





# Module 2-2

## Pain Taxonomy and Physiology

### By the end of the module, you will be able to:

- Define common terms used in pain medicine
- Identify traditional and clinically useful categorizations of pain
- Contrast pain and nociception
- Describe steps involved in pain processing and chronification

### We will review:

Topic One: Pain Terminology

Topic Two: Pain Taxonomy

Topic Three: Pain Physiology and Chronification

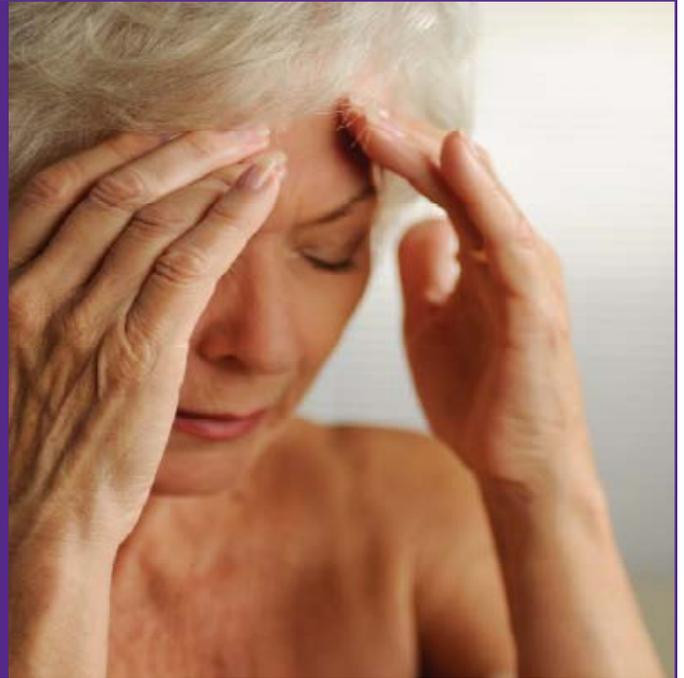
### Lead Authoring Subject Matter Experts

Veterans Health Administration  
Dr. Friedhelm Sandbrink  
Dr. Aram Mardian

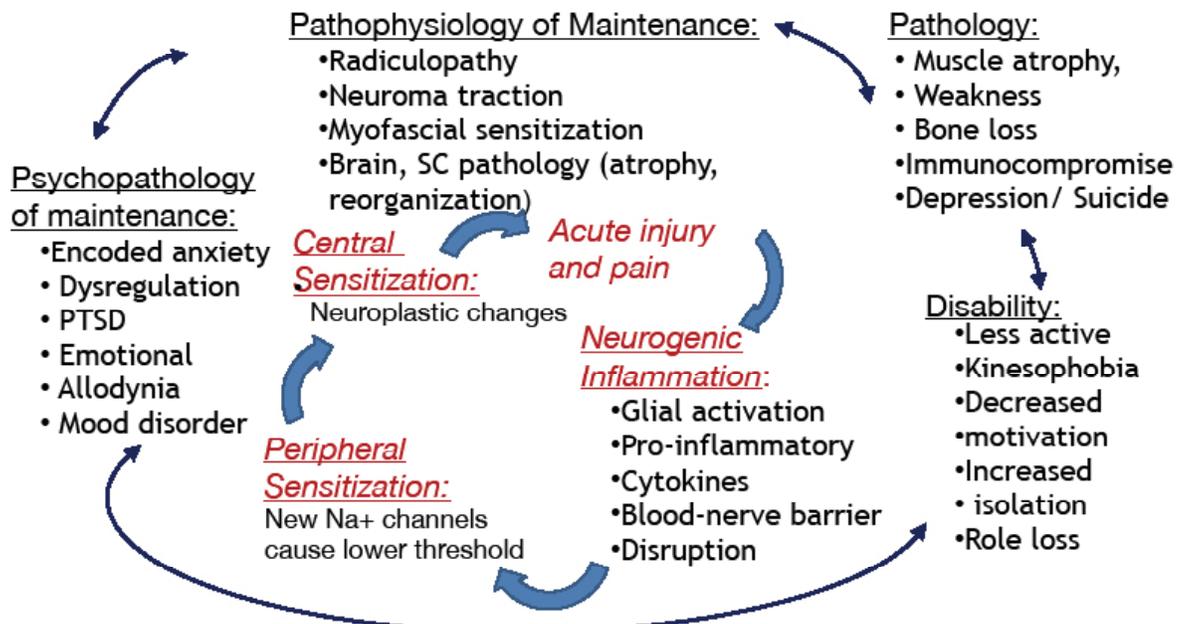
Department of Defense  
CDR Steven Hanling, USN  
Dr. Diane Flynn

# Topic One

## Pain Terminology



### Chronification of pain cycle



(Gallagher RM, in Ebert & Kerns, 2010)

#### Notes

This slide depicts the Chronification of Pain Cycle which will be discussed in greater detail in the upcoming slides.

## Acute pain provides an alarm that may protect the patient from further injury:

- Usually is associated with actual or impending damage of body tissue
- Resolves when damaged tissue heals
- And lasts less than 3 – 6 months
- Some refer to it as simple pain, since there might be less psycho-social stress
- Poorly treated pain risks “chronification”

### Notes

Acute pain serves a protective role. It is a warning system that allows the person to avoid or limit exposure to dangerous threats.

For example, when one touches a hot frying pan, we instinctively withdraw. When one attempts to move a fractured arm, pain is elicited which encourages the person to immobilize the arm to allow the fracture to mend.

Besides categorizing pain into “acute” vs “chronic”, it can be useful to consider the concept of “chronification” of pain, to more accurately view the dynamic continuum of pain. There are biopsychosocial factors that can affect the prognosis that acute pain will become chronic.

## Chronic pain persists beyond the time typically required for tissues to heal:

- Is not associated or correlated with structural pathology
- Lasts more than 3 – 6 months
- Some refer to it as complex pain, since there are psycho-social stressors that may adversely affect treatment response and overall prognosis

### Notes

Chronic pain, on the other hand, persists after tissue damage heals. Unlike acute pain, it serves no protective role for the individuals.

In addition, it can be helpful to distinguish between simple vs complex pain. The majority of individuals with simple pain will continue to remain highly functional, regardless of how the pain is treated. Those with complex pain typically require a comprehensive treatment approach to prevent progress loss of function and quality of life.

It is important to understand that there are many factors that determine the chronicity of pain, not simply the duration of pain. To avoid the transition from acute pain to chronic pain, it is important to identify risk factors for development of chronic pain EARLY in the course of a painful episode.

Problems of duration-based definition of chronic pain (Dunn, Von Korff, and Croft, 2012):

1. Ignores multidimensional nature of pain and implies that the duration of pain is most salient feature
2. Does not allow early identification and appropriate intervention for patients at risk for poor outcome
3. Timescale of actual neurophysiologic and somatosensory changes occur in seconds to days not months
4. windup and central sensitization can occur in seconds to minutes
5. inflammation can produce changes in CNS pain pathways in hours to days
6. No clear association between pain duration and pain related impairment

Besides categorizing pain into “acute” vs “chronic”, it can be useful to consider the concept of “chronification” of pain, to more accurately view the dynamic continuum of pain. There are biopsychosocial factors that can affect the prognosis that acute pain will become chronic

## A prognosis-based definition of pain may be a better approach to understand and manage chronic pain.

- Chronic pain can be defined by identifying the risk factors that will likely cause the persistence of pain and functional impairment. They include:
  - Greater pain severity
  - Longer pain duration
  - Greater number of anatomical pain sites
  - Higher severity of pain-related activity limitations
  - Greater psychological distress
  - Greater social distress
- This dynamic view of pain may provide more useful information about patient trajectory and offer more appropriate treatment decisions

### Notes

Dunn, Von Korff, Croft; 2012

Besides categorizing pain into “acute” vs “chronic”, it can be useful to consider the concept of “chronification” of pain, to more accurately view the dynamic continuum of pain. There are biopsychosocial factors that can affect the prognosis that acute pain will become chronic.

In addition, it can be helpful to distinguish between simple vs complex pain. The majority of individuals with simple pain will continue to remain highly functional, regardless of how the pain is treated. Those with complex pain typically require a comprehensive treatment approach to prevent progress loss of function and quality of life.

Risk factors for the development of complex chronic pain include:

- Greater pain severity
- Longer pain duration
- Greater number of anatomical pain sites
- Higher severity of pain-related activity limitations
- Greater psychological distress
- Greater social distress

Defining chronic pain based on probability of future pain and dysfunction according to the presence and degree of multiple factors other than pain severity may help patients and clinicians view both short term and long term pain as dynamic, with the potential for change (either improvement or deterioration).

Assessing multidimensional prognostic factors can help shift conversation away from sole focus on pain reduction to a broad conversation about a biopsychosocial approach to improving function and quality of life.

## Nociception and pain are not synonymous.

- Nociception  $\neq$  Pain and Pain  $\neq$  Nociception
- Nociception is the neurobiologic phenomenon that involves activation of specialized neurons (nociceptors) and transmission of this information to the spinal cord and brain
- Pain is the conscious experience that involves a complex synthesis of neurologic, cognitive, emotional, memory, and meaning information

### Notes

A nociceptor is a specialized neuron that responds to mechanical, thermal, chemical stimuli and transmits this information to the spinal cord and brain.

Nociception is neither necessary nor sufficient for the experience of pain.

Pain may exist in the absence of nociception and nociception may be present and not lead to experience of pain.

## Other useful terms that are good to know:

- **Sensitization** - amplified response to typical stimulus or response to usually sub-threshold stimuli
- **Allodynia** – pain due to a stimulus that does not normally cause pain
- **Hyperalgesia** – increased pain to a stimulus that is normally painful
- **Catastrophizing** – maladaptive emotional and cognitive process that involves pain amplification, rumination, and helplessness
- **Kinesiophobia** – fear that movement will cause further damage (hurt = harm), leading to avoidance of activity

### Notes

Terms that are important to the understanding of pain include ( from the International Association for the Study of Pain):

- Sensitization – describes when the nervous system changes such that the perception of pain is amplified.
- Allodynia: pain due to a stimulus that does not usually cause pain. For example, people with allodynia will often report pain with light touch. This is common in fibromyalgia.
- Hyperalgesia: increased pain caused by a painful stimulus.
- Catastrophizing: a pattern of dysfunctional thoughts and attitudes which have a negative prognostic impact on response to pain treatments. The three components of catastrophizing include pain amplification (example: “12/10 pain”); rumination (frequent thoughts of expected negative future events); and helplessness.
- Kinesiophobia – fear that physical activity will lead to re-injury and consequent avoidance of physical activity.

## Knowledge Check

Which one of statements below is NOT true?

- a. Acute pain is usually associated with actual or impending tissue damage and resolves in 3 to 6 months when damage tissues heal
- b. Functional impairment is always correlated to the severity of acute pain episode
- c. Allodynia and hyperalgesia are signs of chronic pain
- d. Kinesiophobia and catastrophization are two maladaptive behaviors that can cause acute pain to become chronic

## Knowledge Check – Answer

Which one of statements below is NOT true?

- a. Acute pain is usually associated with actual or impending tissue damage and resolves in 3 to 6 months when damage tissues heal
- b. Functional impairment is always correlated to the severity of acute pain episode**
- c. Allodynia and hyperalgesia are signs of chronic pain
- d. Kinesiophobia and catastrophization are two maladaptive behaviors that can cause acute pain to become chronic

Notes

Read question aloud

# Topic Two

## Pain Taxonomy



The purpose of taxonomy is to create a common language, guide therapy, and inform prognosis.

- Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage
- All pain is real
- All pain has three components:
  - Sensory, Emotional, and Cognitive

### Notes

During this talk, we will discuss other ways to categorize pain, such as nociceptive vs neuropathic, somatic vs visceral and other paradigms which consider multidimensional systems

It is also important to consider the underlying pain diagnosis.

- Does this patient have a specific painful process such as spinal stenosis or diabetic neuropathy?
- Are there underlying mechanisms, such as inflammation, neuropathy or myofascial components that should be addressed?

What prognostic indicators (psychosocial dysfunction, number of pain sites, degree of current pain related activity interference) for future pain and pain related dysfunction are present? What is the best intervention?

Are there perpetuating factors that impact pain?

- Biological factors such as central sensitization or deconditioning?
- Psychological factors such as catastrophizing, fear avoidance?
- Social factors, such as social isolation, conflict with the health care system?

Are there consequences or effects of this patient's pain history

- Such as impaired physical functioning?
- Change in role in the family or society?
- Decreased quality of life?

## Different types of pain include:

- **Somatic pain** is usually a well localized aching, dull, throbbing, pressure-like or sharp pain, most commonly of musculoskeletal origin
- **Visceral pain** is usually poorly localized colicky, cramping, throbbing, deep aching accompanied by diaphoresis, hypertension, tachycardia
- **Myofascial pain** is usually non-dermatomal, widespread secondary to muscle and fascia dysfunction and amplifies other types of pain
- **Neuropathic pain** is caused by a disease or an injury to the peripheral nervous system

### Notes

Pain can be divided into somatic and visceral types

- Somatic pain is usually musculoskeletal in origin
- Typically well localized and described as aching, dull, throbbing, pressure sensation, and/or sharp

Visceral pain originates from inner organs. For example the GI, GU and GYN systems.

- It tends to be poorly localized and a relatively small number of nociceptors are activated
- It is typically described as crampy, colicky, throbbing, pressure-like or deep aching
- There is often associated autonomic activation, such as sweating, elevation of BP and HR.
- Myofascial pain is caused by dysfunction of the muscles and fascia and may be regional or widespread
- Myofascial pain can occur alone or in combination with other types of pain diagnoses

Neuropathic pain is associated with damage to the peripheral sensory neurons and activation of the PNS and amplification in the processing CNS pain signals.

## Neuropathic pain subtypes include:

- **Peripheral:** any mono- or polyneuropathy (diabetes, alcohol abuse, B12 deficiency, HIV, postherpetic neuralgia, cervical or lumbar radiculopathy, trigeminal neuralgia)
- **Central:** spinal cord injury, post-stroke pain (thalamic), multiple sclerosis
- **Mixed** (peripheral and central): complex regional pain syndrome (CRPS) type 1 & 2 (also known as reflex sympathetic dystrophy, causalgia), phantom limb pain

### Notes

Any prolonged severe pain may result in central nervous system (CNS) changes and thus develop a neuropathic pain component (CNS plasticity and central sensitization)

And these are the kinds of patterns that may give you some diagnostic clues. Mononeuropathy, some kind of a compression neuropathy often expressing itself in the extremities, for example, in carpal tunnel syndrome, an ulnar compression neuropathy, or a compressed or irritated spinal nerve in causing sciatica. Mononeuropathy, multiplex -- something like sarcoidosis, where you have several different areas that don't seem connected anatomically, in which a systemic disease of some sort is damaging nerves. Plexopathy, in patients with brachial plexus injuries following an auto accident, or postsurgically when a patient's arm is compressed, and it's usually one extremity completely painful. And then the polyneuropathies, which you see in diabetic neuropathy, toxic neuropathies and some systemic diseases, in which often the pain starts in the periphery in sites supplied by the long nerves that are most vulnerable to toxic or metabolic system damage, such as in the feet and hands, and is usually symmetrical.

Sensations may be negative (loss of sensation) or positive (abnormally present) spontaneous or evoked.

- Burning
- Paresthesias: tingling, pins and needles
- Raw skin
- Numbness
- Paroxysmal sensations: sharp, shooting, lancinating, and electric-shock like
- Paresthesias = abnormal sensation (burning, prickling, tingling, "pins and needles") that arises spontaneously, usually not painful, but may be disturbing
- Dysesthesia = abnormal sensation, spontaneous or provoked, that is unpleasant
- Allodynia = normally innocuous stimulus (thermal or mechanical) is perceived as painful
- Hyperalgesia = exaggerated response to a normally painful stimulus (lowered threshold and/or increased response)

Finally, chronic pain due to a variety of underlying causes, such as osteoarthritis, peripheral neuropathy, LBP, fibromyalgia and headaches, can lead to central sensitization of the nervous system with associated allodynia, hyperalgesia and spread of pain

## Knowledge Check

Pain usually originating in the inner organs and poorly localized is often described as \_\_\_\_\_.

- a. Somatic
- b. Simple
- c. Chronic
- d. Visceral

## Knowledge Check – Answer

Pain usually originating in the inner organs and poorly localized is often described as \_\_\_\_\_.

- a. Somatic
- b. Simple
- c. Chronic
- d. **Visceral**

Notes

Read question aloud

## Topic Three

### Basic Pain Physiology



#### Pain processing occurs in four steps:

1. **Transduction** - pain stimuli are translated by the nerve endings into electrical impulses
2. **Transmission** - these electric impulses travel into dorsal horn of the spinal cord, synapse and ascend into the brain
3. **Modulation** - afferent neural signals are either dampened or amplified at multiple sites in the brain
4. **Perception** - conscious awareness of the experience of pain occurs and generates an emotional, and cognitive response that causes a reaction

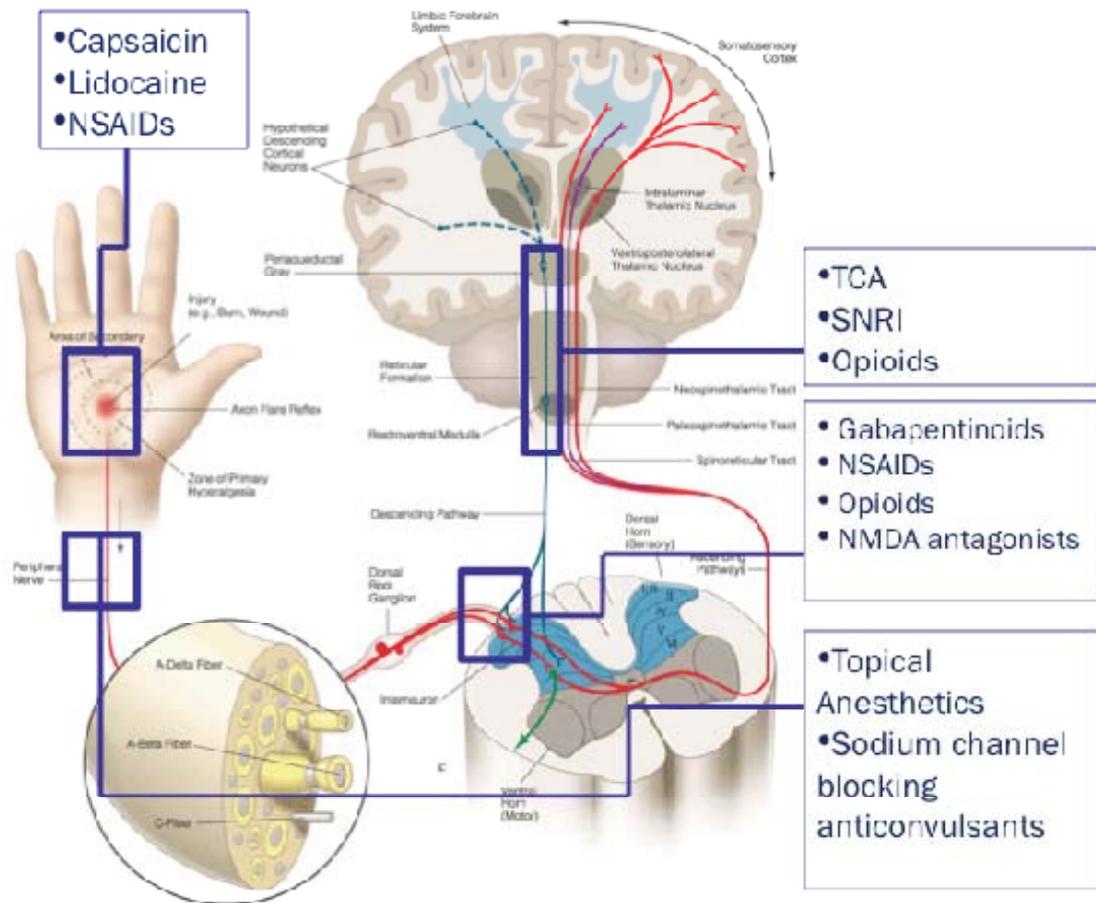
#### Notes

Understanding pain pathways and physiology facilitates understanding of biopsychosocial model of pain care and informs decisions about medication choices.

Pain is processed in the nervous system in 4 steps:

1. The first step is translating noxious (painful) stimuli by the A-delta and C fibers of nociceptive nerve endings into electrical impulses.
2. The second step is transmission of the electrical impulses along the primary nociceptors to the dorsal horn of the spinal cord. There, multiple synapses occur and second order neurons may carry the signal from the dorsal horn to the brain.
3. Then, at multiple levels of the brain and dorsal horn of the spinal cord, the incoming neuronal signals are either dampened or amplified.
4. The 4<sup>th</sup> step is perception – conscious awareness - of the experience of pain. Sensory, emotional and cognitive information is synthesized to determine if the organism is in danger and whether or not a behavioral response is required to protect the organism from threat.

## Pain treatments can be used at each step of the pain process.

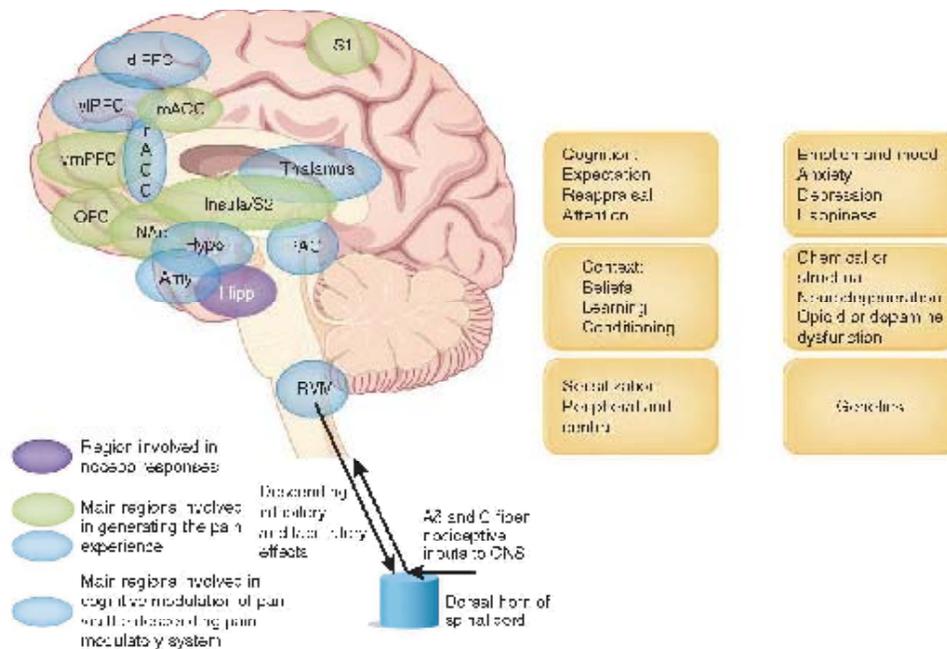


### Notes

This graphic shows the site of action of various medications used to treat pain.

- Capsaicin, lidocaine and Non Steroidal Anti-inflammatory Drugs (NSAIDs) at the site of the nociceptor
- Gabapentinoids, NSAIDs, opioids and NMDA antagonists act at the dorsal horn
- Tricyclic Antidepressants, Serotonin Norepinephrine Reuptake Inhibitors (SNRI) and opioids act at the level of the brain
- Topical anesthetics, sodium channel blocking anticonvulsants act at the site of the peripheral nerve

## The conscious experience of pain involves multiple brain networks:



### Notes

Therefore, the assessment of pain requires an approach that:

- Considers the determinants of the pain experience
- Focuses on ameliorating the determinants and effects of the pain experience
- Addresses the dysfunctional brain changes and central sensitization
- Identifies the activities that are of value to the individual and facilitates return to those activities

Perception of pain is a complex process involving numerous areas of the brain and dorsal horn. The nature of this perception is determined by the interplay of cognitive processes, context of pain, degree of sensitization, emotion and mood, chemical or structural factors and genetics.

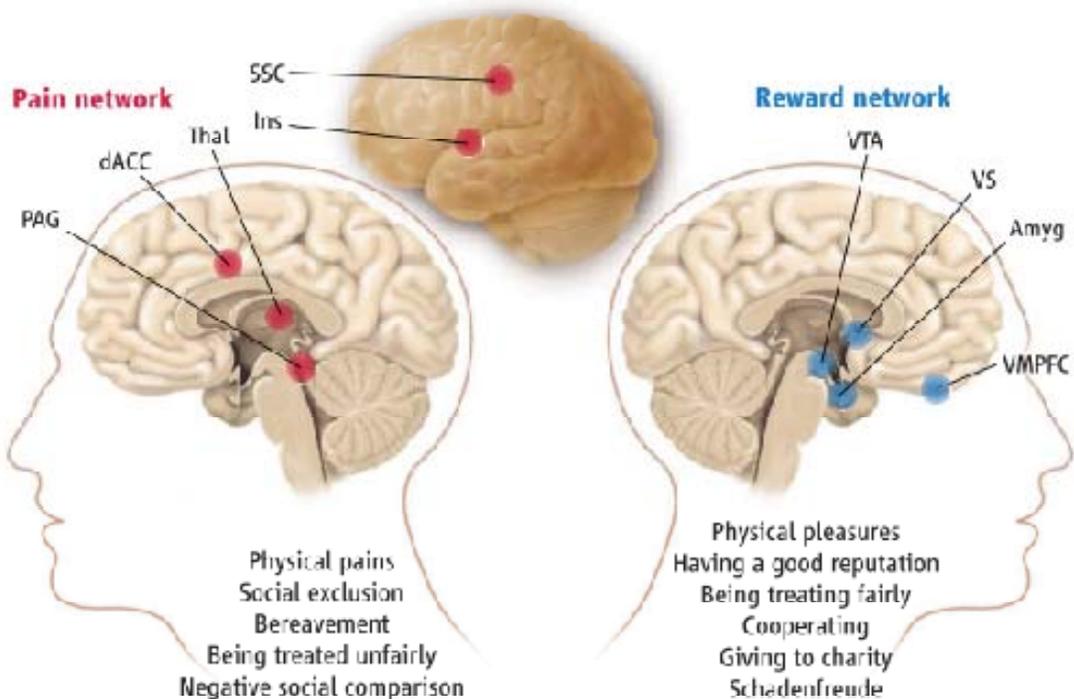
Multiple brain networks are involved in producing the conscious experience of pain:

- Prefrontal cortex (PFC)
- Insula
- Anterior cingulate cortex (ACC),
- Thalamus
- Primary and Secondary somatosensory cortex S1 and S2 (green areas)

Chronic pain changes the brain.

- The black arrows on this graphic show the descending pain pathways; the grey arrows show ascending pathways
- In studies, chronic pain is associated with consistent decreases in grey matter in three cortical areas: the anterior cingulate cortex, the prefrontal cortex and the insula.
- Studies have also identified changes in white matter integrity in these areas
- Molecular imaging shows decreases in opioid receptor binding in patients with chronic pain

That overlap with other physical and social reward networks.



#### Notes

Brain regions that process physical pain are also involved in processing social and emotional pain and social rewards.

Note that the areas of the brain identified as the "pain network" play a role in physical pain, social exclusion and bereavement.

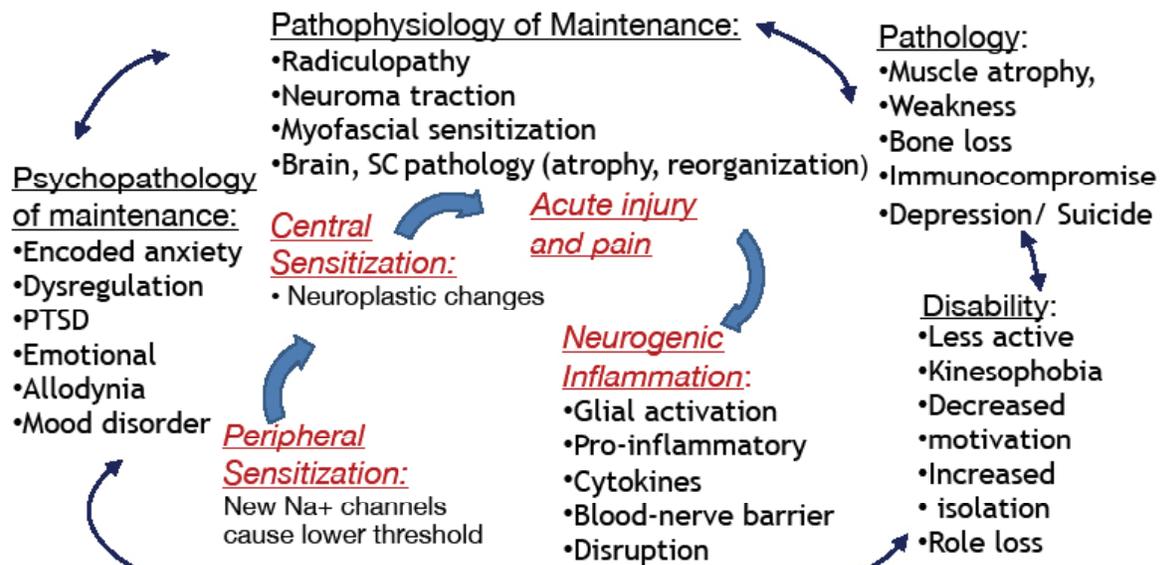
Likewise the "reward network" in the brain plays an important role in physical pleasures, being perceived as having a good reputation, being treated fairly and cooperating.

Pain network: PAG: Periaqueductal Gray, dACC: Dorsal anterior cingulate cortex, Thal: Thalamus, Ins: insula, SSC Somatic sensory cortex

Reward Network: VTA: Ventral Tegmental Area, VS: Ventra Striatum, Amyg: Amygdala, VMPFC: Ventral Medial Prefrontal Cortex

Schadenfreude: The pleasure derived from the misfortune of others. "to gloat"

## Chronification of pain cycle



(Gallagher RM, in Ebert & Kerns, 2010)

### Notes

This slide depicts the complex cycle of the process by which pain becomes chronic.

The process starts with an acute injury and acute pain.

This activates neurogenic inflammation and cellular processes that lead to sensitization to the peripheral nervous system and central nervous system.

These nervous system changes will adversely affect the course subsequent episodes of acute injury and pain.

This process often leads to disability, fear of activity, decreased motivation to achieve goals, social isolation and loss of societal role.

Disability has a bidirectional association with decreased functional level due to progressive deconditioning and weakness and depression

These factors interact with the pathophysiology of pain

The associated psychopathology, such as anxiety, PTSD, depression and other mood disorders, is also integrally associated with disability and pathophysiological factors.

## Knowledge Check

When treating patients with acute nociceptive pain, the most appropriate model to use is \_\_\_\_\_.

- a. Essentials to Good Chronic Pain Care
- b. Biomedical Model
- c. Chronification of Pain Cycle
- d. Biopsychosocial Model

## Knowledge Check – Answer

When treating patients with acute nociceptive pain, the most appropriate model to use is \_\_\_\_\_.

- a. Essentials to Good Chronic Pain Care
- b. Biomedical Model
- c. Chronification of Pain Cycle
- d. **Biopsychosocial Model**

Notes

Read question aloud



## Summary



Recall that acute pain is usually a sign of an injury or a disease, whereas chronic pain is a chronic illness that has biopsychosocial ramifications.

Feel confident to distinguish between acute, chronic, simple, complex, somatic, visceral, neuropathic, myofascial, and centralized pain.

Pain processing occurs in four steps: transduction, transmission, modulation and perception. Each step has its own specific treatment strategy, thus requiring a multi-modal approach.

Treating acute pain early and appropriately is the most important action in order to avoid transition to chronic, intractable pain.

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# JPEP

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