Components and functions of the synapse

B. The connection between two neurons is called a synapse, a term derived from the Latin word that means “ to grasp.” The synapse consists of many components that are essential to the flow of information from one neuron to another. Through an outline of these components, we can begin to understand how processes such as synaptic transmission are possible.

In regards to our understanding of the synapse, it is important to note the accomplishments of Charles Scott Sherrington and his initial work that first outlined the basic properties of the synapse. One of the properties, reflexes, or automatic muscular responses to stimuli was demonstrated by pinching a dog’s leg in his experiments. Sherrington demonstrated that a short delay occurs before the dog flexes the pinched leg and extends the others. This finding is important because he discovered that transmission through the reflex arc is slower than transmission through an equivalent length of axon. This led him to conclude that the delay must occur where one neuron communicates with another, a concept he introduced as a synapse.

Sherrington’s work outlines other basic properties of the synapse such as temporal and spatial summation. Temporal summation is a concept where a single stimulus (a single pinch) is too weak to reach threshold to produce an action potential in the postsynaptic neuron. When stimuli occur in succession (i. e., pinching the dog’s foot several times), however, the combined effect can be enough to produce an action potential, thereby causing a reflex. With spatial summation, several stimuli occurring at different points on the body combine their effects on a neuron. By pinching multiple places on a dog’s body, for example, the combined effect can be enough to produce a reflex. Sherrington work also infers the property of inhibitory synapses. This is a

concept where after a reflex (action potential) occurs, hyperpolarization causes the cell to become more negative, therefore making it difficult for another action potential to immediately occur.

As technology has improved, so has our understanding of the mechanisms of the synapse. Before we can understand the components and functioning of the synapse, however, it is important to first consider neurons. Neurons have the responsibility of producing all of our movements, thoughts, memories, and emotions. There are four major types of neurons: motor neurons, sensory, interneurons, and projection neurons. Each of these neurons shares a common structure and function. For example, the soma, or cell body, contains the cell's nucleus, most of the cytoplasm, and structures that convert nutrients into energy and eliminate waste materials for each of these neurons. This quality is not unique, however, as this is also a component of any cell in the body. The quality that separates neurons from other cells are dendrites, extensions that branch out from the soma to receive information from other neurons, and axons, which extend like a tail from the cell body and carries information to other locations. Branches at the end of the axon culminate in swellings called bulbs or terminals. The terminals contain chemical neurotransmitters, which the neuron releases to communicate with a muscle or an organ or the next neuron in the chain.

As introduced earlier, the connection between two neurons is called a synapse, a site where most communication among neurons occurs. To clarify the function and purpose of the synapse, it is important to understand the sequence of major chemical events that occur at the synapse. At the site of the cell body, neurons synthesize chemicals that serve as neurotransmitters,

specifically peptide neurotransmitters. The neuron then transports the peptide neurotransmitters to the axon terminals. Action potentials then travel down the axon where at the presynaptic terminal, the action potential enables calcium to enter the cell. The calcium then releases neurotransmitters from the terminals and into the synaptic cleft (the space between the presynaptic and postsynaptic neurons). Next, the neurotransmitter binds to the receptor, diffusing across the cleft and altering the activity of the postsynaptic neuron. This alteration also causes the neurotransmitter molecules to separate from their receptors. Finally, reuptake of the neurotransmitter occurs, recycling neurotransmitters back into the presynaptic neuron. All of these events lead a successful transmission at the point of the synapse.

There are different types of synapses used in the flow of information from neuron to neuron. Axodendritic synapses, synapses of axon terminal buttons on dendrites, terminate on dendritic spines, small synaptic buds that cover the surfaces of many dendrites. Also common are axosomatic synapses, synapses of axon terminal buttons on somas. Although axodendritic and axosomatic synapses are the most common synaptic arrangements, there are several others. For example, there are dendrodendritic synapses, which are capable of transmission in either direction; and there are axoaxonal synapses, which can mediate presynaptic inhibition. Also, there are directed synapses, synapses at which the site of neurotransmitter release and the site of neurotransmitter reception are in close proximity. This is a common arrangement, but, there are also many nondirected synapses in the nervous system. Nondirected synapses are synapses at which the site of release is at

some distance from the site of reception. In this type of arrangement, neurotransmitter molecules are released from a series of varicosities along the axon and its branches and thus are widely dispersed to surrounding targets. Because of their appearance, these synapses are often referred to as string-of-beads synapses.

In conclusion, with the initial contributions of Sherrington and with what is known about neurotransmission today, we have been able to outline the basic components and functions of the synapse. The synapse, in turn, is an essential component for the transmission of neurons, which enables the human body to respond to events in the environment. By acting as a “ bridge” between the neurons, the synapse is helping to control human movements, thoughts, memories, and emotions. The synapse is truly a necessary component in the human body.