UNDERSTANDING THE NERVOUS SYSTEM AND PAIN

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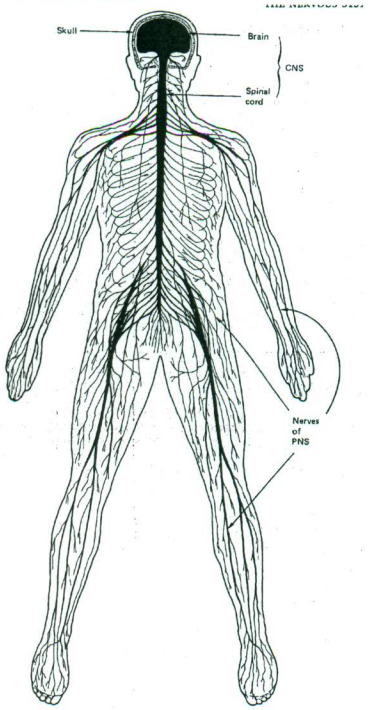
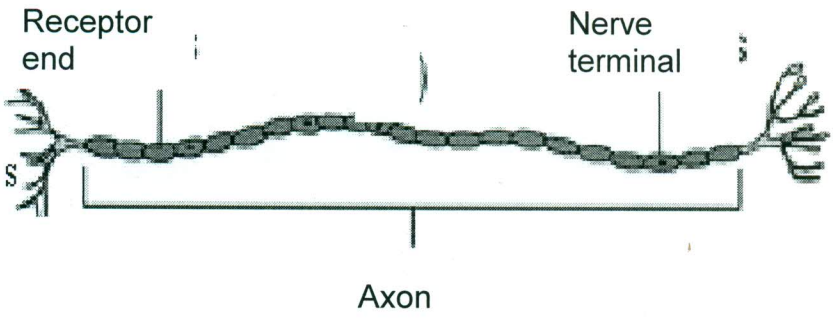
Before we look at how we feel pain, let's look at how our nervous system normally works.

Peripheral Nerves and Receptors in the Tissues

Our body is made up of millions of nerves - most of which are too small to be seen on a scan. Those in our body, arms and legs are called peripheral nerves, and form what is known as the peripheral nervous system. The nerves have special receptors which detect changes in the tissues. Messages from different tissues are carried by the nerves to the spinal cord and then up to the brain. This keeps our brain constantly informed about what is going on in and around our body. Thus nerves are like electrical wires, carrying information to and from the brain. The main nerves (such as the sciatic nerve) are formed from bundles of many tiny nerves.

Each nerve has the same three parts – a receptor (the nerve ending), a long nerve fibre (the axon), and a nerve terminal, as shown in the picture below. The point at which two nerves join together is called a synapse. When something excites the receptor at one end, a message is sent as an electrical current along the axon, and when it reaches the terminal, causes the releases of chemicals, called neurotransmitters. The neurotransmitters latch onto receptors at the end of the next nerve, rather like a docking station, and the message is relayed along the next nerve towards the brain. All nerves work like this.



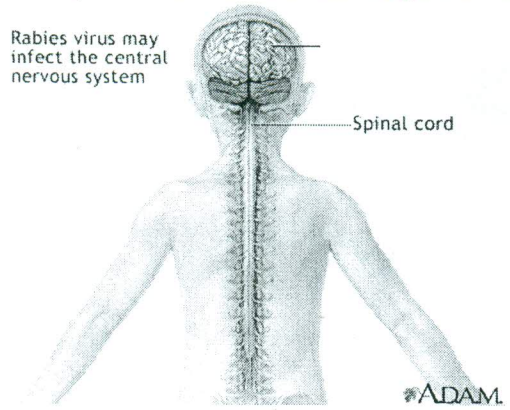


Different things will make these receptors get excited. For example, there are receptors that detect changes in touch, pressure, stretch, and chemicals. In our eye our receptors detect changes to light; in our ear they detect changes to vibration. These receptors are quite specific in what they respond to. Therefore when light shines in your ear, you do not hear anything.

Peripheral nerves are rather like a record player with a needle picking up the information, which is then carried in electrical impulses to the amplifier where it is decoded. The electrical activity in the wire itself means nothing until it is decoded by the amplifier and turned into sound. Likewise, the information carried by a nerve is simply electrical information and is not decoded until it reaches the brain. The sensation of pain is not 'pain' as we know it until it is interpreted by the brain.

The Spinal Cord

The spinal cord and brain together are known as the central nervous system.



Trillions of messages are sent along the peripheral nerves to the spinal cord every day. Not every message from the tissues gets relayed to the brain. This is because the spinal cord acts like a filter - sifting through the millions of messages coming in from parts of the body and deciding what messages need to be relayed up the spinal cord to the brain. You could liken it to a secretary where one of her jobs is to filter the phone calls coming in and decide which ones are important and need to put through to her boss.

Can you feel your watch on your wrist? Yes.
Were you aware of it a few minutes ago? No.
What happened?

When I asked you about it, your brain sent a message down saying – "I'd like to know about my watch please." Until that moment, your spinal cord had been filtering out those messages. This was happening because your brain will have been sending a message down to your spinal cord saying something like "situation normal, she's got her watch on again, you don't need to keep letting me know thanks."

What we can see with the watch example is that the spinal cord acts like a type of 'gate' which can open and shut, to let messages pass or not. This gate is controlled by messages from connecting nerves, especially nerves which pick up pressure or touch. Information from the touch nerves can close the gates on the pain signals.

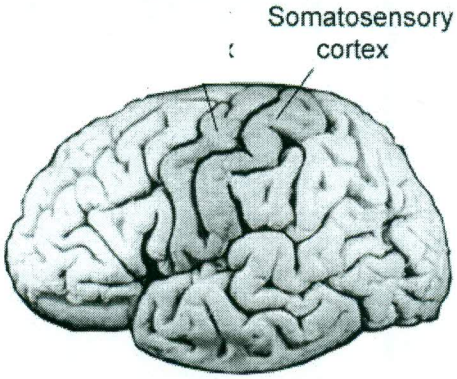
For instance, when you bruise or bump some part of your body, your immediate reaction is to rub it to soothe it. Rubbing the skin around the bruised area sets off messages in the nerves sensitive to touch. These messages travel to the spinal cord where they pass through the open gates and are felt in the brain as touch, not pain. This process closes the gates on the pain to the pain messages, thus helping to block the pain messages from the bruise. This is probably the way in which a TENS unit works (TENS is a small electrical stimulator used in pain clinics to help with some types of pain), and possibly acupuncture.

Information coming down from the brain can also help to open or close the gates. For example, you may have had the experience of cutting your finger but not know about it until you saw the blood. If you are focusing your attention and concern on a cut, what the brain can do is adjust the volume on the messages coming in ("tell me more about that") and the signals from your brain will probably open the gates and you will feel more pain. On the other hand, if you are preoccupied and your attention is elsewhere, your brain might turn the volume down ("tell me less about that") and close the gates and you will feel less pain.

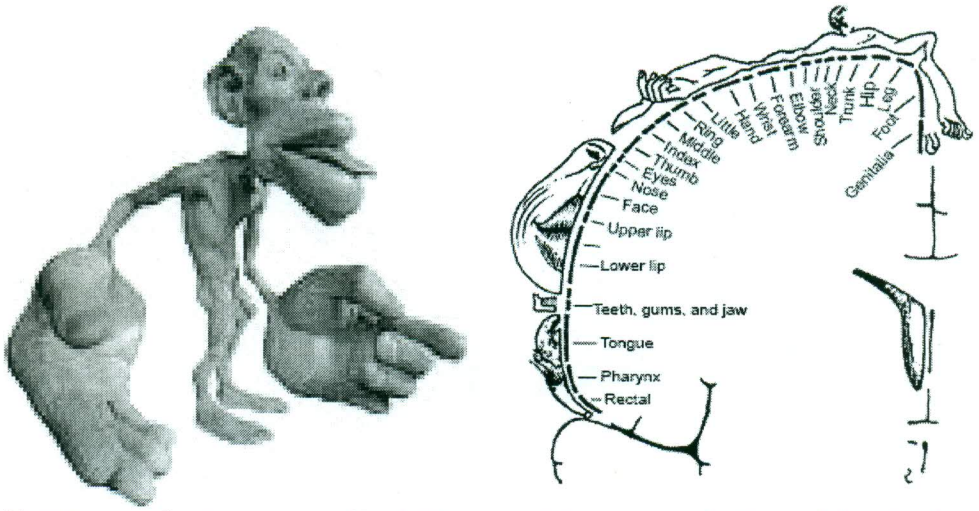
The Brain

The spinal cord feeds into an area of the brain called the brain stem, which passes the sensory information to the higher levels of the brain. There is no one area of the brain that interprets messages about pain; a number of areas do this, collectively known as the pain matrix. It is here that we first feel the sensation of pain.

Everyone has a mental representation of their body. A section of the outermost layer of the brain, called the somatosensory cortex, represents the body most precisely. The somatosensory cortex is the main receptive area for sensations such as touch.



The somatosensory cortex has what is called a somatotropic arrangement i.e. sensory information about the hand is next to sensory information about the arm. Areas of the body which are have a denser nerve supply have a larger representational in the brain. The sensory homunculus is a representation of the concept of "the body within the brain". The image is grotesquely disfigured with disproportionately huge hands, lips, and face in comparison to the rest of the body. This is because larger numbers of sensory nerves are found in these particular parts of the body therefore they are represented as being larger on the homunculus. Parts of the body with fewer sensory connections to the brain are represented as smaller.



Numerous factors can affect this mental representation of the body, such as altered sensory information - consider the feeling of a swollen lip when you have had an anaesthetic injection at the dentist. Certain surgery, such as an amputation, can give rise to phantom sensations or phantom limb pain because the brain has not updated its map of the body and still holds a representation for the missing part. Ongoing pain can also cause rearrangement of the brain's representation of the painful area. This explains why a painful part of your body may feel larger than it appears to be.

Many other areas of the brain are involved with decoding and interpreting the messages it receives. Your brain looks at the **meaning** of the situation. Subconsciously, you are asking yourself, "What does this message mean? What should I do?" The answers to these questions will affect how you respond and react to the messages.

If a loved one were to put their arm around you, receptors in your skin would detect the touch and send messages to your spinal cord, which are relayed to your brain. If you were alone in a dark alley at night and someone came up behind you and put their arm around you, receptors in your skin would detect the touch and send messages to your spinal cord and brain in exactly the same way.

However, we respond differently to these two similar sensations because they have a different meaning. When it is your loved one, that situation is not threatening so your brain will not send messages down that turn the volume up. When you are in the dark alley, your brain will receive messages about that person's touch and will take into account all the circumstances. It will draw on your experiences (e.g. last time someone approached me from behind…), your emotions (e.g. fear), your thoughts (e.g. do they want to mug me?). It's likely that your brain will interpret this message as threatening.

In a nutshell, our brain interprets the messages it receives about sensations in our body and gives them meaning. The more threatening the situation feels, the more it will turn the volume up. This results in more messages coming to the brain. It becomes a vicious circle. This is what is happening in your body when you have chronic pain.

At INPUT we mention acute and chronic pain. The next section covers in more detail the differences between acute and chronic pain and how the nervous system adapts and changes when you have chronic pain. It will help you to understand why you feel pain.

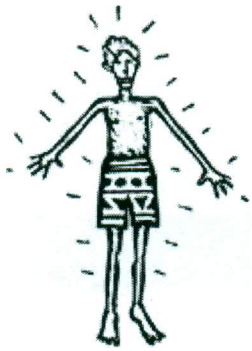
Acute Pain

Acute pain occurs when one of the following structures is damaged: skin (e.g. burns, cuts), bones (e.g. fractures), muscles (e.g. bruises, cramp), joints (e.g. sprains), nerve sheaths (e.g. sciatica), internal organs (e.g. heart attack, appendicitis). This shows us one of the roles of pain - to PROTECT us. This is a helpful thing and prevents us doing further damage. Generally, when we injure something, it is painful and sensitive but when the tissues have healed, the pain goes away.

ACUTE PAIN Injury —Healing→ Pain stops

This is unlike chronic pain which may or may not start with an injury. If there was an injury, it heals but when healing has finished, the pain does not go away and the nervous system remains sensitive. If there is no injury, the nervous system has become sensitive. When you have chronic pain, the pain does not mean there is damage.

CHRONIC PAIN Injury (maybe/maybe not) —Healing→ Pain continues →


When you damage tissue, it results in some swelling, redness, heat and pain: this is inflammation which is a function of healing. Different chemicals will also be found. When you are sunburnt for example, the skin cells damaged by the sun release these chemicals. This 'chemical soup' as it is called, sensitises nerves in the area, the spinal cord increases this sensitisation further, and the sensations you feel are amplified. Have you ever found that you tend to really notice your sunburn after a while; maybe a few hours after coming off the beach. If you get in the shower that evening, have you noticed anything different about the temperature of the water? It can feel hotter. Even the T-shirt on your shoulder can feel very sore, though its touch is clearly not causing damage. What we are seeing here is the nervous system becoming hypersensitive.

However, you don't have to have an injury for your nervous system to change in this way. You may for example remember headaches where even touching your hair hurt. There is no tissue damage when you have a headache yet your nervous system becomes sensitive: for some people even for bright light or noise. Period pain is another example where pain may be experienced but there is no damage: periods are the natural shedding of the womb lining, which may caused increased sensitivity and there may be some painful muscle contractions, but this is not damage. Half of the people who come to INPUT have their chronic pain as a result of an injury and the other half describe how their pain just started and then became constant.

Chronic Pain

Chronic pain is now a recognised diagnosis. As with any chronic illness such as diabetes or asthma, it pays to know as much as possible to enable you to manage it as best you can.

All animals feel pain and there is no doubt that acute pain serves to warn us against further injury or damage. Chronic pain serves no such purpose - it does not function as a warning, does not prevent damage, and has no benefits that we can detect. What changes take place in the nerves when you have chronic pain?

Messages still come from the tissues in chronic pain but they are not the sole reason for the pain; it is the central nervous system's hypersensitivity or misinterpretation that means these normal messages are felt as pain. Tissues that are unhealthy due to lack of good exercise, stretch, circulation and use become uncomfortable and feel stiff, but this is not chronic pain - though it can add to it.

We know that in chronic pain, the sensitivity of the nerves increases so that the pain impulses generated from an area of tissue or an old injury may be amplified in the spinal cord and brain. Some research shows that the central nervous system also has a memory for pain so may recall the pain from an old injury.

There are a number of changes that can occur.

1. Remember those neurotransmitters that are released from the nerve terminal and latch onto receptors on the next nerve. Certain receptors are activated but others remain inactive (called sleeping receptors). What can happen with chronic pain is

that those inactive docking stations open up. Chemicals can now latch onto them as well as the other receptors and that will help to relay more messages to the brain. You could liken this to the supermarket when it gets busy and they open up other tills to get people though as quickly as possible. Once these sleeping receptors have been "woken up", they remain active so more messages get relayed to the brain.

2. The nerve is actually able to produce more receptors so that more and more messages can be relayed to the brain.
3. The nerves are more readily excitable and relay more messages. You could liken to the difference between a car motor that is just ticking over to one that is revving and about to go.
4. Our nerves usually need to have a "rest period" before they can relay another message. The changes mean that the nerves no longer have this rest period and can therefore keep relaying messages to the brain.
5. It is also possible that nerves in the surrounding area which usually transmit messages about touch, pressure, temperature begin to transmit messages about pain so again, more messages can be relayed to the brain.
6. The spinal cord no longer filters as many messages and just allows them all to be relayed to the brain. It's as if that secretary has gone home early and is no longer intercepting any calls.
7. The nerves that transmit pain signals usually enter the spinal cord at a superficial level and those that transmit messages about touch, pressure, movement etc. enter the spinal cord at a deeper level. With nerve damage, those that transmit messages about touch, pressure grow until they come alongside the nerves that transmit pain messages. When they get excited (say by touch), they will now transmit messages about pain, relaying even more messages to the brain. What you may have noticed is that now things like being touched, or changes in the weather, your clothes against your skin or pressure from sitting on a chair can all now feel painful for you.
8. What also happens is that if we get anxious or worried, this releases chemicals that increase the volume and more messages get relayed to the brain. People often tell us that their pain increases when they are stressed.

As you can see, with sensitisation of the nervous system, it can keep triggering itself to send messages to your brain. Research that demonstrates this has been carried out on cats' knee joints. Movement of a normal knee joint resulted in 4,400 messages being sent every 30 seconds. Movement of an inflamed, injured joint resulted in 30,900 messages being sent every 30 seconds.

Once the changes have happened, they are irreversible. The nervous system can become so sensitive that even just watching someone else doing something that you find painful can make your pain worse.

People often tell us that there is no rhyme or reason as to what makes their pain worse. This makes sense when we understand that it can be the system triggering itself.

Let's look at an example of someone who injures their back whilst lifting something.

The same process happens as described. The damaged tissues release chemicals, which excite the receptors and relay messages to their spinal cord. The spinal cord relays the messages to their brain where it interprets them and gives them meaning.

To give these messages meaning their brain will draw on many things. Their past experiences (e.g. when I hurt my back last time, I was off sick for weeks), their predictions about the future (e.g. if I am off again, I might lose my job), their emotions at the time (e.g. anxiety), their beliefs (e.g. lifting is bad for me; my back is weak.) All of these thoughts, feelings and emotions come into play when that message comes up the spinal cord to the brain.

Many other things affect the situation. Say, a person meets a friend who says, "that sounds really bad – you might have slipped a disc." Or, their GP tells them that by now their pain should have gone but hasn't. He gives them stronger painkillers and they hope that these will work, but they don't seem to because the pain is still there.

All the time, they are getting more and more concerned and the situation is feeling really threatening. The brain is turning the volume up and changes are taking place in the nervous system to make it better at relaying messages.

Maybe, some while later, a scan is done and the person is told that they have arthritis. They didn't know this because this is the first time their back has been scanned. They start to think of a relative who was told they had arthritis and ended up in a wheelchair.

Six weeks after injuring your back, the tissues will have healed but with chronic pain, the nervous system stays sensitive and the pain does not go away. Let's take it that this person was to continue avoiding bending and lifting because they thought their back was still damaged. Our brain relies on receiving information from our tissues. If you pull back from doing something or stop doing it altogether, your brain will "turn the volume up" so that if and when you do that movement, your brain is on tenterhooks, waiting to receive messages. You do that movement or activity, your brain receives lots of messages and decides it is threatening because it is not used to so many messages. You feel increased pain and conclude that your back is still damaged and that you should pull back from doing this. The vicious cycle continues.

IN SUMMARY

To understand the way pain is experienced, we need to appreciate that the system is very complicated and very flexible. We have seen that a certain injury does not mean a set amount of pain, but pain can vary depending on whether the pain gates are open, how much the spinal cord is filtering out, and how we understand and interpret the pain in the higher brain centres. Two people can have very similar injuries but describe their pain and suffering in quite different ways.

Pain that has been going on for years, which may be mysterious and frightening, and which has stopped a person from leading the life he or she wants to live, will cause much more suffering than the same physical sensation present for only a short time or interfering very little with lifestyle. The psychological reaction to the pain will affect the interpretation of the physical pain messages in the brain and make the pain worse or more bearable. It won't however have caused it or cured it.

FURTHER READING

'The Challenge of Pain', Ronald Melzack and Pat Wall. 2nd edition, published by Penguin, London, 1996.

'Pain: The Science of Suffering', Pat Wall published by Weidenfeld & Nicholson, London, 1999.