Pain

Dr. C. George Boeree

Pain is a perception, and like any perception, it is rooted in sensation, and on the biological level, in the stimulation of receptor neurons. Also like other forms of perception, pain is sometimes experienced when there is no corresponding biological basis!

Nociceptors

In the skin and other tissues of the body, there are special sensory neurons called **nociceptors**. These neurons translate certain stimuli into action potentials that are then transmitted to more central parts of the nervous system, such as the brain. There are four kinds of nociceptors:

Thermal nociceptors are sensitive to high or low temperatures.

Mechanical nociceptors respond to strong pressure to the skin that comes with cuts and blows. These receptors respond quickly, and often trigger protective reflexes!

Chemical nociceptors respond to a variety of chemicals released with tissue damage, as well as to external chemicals such as capsaicin (the chemical that makes hot peppers "hot") and spider venom.

Polymodal nociceptors can be excited by strong pressure, by heat or cold, and by chemical stimulation as well.

Silent (or sleeping) nociceptors stay quiet - hence the name - but become more sensitive to stimulation when they are surrounded by inflammation.

When there is significant damage to tissue, several chemicals are released into the area around the nociceptors. This develops into what is called the "**inflammatory soup**," an acidic mixture that stimulates and sensitizes the nociceptors into a state called **hyperalgesia**, which is Greek for "super pain." Some of the chemicals involved:

Prostaglandins are released by damaged cells
Potassium is released by damaged cells.
Serotonin is released by the blood platelets.

Bradykinin is released by blood plasma.
Histamine is released by mast cells.
In addition to all this, the nociceptors themselves release "**substance P**," which causes mast cells to release histamine, which in turn stimulates the nociceptors!

Histamine is interesting in that, when it stimulates nociceptors, it is experienced as an itch rather than pain. We don't know why. We use **antihistamines**, of course, "to relieve the itch."

There are tissues that contain nociceptors which do not lead to pain. In the lungs, for example, there are "pain receptors" which cause you to cough, but do not cause you to feel pain.

Transmission upwards

The nerves that carry messages from the nociceptors up the spinal cord follow several different tracts. Most go to the **thalamus**, where they are distributed to various higher centers. Some also go to the **reticular formation** (which, among other things, governs alertness) and to the **amygdala** (a part of the limbic system involved in emotion).

Referred pain, such as the pain that people sometimes feel in their left arms and shoulders when they are having a heart attach, is due to the way in which nerves come together in the spinal cord. The brain sometimes loses track of where the pain is coming from.

Gate theory is based on this idea of confusion of neural signals. It seems that some non-pain stimulation can sometimes interfere with the experience of pain. This is the explanation behind such phenomena as the benefits of rubbing a painful area, the use of hot or cold compresses, acupuncture, and acupressure.

There are people who have had damage to some part of these tracts, often after a stroke, who feel tingling or a burning pain that is aggravated by touch. Other people have damage higher in the brain that lets them feel pain like everyone else, but eliminates the connections to the emotional centers. They feel pain, but they don't suffer emotionally!

Phantom pain - the pain amputees sometimes feel in the very limb they are missing - is due to the fact that, when nociceptors are damaged or missing, the neurons in the spinal cord that transmit pain messages sometimes become hyperactive. So the brain gets messages of pain where there isn't even any tissue left!

In the brain and spinal cord, there are certain chemicals called **opioids**, or more specifically enkephalin, endorphin, and dynorphin. These opioids, as the name implies, are the body's very own forms of opium and its derivatives morphine and heroin. When they are released into synapses, they diminish the levels of pain transmitted, exactly like heroin.

There are actually a variety of things which diminish the experience of pain: marijuana, mother's milk (for newborns, of course), pregnancy, exercise, fear and shock, aggression, and diabetes. A reduced experience of pain is called, logically, **hypoalgesia**.

And there are people who are born with a genetic inability to feel pain at all. It is very rare, and at first sounds like a blessing. But the rate of early death is quite high in these people, usually because injuries that normal people would attend to (small ones, like sprains) go unattended and develop into more serious problems. There have been people with appendicitis who died of it simply because they hadn't noticed.

That, of course, is the reason why pain has evolved as it has: It warns us to sit down, rest, attend to an injury, avoid things that cause pain, and so on. On the other hand, pain is not always useful. The cancer patient, for example, knows about his or her disease and is taking care of it. The often excruciating pain is totally unnecessary, and we should do what we can to get rid of it!
