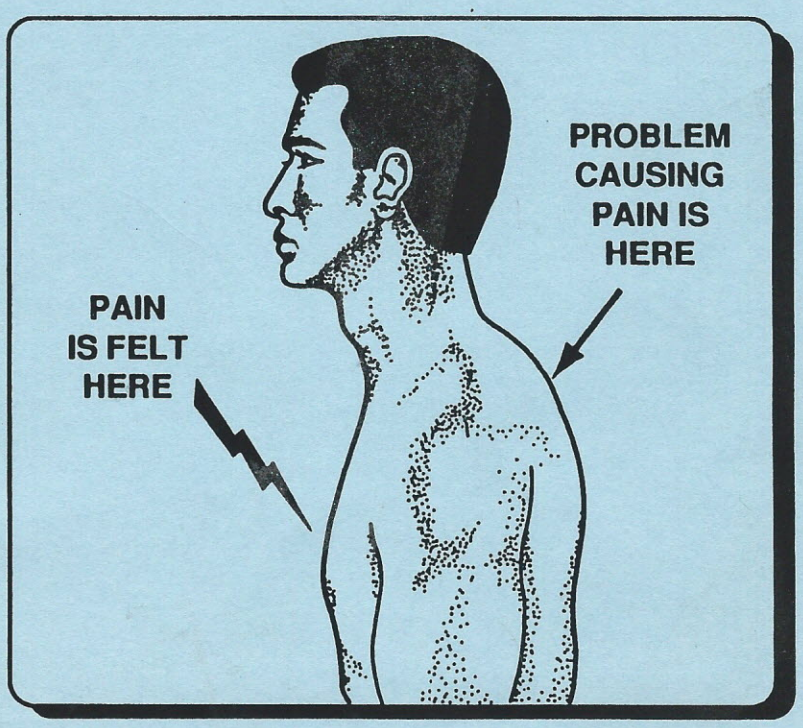
PAIN

AND THE PROBLEM CAUSING IT

AREN'T ALWAYS IN THE SAME PLACE



LTC Richard A. Sherman, MS, PhD,
Douglas E. Hemler, MD

Clinical Investigation • Rehabilitative Medicine • Orthopedic Surgery

FITZSIMONS ARMY MEDICAL CENTER

TABLE OF CONTENTS

FIGURES:

INTRODUCTION

It is common knowledge that much or all of the pain experienced during a heart attack is frequently felt in the left shoulder and upper arm. Just about everybody has felt pain in the forearm and hand after the elbow - "funny bone" is hit. It is also common for the forehead to hurt while eating or drinking something very cold. In all of these examples, there is nothing wrong with the areas that are hurting and the problem is clearly some distance away.

These common examples are just the tip of the iceberg. When we hurt, there is frequently nothing wrong at the site of the pain. Instead, the problem is in an area somehow associated with the painful site as illustrated in Figure 1 on the cover.) .

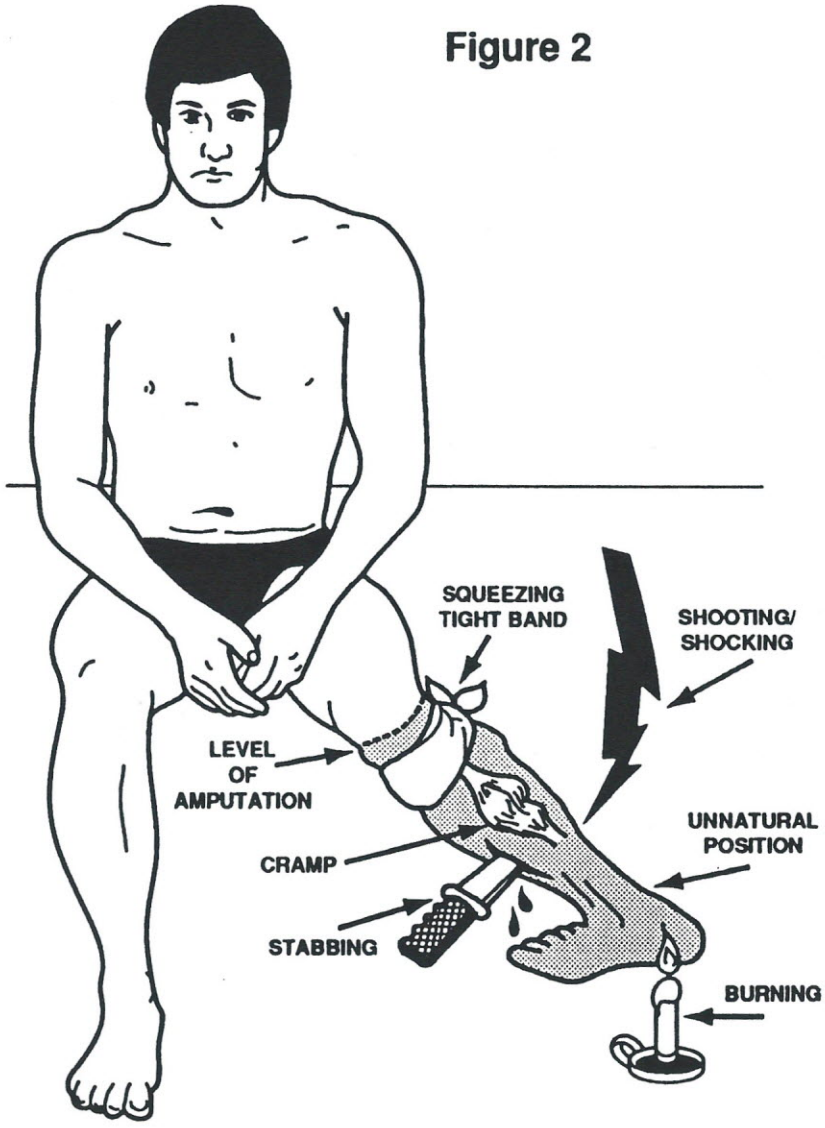
Perhaps the most unusual example of pain felt at a site which is not causing the pain is **PHANTOM LIMB PAIN**. Typical phantom pains are illustrated in Figure 2. In this case, a person who has had an amputation experiences pain which appears to be emanating from the portion of the limb which was removed. Our research has proven (a) that about 90% of amputees experience phantom pain and (b) that its origin is in the residual limb (stump) rather than the imagination. For example, burning phantom pain is caused by too little blood flow in the residual limb while cramping phantom pain is caused by muscle spasms in the residual limb.

Common sites of pain caused by problems at distant sources are illustrated in Figure 3. The locations of these painful sites and many of the theories explaining their presence were compiled from numerous sources which are listed at the end of the pamphlet.

Phantom Limb Pain

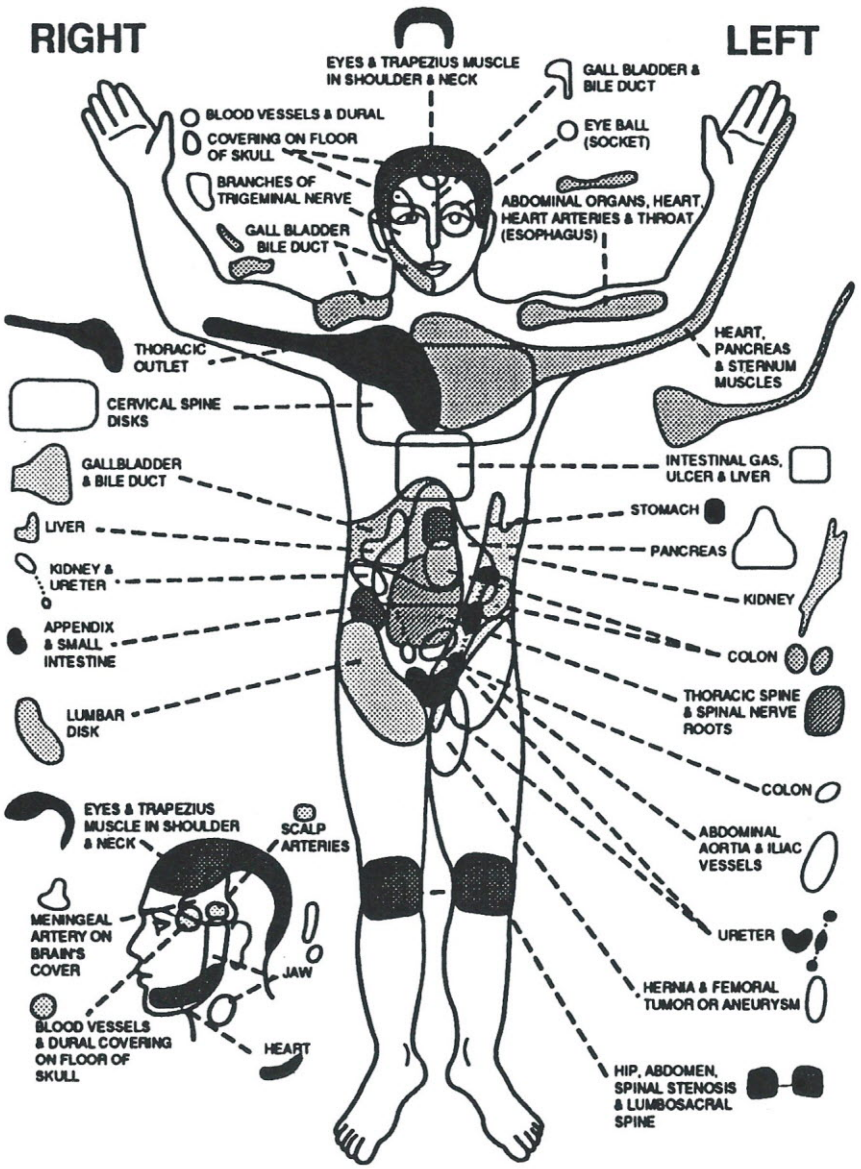
Some of the typical painful feelings which seem to stem from the missing limb

Figure 2

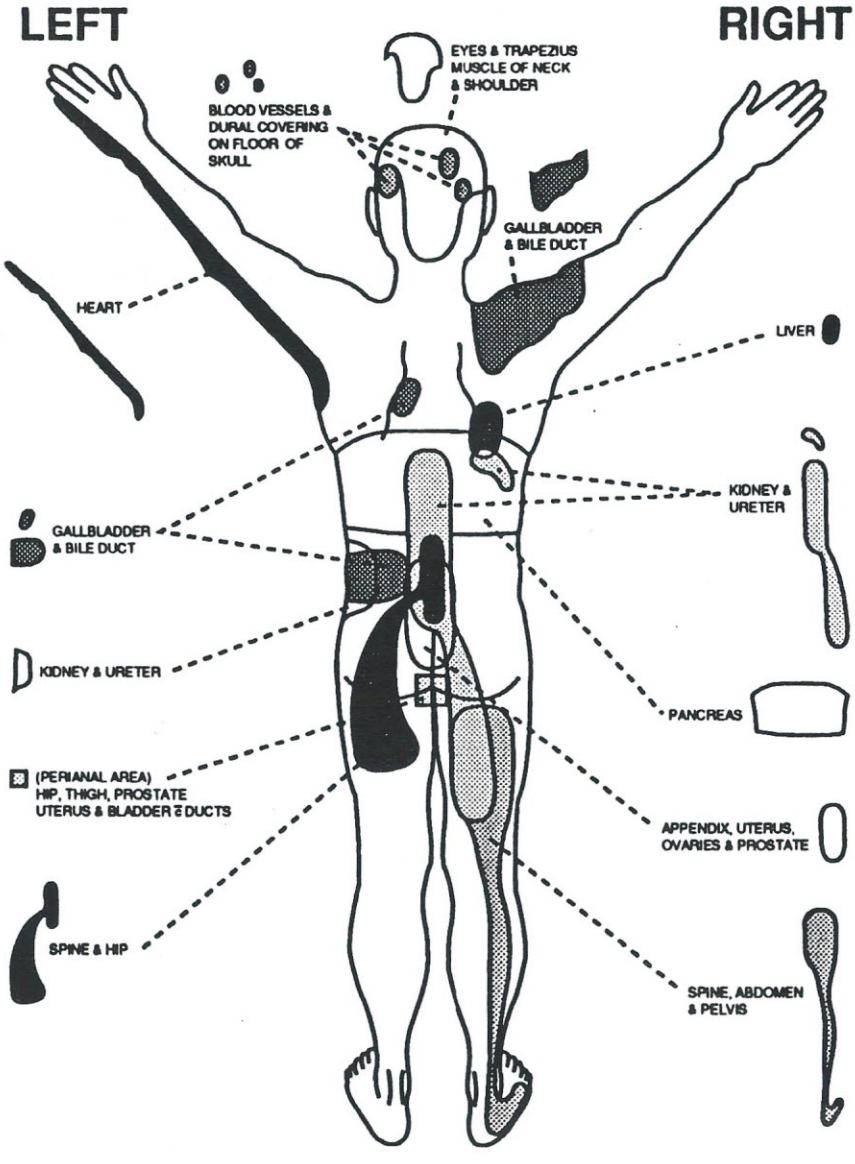


COMMON SITES OF PAIN CAUSED BY

Figure 3



PROBLEMS AT DISTANT SOURCES



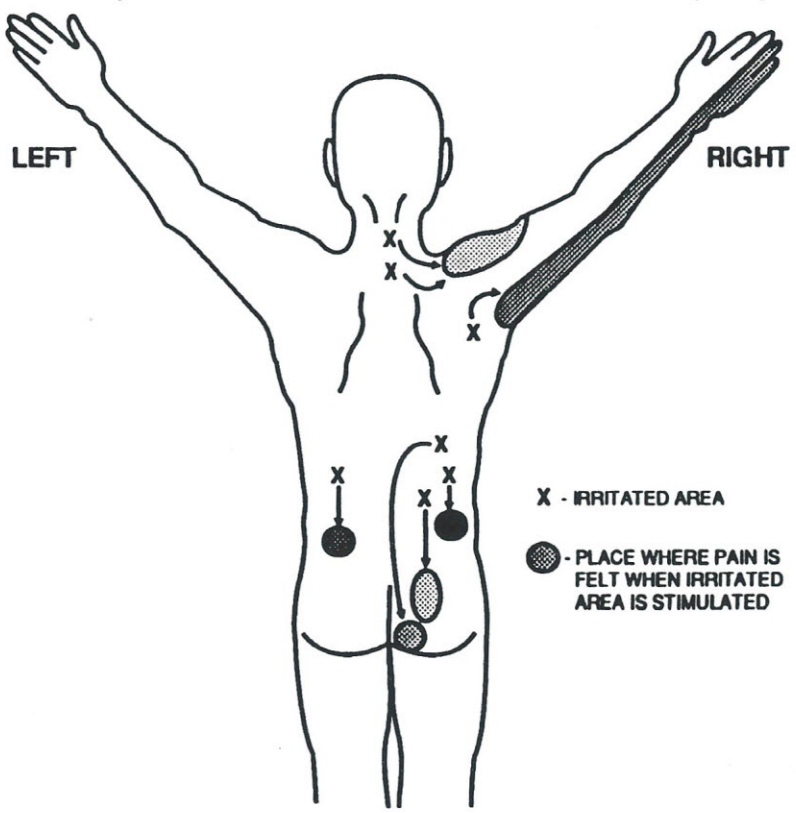
TRIGGER POINTS

Sometimes pain which seems to come from one part of a muscle may be caused by an irritation or other problem in an associated muscle area or tendon. If pressing on one small spot consistently causes (or "triggers") pain in the same, separate area of the muscle, it is called a trigger point. Several such points are illustrated in Figure 4.

SOME SOURCES OF PAIN CAUSED BY IRRITATED POINTS ON ASSOCIATED MUSCLES AND TENDONS

Figure 4.

Partially based on information from Travel and Simons (1983).



POSSIBLE MECHANISMS

In order to understand how we can feel pain at one site when the problem is at another, we have to understand how the body's wiring tells the conscious mind where pain is coming from.

Many of the connections in major parts of the brain are fairly permanent and do not change much after birth. The CORTEX is the outermost layer of the brain near the top of the head. The Somatosensory (body feeling) part of the cortex has areas which correspond to all of the parts of the body. Nerve impulses which begin at any part of the body pass through the body, the spinal cord, and many parts of the brain before finishing up at the corresponding place on the cortex (the post central gyrus). This area of the brain is sometimes called a HOMUNCULUS (little person) because it would look like a distorted person if the areas it receives information from were drawn in. It is distorted because some parts of the body (such as the fingers and lips) have more nerve beginnings than others (such as the upper arms) which means that the representations of some body parts take up more space on the cortex than others. Thus, when you touch something with your left pinkie fingertip, a nerve impulse begins at your left pinkie finger, travels through your hand, arm, elbow, etc. until it reaches your spinal cord; goes up the spinal cord; and then through much of your brain to the left pinkie fingertip position on your cortex. The sensory cortex has no way to know where a signal began. Thus, if a signal comes in on the nerve pathway which begins at the left pinkie fingertip it will go to the corresponding left pinkie fingertip position in the cortex and the conscious mind will be informed that something has stimulated the left pinkie fingertip. This is true regardless of where the signal actually began.

The ulnar nerve passes along the elbow after gathering information from the fingers, hand, forearm, etc. If the elbow is hit hard enough, the ulnar nerve is stimulated at the same time as the nerves which gather information from the elbow. The information reaches the corresponding areas of the

cortex so the mind "feels" the pain at those places. Of course, since sensors at the elbow are also stimulated, the elbow hurts also.

If the arm had been amputated just below the elbow, when the elbow is hit, the mind would still "feel" the pain in the fingers, etc. the same way as it does with the arm present. This is because the location part of the cortex does not change significantly after an amputation. This is the mechanism through which phantom pain works.

DIAGRAMMATIC ILLUSTRATION OF NERVE CONNECTIONS BETWEEN FINGER AND BRAIN

1. LEFT SIDE:

If the pinkie is tapped, the signal goes through the hand and forearm; past the elbow, through the upper arm and into the spinal cord. From there it goes through many parts of the brain to the cortex where the pinkie finger part receives the information.

2. RIGHT SIDE:

If the elbow is hit hard enough, the blow not only stimulates the nerves that start at the elbow, but also those passing through the elbow from their starting places in the fingers, hand, and forearm. These signals go to the finger, hand, and forearm positions on the cortex. So, the conscious mind thinks these areas have been hit also. Note that the feelings would seem to come from these areas even if they had been amputated.

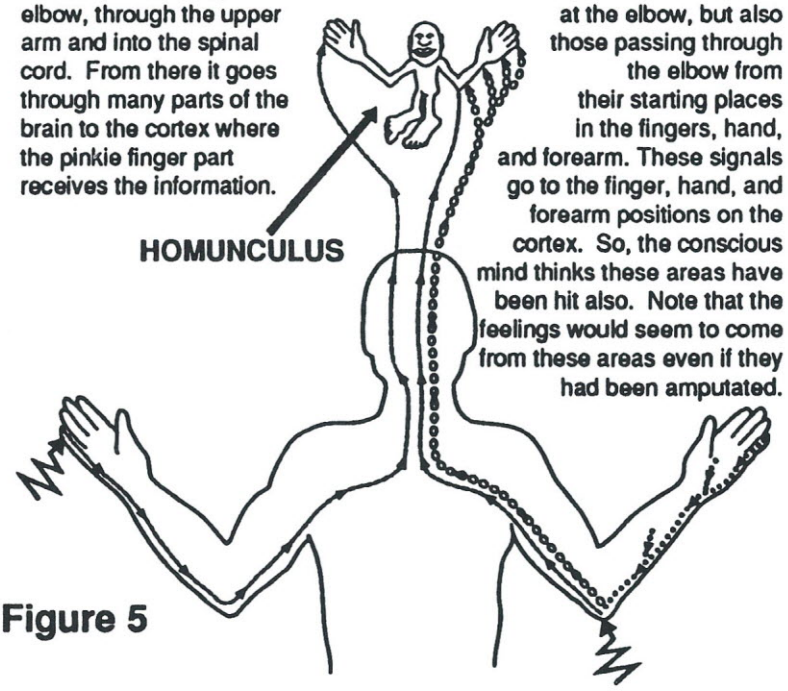


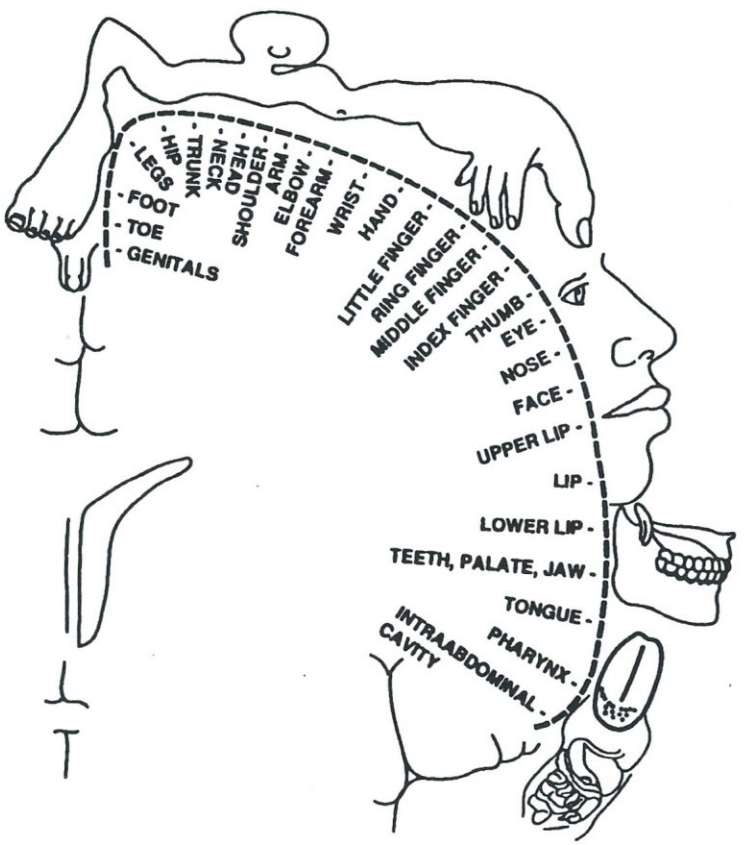
Figure 5

These processes are illustrated in figures 5-7. Figure 5 diagrammatically shows why a signal started anywhere along a nerve's track is felt as though it came from the nerve's normal starting place. Figure 6 shows how the body's parts are actually arranged on the cortex and Figure 7 shows the route the nerves actually follow to get from the body to the cortex.

ACTUAL LAYOUT OF POINTS IN BRAIN CORRESPONDING TO POINTS ON BODY

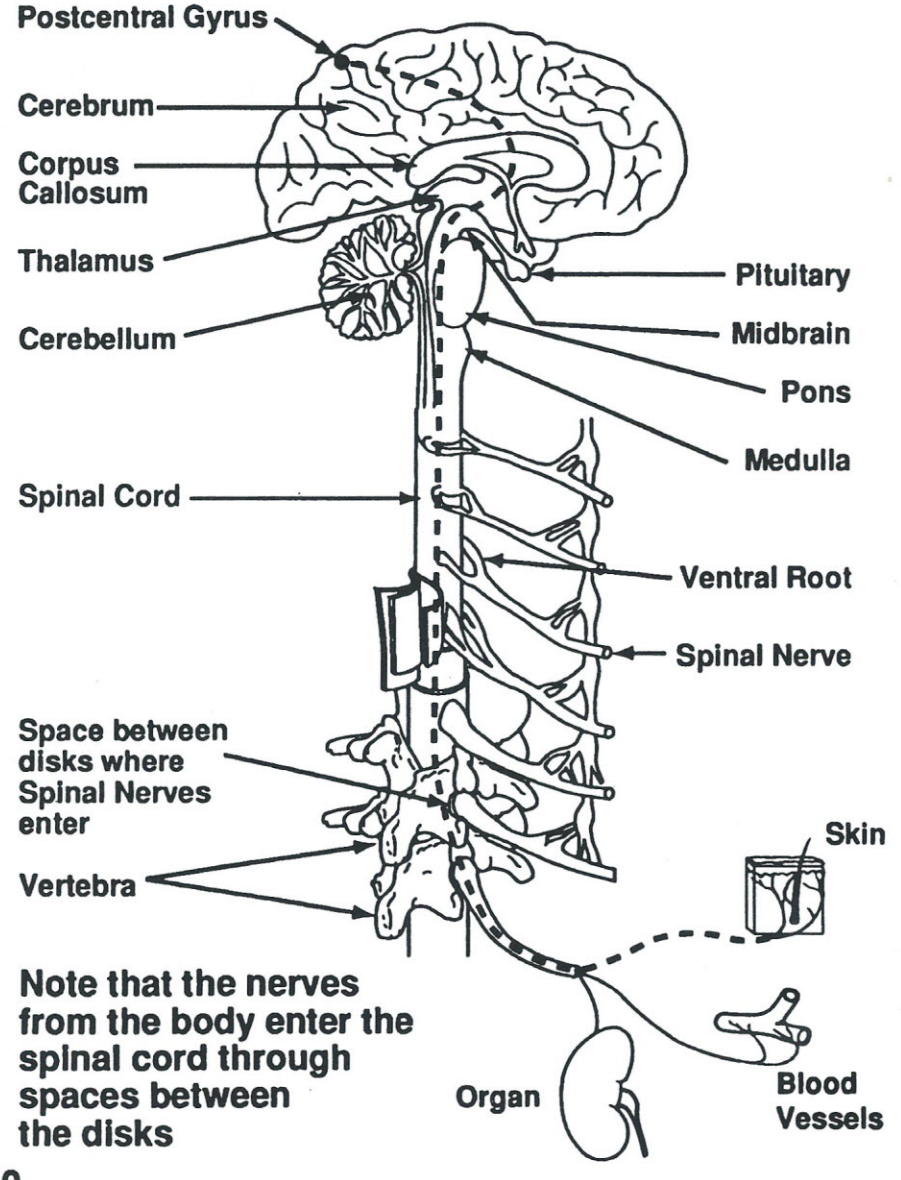
Figure 6

Adapted from a figure by Penfield and Rasmussen (1950).



ACTUAL ROUTE NERVES FOLLOW TO GET FROM THE SKIN TO THE BRAIN'S CORTEX

Figure 7. Partially based on a figure by Gardner (1963).



Note that the nerves from the body enter the spinal cord through spaces between the disks

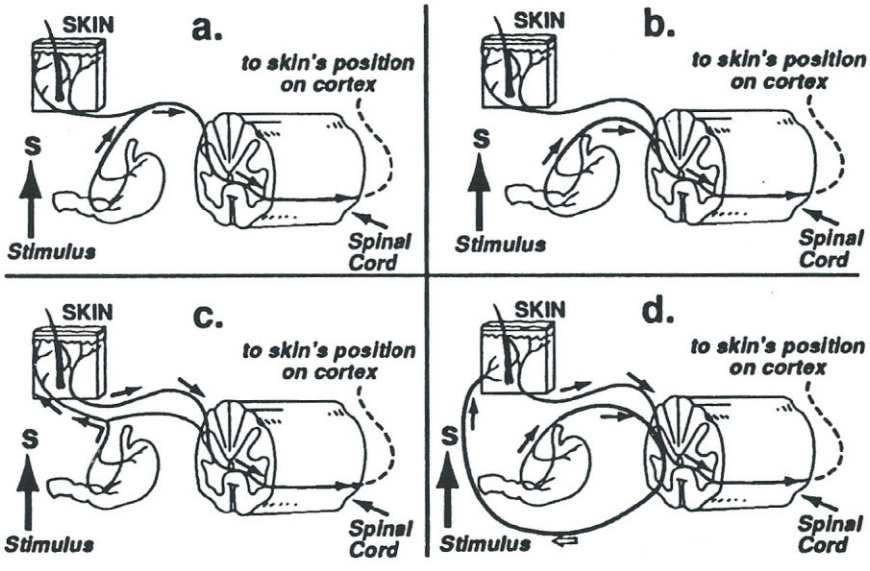
HOW PROBLEMS IN AN ORGAN CAN BE FELT AS PAIN ON THE SKIN:

When problems in an organ are felt on the skin the pain is said to be "projected" or "referred" from the organ to the skin, so it is called REFERRED PAIN. The four main theories which try to address this problem are illustrated in Figure 8. None have been proven to be either right or wrong. Two of the theories explain how you could feel the cold from eating ice cream as pain in the forehead by having the signals from the roof of the mouth mixed up with those from the forehead either before entering the spinal cord (a) or someplace inside it (b). The other two theories require nerve signals from the mouth to stimulate the forehead itself either through a direct connection (c) or indirectly though connections made in the spinal cord (d). In Figure 8, signals start at the "s" and follow the path of the arrows. The final arrow leads to the skin area in the brain's cortex.

Stimulation of (a) the intercostal spaces and muscles and (b) the interspinous ligaments produces pain sensations on a variety of distant areas of the skin which are not associated with any of the usual nerve distributions. Thus, a careful evaluation of muscles and ligaments needs to be included in any evaluation of pain which does not appear to come from sites just below the skin. Typical referral patterns are illustrated on pages 163 - 167 of Bonica's (1990) book on management of pain.

POSSIBLE WAYS PROBLEMS IN AN ORGAN COULD BE FELT AS THOUGH THEY COME FROM THE SKIN

Figure 8.



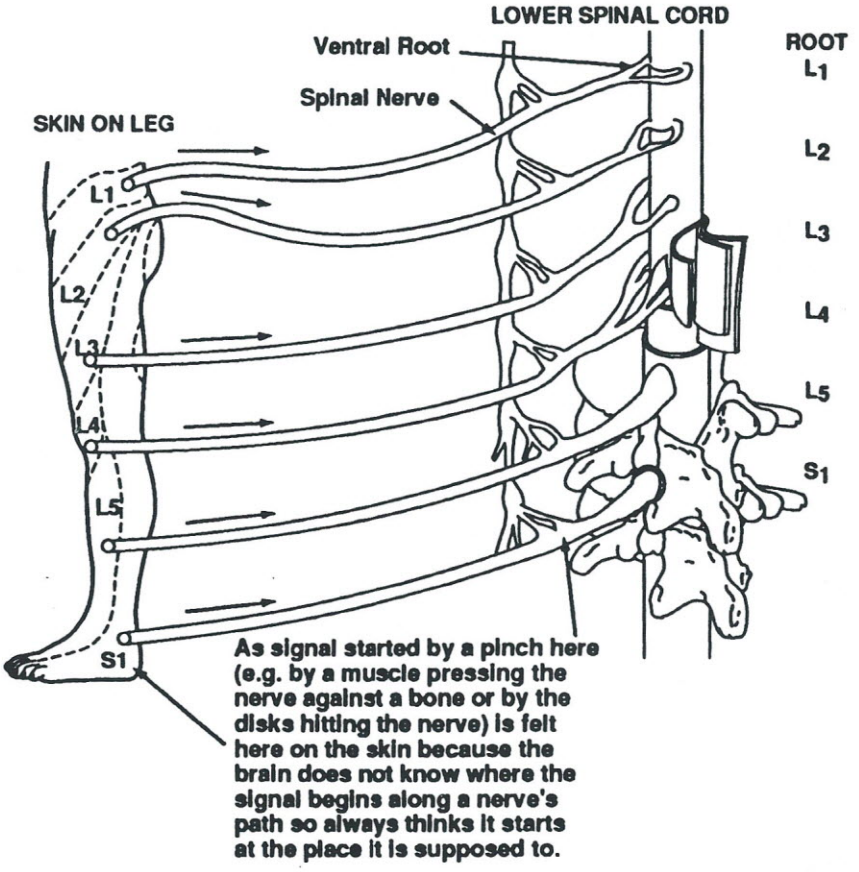
Redrawn and modified from a figure by Fields (1987).

HOW PROBLEMS IN A NERVE CAN BE FELT AS PAIN ON THE SKIN:

Most of the nerves which pick up information about pain from the skin go into the spinal cord through spaces between the disks. The specific surface areas served by each nerve have been approximately worked out over many years and are pictured in the diagram below. The area of skin served by a particular nerve is called its DERMATOME and is named after the spinal nerve. If the nerve is stimulated anywhere along its path, such as by (a) being pinched between two spinal disks, (b) squeezed against a hard spot by a muscle, or (c) damaged during an accident, the pain will feel as if it was coming from the skin the nerve collects information from. This is because the tract leads directly to a corresponding area in the cortex which represents that position on the body. This type of pain is frequently called NEUROGENIC because it is caused by stimulation of a nerve track somewhere other than at its normal starting point. Figure 9 shows how the body's surface is served by the different nerves entering the spine while Figure 10 shows how all of the body's surface is divided up to be served by different spinal nerves.

RELATIONSHIP BETWEEN SPINAL NERVES AND SKIN AREAS ILLUSTRATING HOW A SIGNAL STARTED ALONG A NERVE TRACK CAN BE FELT AT THE SKIN

Figure 9



LOCATION OF SKIN AREAS SERVED BY INDIVIDUAL SPINAL NERVES (DERMATOMES)

Figure 10

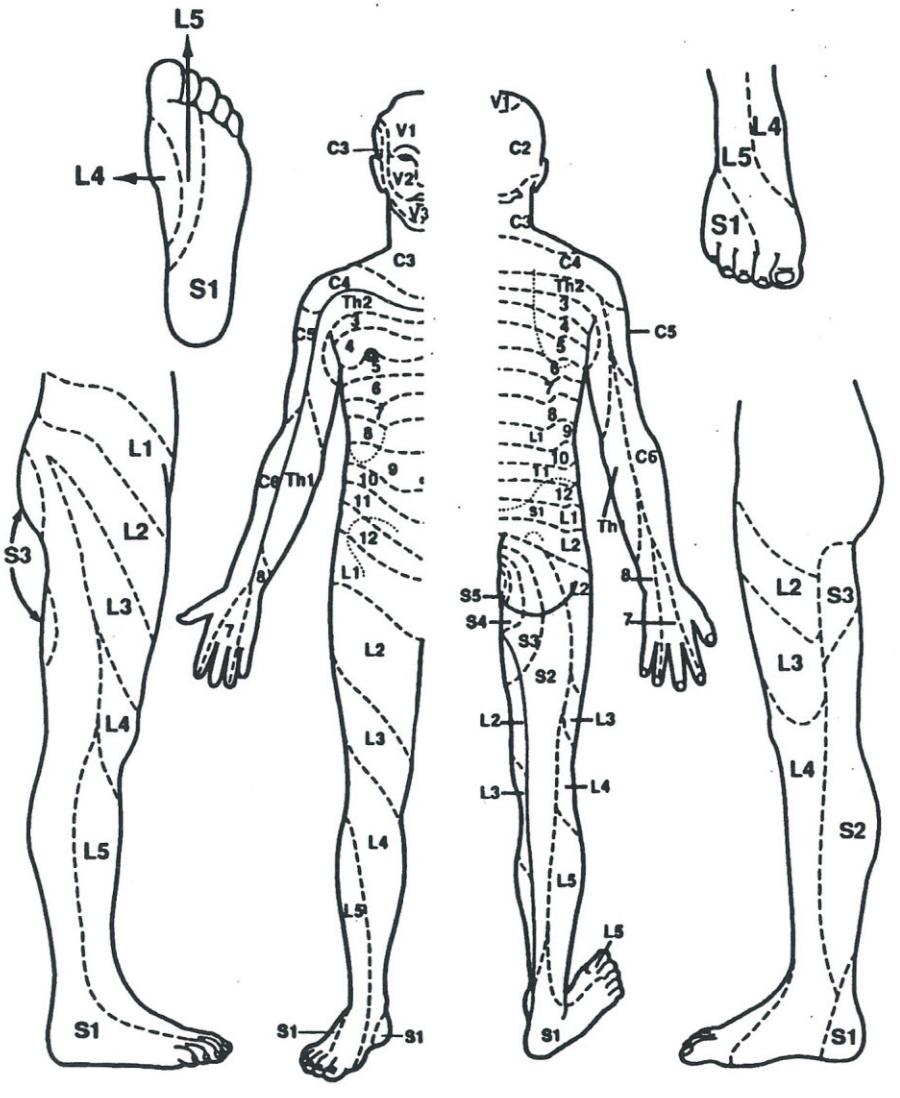


Figure used with permission of Bonica (1990).

SOURCES USED TO COMPILE THIS INFORMATION:

1. Bonica J: Management of Pain, 2nd ed. Lea & Febiger, Malvern PA, 1990.

2. Fields H: Pain. McGraw-Hill, New York, 1987.

3. Gardner, E: Fundamentals of Neurology, Saunders, Philadelphia, 1963.

4. Guyton A: Textbook of Medical Physiology, 6th ed. W.B. Saunders CO., Philadelphia, 1983.

5. Netter F: CIBA collection of medical illustrations. CIBA, West Caldwell New Jersey, 1983.

6. Penfield, W. and Rasmussen, T: The Cerebral Cortex of Man, Macmillian, New York, 1950.Macmillian, New York, 1950.

7. Sherman R: Stump & Phantom Pain. Neurologic Clinics 7: 249-264, 1989.

8. Smith D: General Urology, 11th ed. Lange, Los Altos California.

9. Thompson R: Foundations of Physiological Psychology, Harper & Row, New York, 1967.

10. Travell, J. and Simons, D: Myofascial Pain and Dysfunction. Williams and Wilkins, Baltimore, 1983.

ACKNOWLEDGEMENTS:

This research was entirely supported by the US Army Health Service Command's Clinical Investigation Activity. Many of the concepts and data are from the works of Dr. John Bonica to whom we are deeply greatful. The figures were finalized by Karen Wyatt Brown and Judy Grubaugh, medical illustrators at Fitzsimons AMC, from sketches provided by the senior author. The text and figures were reviewed by Steve Caminer, Melissa Damiano, Cecile Evans, Vernice Griffin, Carson Henderson, Crystal Sherman, Seth Sherman, and Stanford Varnardo of Clinical Biometrics and Orthopedic Research Section at Fitzsimons AMC.