Why do we get chronic pain?

One of the most frequently asked questions of any pain specialist is why we get chronic pain. This is a detailed explanation from scientists at the National Institute of Health.

Most pain originates when special nerve endings, called nociceptors (no-si-SEP-turs), detect an unpleasant stimulus. You have millions of nociceptors in your skin, bones, joints, muscles and internal organs. There may be as many as 1,300 in just one square inch of skin.

Some nociceptors sense sharp blows, others heat. One type senses pressure, temperature and chemical changes. Nociceptors can also detect inflammation due to injury, disease or infection. It's as though nature had sprinkled your skin and your insides with a variety of pain-sensitive cells, not only to report what kind of damage you're experiencing, but to make sure the message gets through on at least one channel.

Nociceptors use nerve impulses to relay pain messages to networks of nearby nerve cells (your peripheral nervous system). Messages then travel along nerve pathways to your spinal cord and brain (your central nervous system). Each cell-to-cell relay is almost instantaneous, thanks to chemical facilitators called neurotransmitters. These chemicals flow from one nerve cell to the next in less than a thousandth of a second.

Some nerve pathways are faster than others. One type makes connections with many surrounding nerve cells en route. They transmit more slowly. You feel this type of pain as dull, aching and generalized. Another type relays impulses almost instantaneously and signals sharp pain focused in one spot.

For example, suppose you touch a hot stove. Some incoming pain signals are immediately routed to nerve cells that signal muscles to contract, so you pull your hand back. That streamlined pathway is a reflex, one of many protective circuits wired into your nervous system at birth.

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Meanwhile the message informing you that you've touched the stove travels along other pathways to higher centers in the brain. One path is an express route that reports the facts: where it hurts; how bad it is; whether the pain is sharp or burning. Other pain pathways plod along more slowly, the nerve fibers branching to make connections with many nerve cells (neurons) en route. Scientists think that these more meandering pathways act as warning systems alerting you of impending damage and in other ways filling out the pain picture. All the pathways combined contribute to the emotional impact of pain---whether you feel frightened, anxious, angry, annoyed. Experts called those feelings the "suffering" component of pain.

Still other branches of the pain news network are alerting another major division of the nervous system, the *autonomic nervous system*. That division handles the body's vital functions like breathing, blood flow, pulse rate, digestion, elimination. Pain can sound a general alarm in that system, causing you to sweat or stop digesting your food, increasing your pulse rate and blood pressure, dilating the pupils of your eye, and signaling the release of hormones like epinephrine (adrenaline). Epinephrine aids and abets all those responses as well as triggering the release of sugar stored in the liver to provide an extra boost of energy in an emergency.

Obviously not every source of pain creates a full-blown emergency with adrenaline-surging, sweat-pouring, pulse-racing responses. Moreover, observers are well aware of times and places when excruciating pain is ignored. Think of the quarterback's ability to finish a game oblivious of a torn ligament, or a fakir sitting on a bed of spikes. One of the foremost pioneers in pain research adds his personal tale, too, of the time he landed a salmon after a long and hearty struggle, only then to discover the deep blood-dripping gash on his leg.

Acknowledging such events, neuroscientists have long suspected that there are built-in nervous system mechanisms that can block pain messages. Now it seems that just as there is more than one way to spread the news of pain, there is more than one way to censor the news. These control systems involve pathways that come down from the brain to prevent pain signals from getting through.

The gate theory of pain

Interestingly, a pair of Canadian and English investigators speculated that such pain-suppressing pathways must exist when they devised a new "gate theory of pain" in the midsixties. Their idea was that when pain signals first reach the nervous system they excite activity in a group of small neurons that form a kind of pain "pool." When the total activity of these neurons reaches a certain minimal level, a hypothetical "gate" opens up that allows the pain signals to be sent to higher brain centers. But nearby neurons in contact with the pain cells can suppress activity in the pain pool so that the gate stays closed. The gate-closing cells include large neurons that are stimulated by nonpainful touching or pressing of your skin. The gate could also be closed from above, by brain cells activating a descending pathway to block pain.

The theory explained such everyday behavior as scratching a scab, or rubbing a sprained ankle: the scratching and rubbing excite just those nerve cells sensitive to touch and pressure that can suppress the pain pool cells. The scientists conjectured that brain-based pain control systems were activated when people behaved heroically--ignoring pain to finish a football game, or to help a more severely wounded soldier on the battlefield.

Thus, this "gate control" theory holds that specialized nerve cells in your spinal cord act as gates that open to allow pain messages to pass, depending on the strength and nature of the pain signal.

The gate theory aroused both interest and controversy when it was first announced. Most importantly, it stimulated research to find the conjectured pathways and mechanisms.

Pain studies got an added boost when investigators made the surprising discovery that the brain itself produces chemicals that can control pain.

The landmark discovery of the pain-suppressing chemicals came about because scientists in Aberdeen, Scotland, and at the Johns Hopkins University Hospital in Baltimore were curious about how morphine and other opium-derived painkillers, or analgesics, work.

A message-routing section in your brain

Pain signals travel from your peripheral nerves to your spinal cord to your thalamus, a message sorting and switching station in your brain. The thalamus sends two types of messages. One goes to your cerebral cortex, the thinking part of your brain, which assesses the location and severity of damage. The second is a "stop-pain" message back to the injury site to tell local nociceptors to stop sending any more pain messages. Once alerted, your brain doesn't need additional warning. But sometimes, this mechanism fails and pain persists.

Meanwhile, your cerebral cortex relays the pain message it received to your brain's limbic center. Your limbic center produces emotions, such as sadness or anger, in response to pain messages. Your limbic center can affect the way your cerebral cortex perceives pain messages, and can lessen or intensify your pain. Your cerebral cortex also sends messages to your autonomic nervous system, which controls vital body functions such as breathing, blood flow and pulse rate.

For some time neuroscientists had known that chemicals were important in conducting nerve signals (small bursts of electric current) from cell to cell. In order for the signal from one cell to reach the next in line, the first cell secretes a chemical "neurotransmitter" from the tip of a long fiber that extends from the cell body. The transmitter molecules cross the gap separating the two cells and attach to special receptor sites on the neighboring cell surface. Some neurotransmitters *excite* the second cell--allowing it to generate an electrical signal. Others *inhibit* the second cell--preventing it from generating a signal.

Several types of neurotransmitters (proteins and hormones produced in your brain or nervous system) can increase or decrease pain signals. A hormone--one of the prostaglandins--speeds transmission of pain messages and makes nerve endings more sensitive to pain. And a protein called substance P continuously stimulates nerve endings at the injury site and within your spinal cord, increasing

pain messages. Serotonin and norepinephrine (nor-ep-i-NEF-rin) seem to decrease pain by causing nociceptors to release natural pain-relievers called endorphins.

When investigators in Scotland and at Johns Hopkins injected morphine into experimental animals, they found that the morphine molecules fitted snugly into receptors on certain brain and spinal cord neurons. Why, the scientists wondered, should the human brain--the product of millions of years of evolution--come equipped with receptors for a man-made drug? Perhaps there were naturally occurring brain chemicals that behaved exactly like morphine.

The brain's own opiates

Both groups of scientists found not just one pain-suppressing chemical in the brain, but a whole family of such proteins. The Aberdeen investigators called the smaller members of the family *enkephalins* (meaning "in the head"). In time, the larger proteins were isolated and called *endorphins*, meaning the "morphine within." The term *endorphins* is now often used to describe the group as a whole.

The discovery of the endorphins lent weight to the general concept of the gate theory. Endorphins released from brain nerve cells might inhibit spinal cord pain cells through pathways descending from the brain to the spinal cord. Endorphins might also be activated when you rub or scratch your itching skin or aching joints. Laboratory experiments subsequently confirmed that painful stimulation led to the release of endorphins from nerve cells. Some of these chemicals then turned up in cerebrospinal fluid, the liquid that circulates in the spinal cord and brain. Laced with endorphins, the fluid could bring a soothing balm to quiet nerve cells.