this rule to build by can be seen the electrical and chemical signaling systems of the nervous system.

Human-Built: In the 1800s this rule was illustrated well by the Pony Express system of mail delivery.

How:

Biological: Impulses and signals are carried throughout the body by the nervous system. It is these signals which get our limbs to move, our digestive system to work, and secretions to be released. Both voluntary and involuntary systems of nerves pass impulses from cell to cell in the form of action potentials. These action potentials can reach the next cell either through chemical synapses or electrical synapses. When the chain of neurons finally reaches a target cell, say a muscle fiber, the action potential causes a reaction such as muscle contraction (Alberts 2010).

A single neuron consists of a soma or cell body, dendrites, an axon, the axon's terminal branches and presynaptic nodes (Alberts 2010).

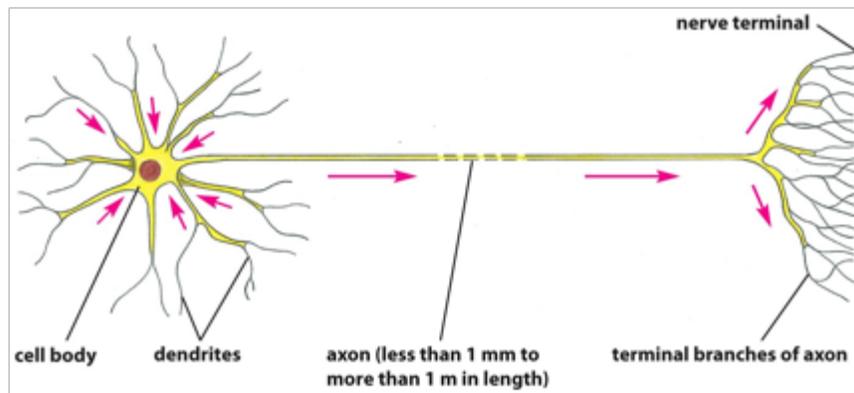


Figure 1: Anatomy of a neuron. This figure shows how both the cell body and the axon are connected to numerous branching processes. (Figure 12-31 *Essential Cell Biology*. Garland Science 2010)

The dendrites allow for more input to reach the cell body and the terminal branches of the axon allow one neuron to act upon many other cells. In these cells an action potential is triggered at the axon hillock (between the cell body and the axon). This action potential travels down the axon as a series of membrane depolarizations which cause and are caused by an influx of sodium. When this signal reaches the presynaptic nodes the opening of calcium channels is triggered (Sherwood 2010). In cells connected by chemical synapses, this results in the release of neurotransmitters. These chemicals, such as acetylcholine or norepinephrine are exocytosed into the synaptic cleft where they attach to receptors on the postsynaptic cell. They are then reabsorbed by the presynaptic cell or degraded by enzymes to stop the stimulation on the postsynaptic cell. These chemical signals can either be excitatory or inhibitory, they can either hypopolarize or hyperpolarize the membrane of the postsynaptic cell (Alberts 2012; Mann 2011). Thus, this point in the signal relay chain can be a decision point. A change in stimulus can result in a halting of the signal transmission altogether.

Neurons connected by electrical synapses, on the other hand, simply pass a signal from cell to cell without involving neurotransmitters. These cells are connected by gap junctions which allow electrical impulses to simply pass from the membrane of one cell directly into the membrane of the next. Not only does this speed up the process, it takes any chance for options out of the equation. These gap junctions consist of several connexons which join together to form a cylinder which bridges the space between two cells. Unlike chemical synapses which translate a stimulus into neurotransmitters before relaying it to the next cell and possibly inducing another action potential, electrical synapses merely allow that action potential to continue traveling through the next cell's membrane (Purves et al. 2001).

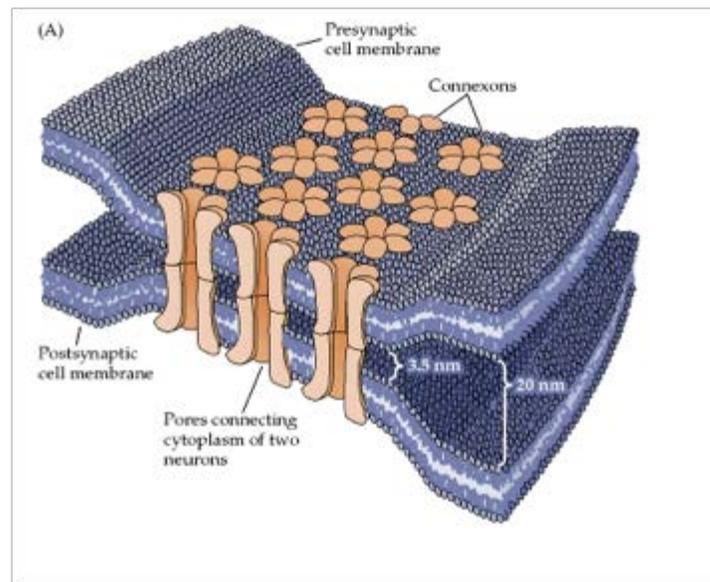


Figure 2: The electrical synapse between two cells is made up of gap junctions which allow for direct passage of the signal from one cell to the next. (Figure 5-2 *Neuroscience*. Sinauer Associates. 2001)

Both of these neural systems are meant to carry a signal. However one is more automatic – electrical synapses. When these systems act together a signal can start in chemically connected neurons and then, when a signal merely needs to be sent not altered along the way, electrical synapses are used.

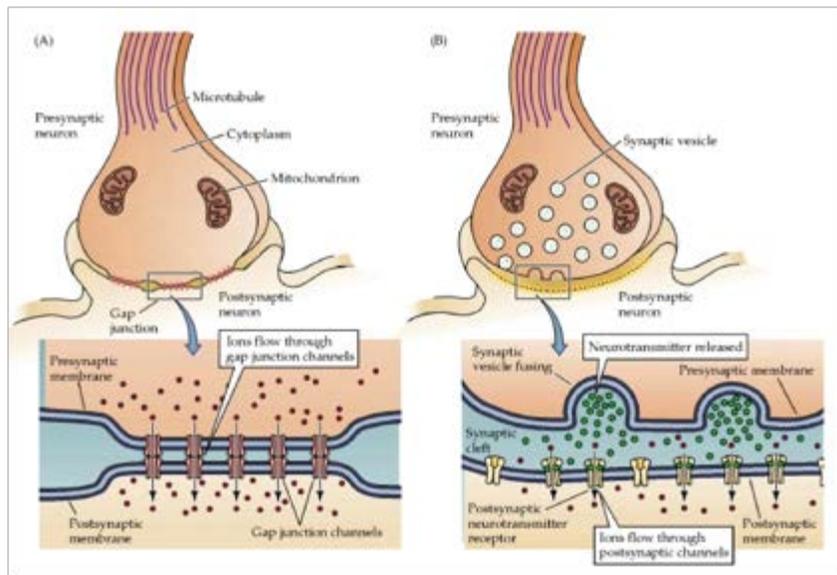


Figure 3: The difference between chemical and electrical synapses can be seen here in the direct or indirect way ions flow into the postsynaptic cell. (Figure 5-1 *Neuroscience*. Sinauer Associates. 2001)

Human-Built: The Pony Express was the most efficient form of transcontinental communication in the United States during the mid-1800s.

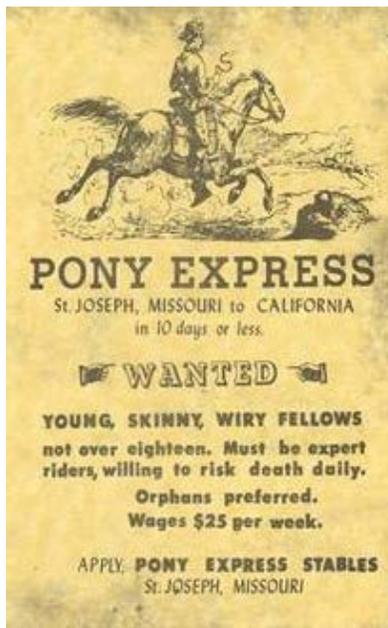


Figure 3: When it first began the Pony express had to recruit light, hearty riders. official pony express page. (Phoenix JC Comancheros. *The Pony Express History*. 2012.)

The system consisted of a couple hundred relay stations about 10-15 miles apart where horses could be switched out and others 90-120 miles apart where riders could be switched out. This network of horses and riders was to carry mail from

St Joseph, Missouri to Sacramento, California and with this system of relays, it could be done in ten days (The Pony Express National Museum).

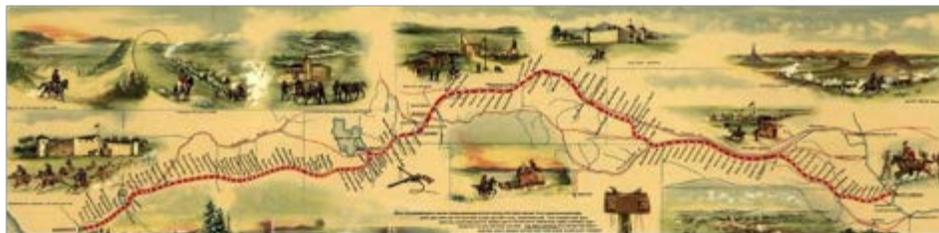


Figure 4: Though the individual station names cannot be seen here this map shows the original route of the Pony Express riders from Missouri to California. View the original image [here](#). (The World of Historic Maps)

Letters, news and documents would be brought by train to St Joseph. Both this step and the preceding one of someone actually writing a letter are decision points. All the letters written across the East would be collected and funneled to St Joseph. Here there was a possible stopping point before the mail was picked up by a rider and relayed without question from checkpoint to checkpoint all the way to California (The Pony Express National Museum).

Why:

Biological: Though communication might have been quite simple within single celled organisms, things became more complicated when signals had to be passed from one cell to another and then between cells in diverse locations within the body (Nervous System, Britanica). There are a number of multicellular organisms such as sponges which have the appropriate genes for a nervous system but do not turn them on and off in the right way (Kosik 2012). Though these organisms have other forms of intercellular communication it is not as efficient nor as functionally diverse as a network of interconnected neurons. The nervous system present in modern day humans (and other vertebrates) allows for communication between many different tissues. By having one system essentially talking to all the other systems, order and efficiency are possible. Moreover, the cells making up the nervous system consist of one central location and many branching processes and each of these processes (the neurons) are made of cell bodies and branching axons. This further increases the efficiency of the system. The presence of two types of signal transduction, chemical and electrical, creates two types of communication. The translation of action potentials into neurotransmitters creates a gap in the signal pathway that can be disrupted. This is an important part of the nervous system as it is a possible decision point. Electrical synapses, on the other hand, allow for the simple continuous movement of an action potential from one cell to the next via gap junctions creating a fast, seamless transport of the signal across great distances.

Human-Built: When the gold rush began in 1849 a great many people took the long and dangerous journey to California. With so much of the population spread throughout the east but now a large sector segmented away in California, a reliable and efficient form of communication had to be found. Thus, in 1860, the Pony Express was formed. The use of horses and multiple switching points allowed for extreme speed and efficiency. Moreover, the many loci of mail generation throughout the east were able to converge in one central location, as far West as was reasonably possible for the train system and then be transported directly to California without further processing.

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