

# The brain: How it works and develops

New discoveries are changing old concepts of how the brain develops and works. One new theory holds that our actions can help shape our brain's capacity, and high levels of mental stimulation as a child and an adult build more information-processing connections between brain cells.

## THE BRAIN'S COMPUTER CHIPS

Brain cells, also known as neurons, receive, analyze, coordinate and transmit information. The brain learns and remembers throughout life by constantly changing its network of trillions of connections between neurons as a result of stimuli from its environment. Researchers now know that some of these connections, or synapses, grow stronger with learning and weaken or disappear when not used.

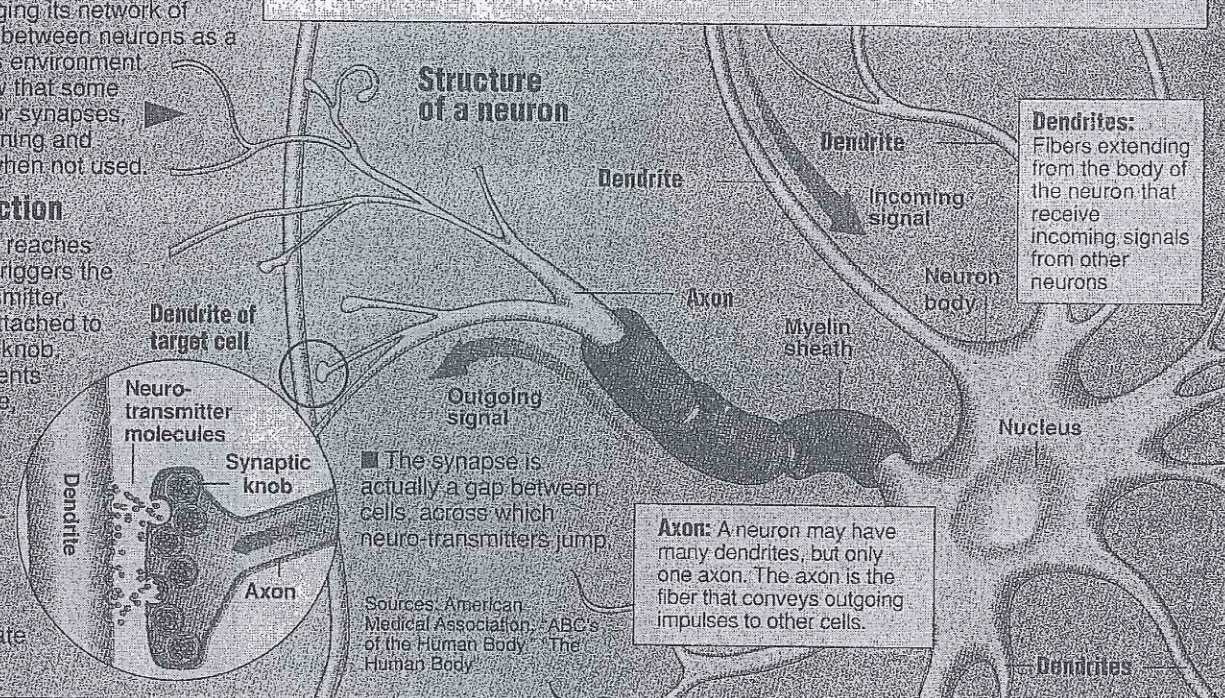
## Making the connection

An electrical impulse reaches the axon terminal and triggers the release of a neurotransmitter contained in vesicles attached to surface of the synaptic knob. Vesicles spill their contents into the gap, or synapse, between the synaptic knob and the target cell's surface. Once across the gap, neurotransmitter molecules bind to specific receptor molecules on target cell's surface and activate a response.

## The growing brain

### Major structural developments

- **Fetal development:** Billions of brain cells are formed in the first months of fetal life. Half of them die as hormones and other stimuli eliminate and organize them to form the brain's basic scaffolding, i.e. male or female.
- **After birth:** Trillions of brain cell connections are established and form the brain's physical "maps" that govern such things as vision, language and hearing.
- **Age 4 to 10:** New learning reorganizes and reinforces connections between brain cells. New connections are formed as new things are learned.
- **After age 10:** Still able to undergo physical changes, the brain learns and remembers throughout life.



The synapse is actually a gap between cells, across which neuro-transmitters jump.

Sources: American Medical Association; ABC's of the Human Body; The Human Body

## EFFECTS OF DRUGS OF ABUSE ON THE BRAIN

Pleasure, which scientists call reward, is a very powerful biological force for our survival. If you do something pleasurable, the brain is wired in such a way that you tend to do it again. Life-sustaining activities, such as eating, activate a circuit of specialized nerve cells devoted to producing and regulating pleasure. One important set of these nerve cells, which uses a chemical neurotransmitter called dopamine, sits at the very top of the brainstem in the ventral tegmental area (VTA) (Figure 6). These dopamine-containing neurons relay messages about pleasure through their nerve fibers to nerve cells in a limbic system structure called the nucleus accumbens. Still other fibers reach to a related part of the frontal region of the cerebral cortex. So, the pleasure circuit, which is known as the mesolimbic dopamine system, spans the survival-oriented brainstem, the emotional limbic system, and the frontal cerebral cortex.

All drugs that are addicting can activate the brain's pleasure circuit. Drug addiction is a biological, pathological process that alters the way

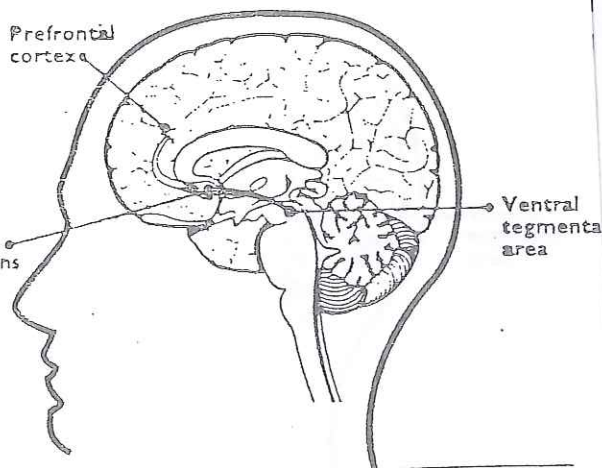


FIGURE 6 This drawing of a brain cut in half demonstrates the brain areas and pathways involved in the pleasure circuit

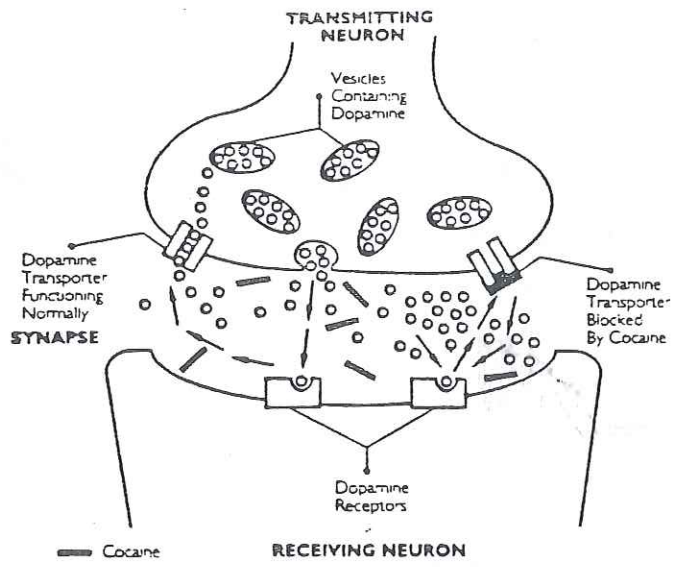


FIGURE 7 When cocaine enters the brain, it blocks the dopamine transporter from pumping dopamine back into the transmitting neuron, flooding the synapse with dopamine. This intensifies and prolongs the stimulation of receiving neurons in the brain's pleasure circuits, causing a cocaine "high."

in which the pleasure center, as well as other parts of the brain, functions. To understand this process, it is necessary to examine the effects of drugs on neurotransmission. Almost all drugs that change the way the brain works do so by affecting chemical neurotransmission. Some drugs, like heroin and LSD, mimic the effects of a natural neurotransmitter. Others, like PCP, block receptors and thereby prevent neuronal messages from getting through. Still others, like cocaine, interfere with the molecules that are responsible for transporting neurotransmitters back into the neurons that released them (Figure 7). Finally, some drugs, such as methamphetamine, act by causing neurotransmitters to be released in greater amounts than normal.

Prolonged drug use changes the brain in fundamental and long-lasting ways. These long-lasting changes are a major component of the addiction itself. It is as though there is a figurative "switch" in the brain that "flips" at some point during an individual's drug use. The point at which this "flip" occurs varies from individual to individual, but the effect of this change is the transformation of a drug abuser to a drug addict.

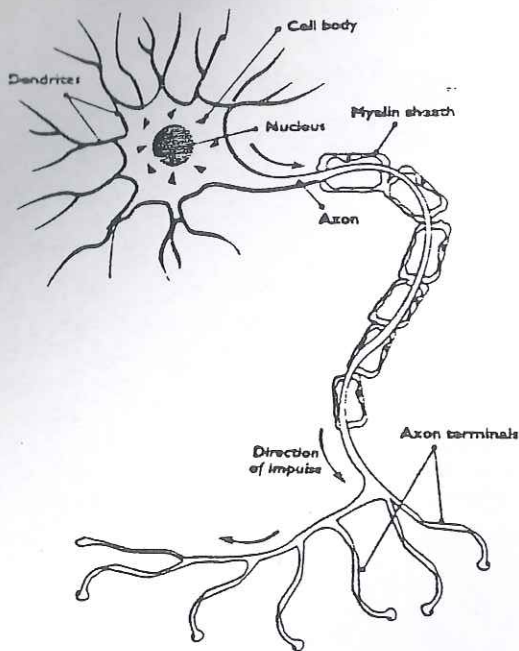


FIGURE 4

There are many different types of neurotransmitters, each of which has a precise role to play in the functioning of the brain. Generally, each neurotransmitter can only bind to a very specific matching receptor. Therefore, when a neurotransmitter couples to a receptor, it is like fitting a key into a lock. This coupling then starts a whole cascade of events at both the surface of the dendrite of the receiving nerve cell and inside the cell. In this manner, the message carried by the neurotransmitter is received and processed by the receiving nerve cell. Once this has occurred, the neurotransmitter is inactivated in one of two ways. It is either broken down by an enzyme or reabsorbed back into the nerve cell that released it. The reabsorption (also known as re-uptake) is accomplished by what are known as transporter molecules (Figure 5). Transporter molecules reside in the cell membranes of the axons that release the neurotransmitters. They pick up specific neurotransmitters from the synapse and carry them back across the cell membrane and into the axon. The neurotransmitters are then available for reuse at a later time.

As noted above, messages that are received by dendrites are relayed to the cell body and then to the axon. The axons then transmit the messages, which are in the form of electrical impulses, to other neurons or body tissues. The axons of many neurons are covered in a fatty substance known as myelin. Myelin has several functions. One of its most important is to increase the rate at which nerve impulses travel along the axon. The rate of conduction of a nerve impulse along a heavily myelinated axon can be as fast as 120 meters/second. In contrast, a nerve impulse can travel no faster than about 2 meters/second along an axon without myelin. The thickness of the myelin covering on an axon is closely linked to the function of that axon. For example, axons that travel a long distance, such as those that extend from the spinal cord to the foot, generally contain a thick myelin covering to facilitate faster transmission of the nerve impulse. (Note: The axons that transmit messages from the brain or spinal cord to muscles and other body tissues are what make up the nerves of the human body. Most of these axons contain a thick covering of myelin, which accounts for the whitish appearance of nerves.)

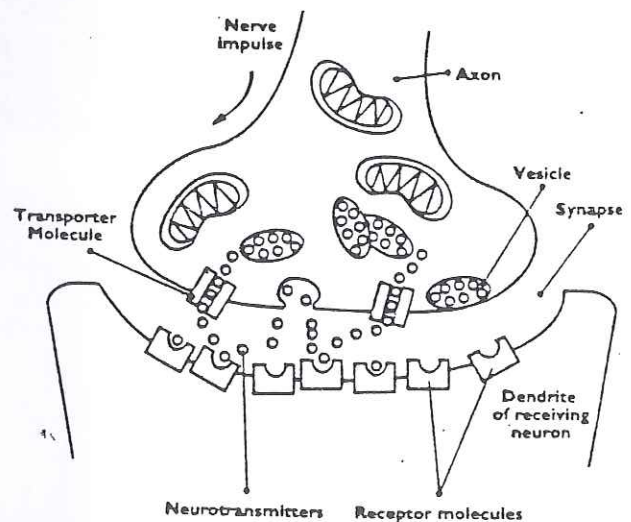


FIGURE 5