More than 9% of the world population is older than 60. With age comes additional vulnerability to pain and the accumulation of insults that can engender ongoing misery. Insights into molecular and cellular aspects of pain might help escort people more comfortably into the senior ranks, but research that specifically addresses pain in the elderly is only now gearing up. Although a comprehensive understanding of how aging affects pain—and vice versa—is far off, experts report a good outlook for helping the millions of undertreated older people who experience pain on a daily basis.

At the time in life when memory tends to go, pain often arrives. It’s never welcome, but during one’s senior years, pain can linger longer, hungrily down like irritating relatives. Rickety joints, old injuries, and age-related diseases such as thinning bones accumulate and pummel aging bodies. For some people, the sheer number of bodily insults piled on over time brings wretchedness. Furthermore, older individuals heal more slowly from injuries, and even those who recover are sometimes left with pathological pain.

Although little research has focused on pain that elderly people experience, interest in this topic is burgeoning. With more and more of the human population joining the senior ranks, understanding pain’s underpinnings and how the autumnal years affect it—and are affected by it—is gaining attention. Recent advances in the basic mechanisms of pain reveal the molecular intricacies of how a variety of stimuli convey unpleasant sensations to the brain. In other research, virologists and cancer investigators are uncovering how diseases that disproportionately afflict the elderly aggravate patients’ bodies. Finally, geriatricians are paying increased attention to pain management for their patients, with the hope of making the journey into advanced age more comfortable.

Sensing Pain
Researchers are just beginning to study how aging affects nerves in internal organs, skin, and bones. Because many cells in elderly bodies degenerate, researchers in the 1990s were curious as to whether aging human and rat skin loses pain-detecting sensory nerves called nociceptors. (Noxious arise from the Latin word that means “to do harm.”) In 1999, Justin McArthur of Johns Hopkins University School of Medicine in Baltimore, Maryland, snipped bits of skin from the legs of healthy volunteers and found the same number of nerve endings, regardless of age (1).

Despite this similarity, oldsters experience pain differently than youngsters do. Didier Jourdan of the University Hospital in Clermont-Ferrand, France, and colleagues found that old rats are more sensitive to some types of pain than young rats are (2). The group followed up on the rat work by examining elderly humans, they reported in the March issue of Gerontology. To test pain tolerance, each volunteer inserted a finger into a device that squeezed the hapless digit as long as the person pushed a button, and the researchers recorded the pressure at which the individuals first felt pain and how much they could withstand. To test heat tolerance, the team performed the same type of experiment using a small hot plate on the skin. The older subjects felt mechanical stimulation at significantly lower pressures than the younger people did, and the over-70 set was also more sensitive to heat. In addition, pain sensitivity increased far more dramatically with age for men than for women (3).

Older people might be more sensitive to pain because the neuronal mechanisms that numb discomfort are failing, some researchers suggest. Plunging a 20-something’s hand into ice-cold water nearly doubles his or her ability to withstand subsequent electric shocks to the hand and ups tolerance for pain from a heat laser by 30%. Robert Helme and colleagues at the University of Melbourne, Australia, showed that people in their late 70s were less numbed by immersing their hands in cold water than were young people. The older crowd tolerated only a third of the postplunge zapping and half of the burning pain that people in their 20s were able to bear (4).

Long Fast Trip It Is
The environmental cues that initiate painful sensations include blasts of heat, cold, pressure, and acid. If the stimuli are intense enough to threaten injury, they activate protein sentinels embedded in the nociceptor tips. Then, like a telegraph, the wiry, powered-up nerve cells rush the warning through the spinal cord to the brain.

The sentinel proteins come in two varieties: channels and receptors. Channels are pores in the cell membrane that allow ions to surge into a neuron, where they can cause it to fire. Some of these apertures loosen up directly upon stimulation; others require proteins—called receptors—that span the cell membrane in order to operate. When receptors are jabbed appropriately, they pass messages through the cell’s internal relay system that can open channels and also turn genes on and off. More than a dozen specialized pain receptors and channels have been identified, many of which respond to more than one type of pain signal.
of provocation. “One of the hot areas [of pain research] is identifying all the buttons that get pushed on nerve cells,” says David Julius, a molecular biologist at the University of California, San Francisco (UCSF).

He should know. Five years ago, his group isolated the main pain button in mice: a channel protein called VR1 that responds to heat and noxious chemicals, including the compound capsaicin, which gives jalapeños their scorch (5). To test its importance, Julius and colleagues obliterated VR1 in mice. Application of capsaicin to a mouse’s paw normally causes the animal to frantically lick away the painful chemical, but mice lacking VR1 washed the paw for only a few seconds. These mutant mice also dawdled on hot plates and let their tails dangle in hot water for much longer than normal. Their neurons didn’t fire in response to capsaicin, acid, or heat—but they did respond when researchers pinched the animals’ tails, indicating that some other channels or receptors respond to pressure (6).

VR1 belongs to a class of molecules called TRP channels. Another TRP channel, VRL-1, fires at a higher temperature than VR1 does, and it fails to respond to spice (7). A third member of this family, the CMR1 channel, is sensitive to nippy temperatures and the compound menthol, Julius and colleagues reported in a March issue of Nature (8). These discoveries suggest that the TRP group of nociceptor proteins are temperature sensors.

A family of four acid-sensing ion channels (ASICs) appears to have the lock on detecting protons, the ions that put the bite in vinegar. Shinya Ugawa and colleagues injected human volunteers with solutions of varying acidity, along with compounds that block either ASICs or VR1, and asked how much pain the people felt. On a scale of zero to 10, volunteers reported “2” when jabbed with neutral liquid. A shot of pH 6.0 had volunteers proclaiming “9,” which dropped to “2” when the researchers blocked ASIC function. Impeding VR1 reduced the pain assessment by a smidgen, indicating that ASICs, and not VR1, are the main sensor at this pH. At pH 5.0, VR1 contributed to just over a third of the pain felt, suggesting that ASICs handle most acid-induced pain (9).

The variety of receptors and channels that reside on nociceptors is likely to be very large, says Xinzhong Dong, a molecular neuroscientist at the California Institute of Technology in Pasadena. Dong and colleagues pinpointed about 50 likely channel candidates in this type of cell. Upon further testing, the researchers found that a third of these proteins fit the description of pain sensors: They reside in nociceptors and open in response to stimulation by certain small proteins (10).

The identification of pain receptors and channels is key to designing new drugs that mitigate pain. At the moment, says Julius, very few targets for modulation of the pain pathways are known. Neurobiologist Patrick Mantyh of the University of Minnesota, Minneapolis, predicts that up to 100 receptors and channels might be found, each scouting for a particular assault. “You’ve got the ability to pick up cues in any pathological situation,” he says.

**Soupin’ Up Transmission**

An injury doesn’t just tag nerves and run away. Even after the initial insult, elements of the pain system keep the nerve pulsating with activity, making the area sensitive to touch or heat. Cuts and gashes incite immune cells to redecorate the area with inflammatory compounds that they liberate as they clean up tissue damage—molecules such as ATP, which escapes from broken cells, and inflammatory chemicals such as histamine, prostaglandins, and cytokines. These molecules tickle the channels and receptors that respond to external stimuli, setting off the neuron again. In addition, inflammation creates acid, which ASICs detect.

The activated nerve cells exacerbate the problem by releasing substances that promote inflammation, causing nearby nerve cells to fire more frequently and increasing their sensitivity to additional painful stimuli. Substance P, bradykinin, and nerve growth factor (NGF) are some of the proteins involved in this neurogenic inflammation. Substance P passes pain messages to the neurons that headed for the brain. Although bradykinin normally provokes swelling and NGF encourages nerve growth, Julius and colleagues reported in a June issue of Nature that the two molecules work...
through VR1 to crank up an injured tissue’s awareness of heat. Other compounds are also involved, although they don’t all employ VR1 (11). Julius calls the mishmash of chemicals produced by immune cells and neurons “an inflammatory soup” that sensitizes the nerves after they’ve been activated by a painful stimulus (12). “[The soup] tells you that you should guard that area,” he says. “[You] learn not to touch it.”

The Paths to Pain

Three types of nociceptors connect the body’s periphery to the spinal cord: thick, fast-shooting Aδ fibers that come in two flavors and a thinner, slower C fiber. Although both mechanical and chemical stimuli discharge these fibers, they also perceive temperature, and their response to this stimulus defines them. One kind of Aδ fiber and the C fibers detonate at 43°C Celsius. This group represents just fewer than half of all nociceptors. Most of the other kind of Aδ fibers require a higher temperature—53°C—to shoot. New research into noxious cold suggests, however, that some of these fibers detect not only high temperature: A subset of C and Aδ fibers, for example, apparently fires in response to cold as well as heat, if decorated with the cold-sensing channel CMR1 (8).

In organs and the peripheral skin, nociceptor ends called dendrites splay like whiskers, their tips chock-full of pain-sensing receptors and channels. These stimulus-receiving terminals meld into a long projection called an axon that stretches to the spinal cord, a nerve impulse conduit that runs the length of the backbone up to the brain. Cell bodies protrude from the axon into the dorsal root ganglion just before the axon tip reaches the cord. In the dorsal root ganglion, the cell bodies manufacture vital cellular components such as enzymes and ATP and ship these resources to the farthest reaches of the cell’s extremities, such as dendrites in the toes or the gut.

In the spinal cord, nociceptors communicate using small molecules called neurotransmitters. An activated cell’s axon releases these signaling compounds, and spinal cord nerve cells pick them up with their receptor-laden dendrites and deliver the message to the brain. The nature of the nociceptor’s message depends on which pain receptors have been activated and what type of nerve fiber they reside in, among other things. Nociceptors use a variety of signaling molecules, usually more than one at a time, to pass the pain baton to the spinal cord neurons. The most common are the amino acid glutamate and several related chemicals.

At least three types of receptors on spinal cord cells respond to glutamate’s presence but also react to glutamate-like molecules, for which the receptors are named. Perhaps the best understood of these receptors involved in chronic pain is the one that responds to NMDA. “The NMDA receptor induces long-term changes in neurons,” says UCSF neuroscientist Allan Basbaum. In response to NMDA, “genes get turned on and enzymes triggered.” The coordinated changes to the cell’s gene expression program make the nociceptors extra sensitive to touch, a condition that can persist (see “Adjusting the Reception” below). Researchers suggest that different glutamate-related molecules perform different tasks in pain transmission. For example, receptors activated by glutamate’s cousin kainate transmit high, but not low, intensity signals (13). Another related receptor, AMPA, turns down the volume of broadcasts by preventing the release of additional glutamate and damps the firing of the nerve cells (14).

Neurotransmitters can also be bits of protein such as substance P and calcitonin gene-related peptide (CGRP). Substance P contributes to the neuron-derived portion of the inflammatory soup; neurons in mice that don’t make the peptide cook up very little neurogenic inflammation. When a C fiber is activated, it releases substance P at both ends of the neuron, which gets stirred into the pain-boosting broth (15).

The spinal cord and the brain share many of the same neurotransmitters. Along with glutamate, a collection of fatty acid–derived compounds called prostaglandins crops up in both places. The most common anti-inflammatory drugs, so-called COX inhibitors such as ibuprofen, obstruct prostaglandin production throughout the central nervous system (CNS). Research reported online in September in the Proceedings of the National Academy of Sciences uncovered a new COX enzyme, which exists only in the brain and heart and appears to be the much-sought-after target of acetaminophen (16).

The brain exerts considerable control over the response to painful stimuli, as anyone who’s ever been too busy to notice a small scrape can attest. People who are performing simple tasks, such as counting how many times a word appears on a computer screen, wince at lower degrees of inflicted pain than do individuals who are concentrating on more difficult counting tasks in which they must pay attention to what the words mean (17). Emotions affect pain perception in the same way as concentration does, according to experts (18, 19). In one experiment, men who were looking at pictures of nude women tolerated cold water 39 seconds longer than did men looking at pictures of household objects (20). Unlike smell, which the brain relegates to a particular region for processing, the brain deals with incoming pain sensations in many places. By imaging the brain activity of people subjected to painful stimuli, researchers are beginning to understand how cognitive and emotional distractions allow pinpricks to go unnoticed (17, 21, 22). “Pain is more of a perception than a sensation,” says the University of Minnesota’s Mantyh. “The brain ultimately decides which [pain signals] to interpret and act on, and it can override them.” Just as beauty is in the eye of the beholder, pain is in the brain of the injured. Such subjectivity complicates studies of pain and its management (see “An Unnecessary Evil” below).

Adjusting the Reception

Just as it grays hair and wrinkles skin, age alters the pain pathway, especially in the spinal cord. Some changes are due to diseases such as cancer or a resurgence of viruses. Others can occur even in healthy individuals over time.

For example, age might eliminate pain-dampening nerve cells in the spinal cord. When Koichi Iwata of Osaka University in Japan and colleagues compared pain delivery through the spinal cord in young adult and old rats, the senior animals yanked their paws from a hot plate quicker than youthful rats...
did, suggesting that the animals acquired sensitivity to pain late in life. By monitoring electrical activity in the spinal cord, the researchers found that nociceptors in elderly rats spontaneously fired more than five times as often as did those in their younger compatriots, even though the nerve cells in the aged rats occupied less space in the backbone conduit. In addition, a local anesthetic that blocks pain-restricting circuits increased neuronal activity in middle-aged rats, as expected, but it had little effect in old rats, suggesting that aging causes loss of spinal cord neurons that would normally turn down signals entering from the periphery (23).

Researchers have found other alterations in animals with chronic pain, a state in which many older people find themselves. Unlike acute pain due to injury, persistent pain doesn’t simply advertise an underlying affliction. “Chronic pain is a disease, not a symptom,” says UCSF’s Basbaum.

Some neurotransmitters are more likely than others to contribute to persistent pain. Rodents that don’t make substance P or its receptor fail to experience chronic pain (15, 24), for example, indicating a key role for the peptide in this condition. In addition, Min Zhuo of Washington University in St. Louis reported in the 14 November issue of *Neuron* that NMDA receptors in the brain contribute to long-term misery by activating neuronal proteins called AC1 and AC8. These proteins appear to play an essential role in chronic pain; mice lacking them suffer pain acutely but not persistently (25).

Chronic pain doesn’t just cloud your grandmother’s sunny disposition. It also changes the way nerves hook up with one another in the CNS, a quality referred to as plasticity. In mice with bone cancer, which causes considerable pain, spinal cords grow new cells and their neurons change the sets of proteins and neurotransmitters that they produce, says Mantyh. “It’s clear that the central nervous system does rewire,” he says. “It’s like someone playing a piano; the more the CNS conducts pain, the better it gets at it.”

To understand how chronic pain affects the CNS, Mantyh and colleagues quantified pain-activated neurochemical signals in mice that suffered bone tumors—and pain—on only one side (26). Within 3 weeks of bone tumor inoculation, Mantyh’s team observed an increase in nerve firing on the side of the spinal cords receiving chronic pain messages due to the expanding, destructive tumors, despite a decrease in glutamate concentration on the same side. This result indicates that the side of the CNS under constant distress learned to conduct the message “I’m in pain” more efficiently than did the side that was pain-free, he says.

In addition, the number of neuron support cells called glia swells markedly on the diseased side of the mouse spinal cord. Although glial cells normally sop up glutamate, constant pain shrinks the number of glial receptors that act as sponges, allowing the neurochemical to bathe dendrites longer than normal despite the increased number of cells. Glia also release NGF and inflammatory chemicals such as cytokines, both of which enhance the feeling of pain. The good news, says Mantyh, is that these changes aren’t permanent: “Once the pain is relieved, many of the plastic changes go back to normal” (27, 28).

The differences between chronic and temporary pain are apparent at a molecular level. Mantyh compared spinal cord alterations in mice that were experiencing pain induced by three different assaults: short-term inflammation and chronic pain arising from either cancer or injury to pain receptors. Each type of insult produced a characteristic response, as measured by quantities of particular neurotransmitters and receptors, suggesting that different types of pain cause specific changes in the spinal cord (29).

**Shingles on the House of Age**

Like all cells in the body, nociceptors are susceptible to injury. Such harm results in neuropathy: pathological pain caused by damage to the sensory nerves. Some neuropathy is caused by diseases that attack nerves, such as trigeminal neuralgia. Diabetics often suffer neuropathy after years of poor glucose control, although it’s not clear exactly how the nerves sustain dam-

*CREDIT: MATTHEW SCHWEI AND P.MANTYH/UNIVERSITY OF MINNESOTA*
General Hospital in Boston, likens neuropathic pain to a wiring problem in a car that makes the oil light come on erroneously. The oil light, like a bolt of pain, flashes its warning; the underlying problem, however, is not that the oil is low or that a harmful stimulus exists, but that the wire is transmitting information inappropriately. The density of nerves in healthy skin remains constant up to about 75 years of age, but oddly enough, it seems to be lower in neuropathic areas. Oaklander measured the number of nerve endings in skin samples taken from PHN patients. She found fewer than in people who had recovered from shingles but who didn’t acquire PHN, an observation that puzzled her (30): “How can it be that losing neurons makes pain?”

Work by another group clarifies this counterintuitive result. In research published in the July issue of Pain, neurologist Michael Rowbotham of UCSF and colleagues cut PHN-affected skin from a patient who was experiencing excruciatingly painful sensations, in an attempt to alleviate the discomfort; obliteration of offending nerves sometimes reduces pain, as it did in this case. They sliced the skin and a sample of the patient’s normal skin and identified neurons by the pain receptors found on these cells. Using this method, they confirmed Oaklander’s work—PHN-affected skin lodged fewer nerve endings—but they also discovered that each nerve ending harbored unusually large numbers of receptors, especially capsaicin-responsive ones (31). “The nerve fibers with extra capsaicin receptors may be unstable ... firing all the time,” says Rowbotham.

**Skeletal Pain Disables**

Next to skin, some of the most painful problems of the elderly strike their bones and joints. Among the pain-causing ailments of the skeleton are back problems from old injuries, cancers that spread to the bone, and the trio of similar-sounding conditions: osteoporosis, osteoarthritis, and rheumatoid arthritis.

Although bone appears solid, it is constantly being destroyed and created, and this balance goes awry with age. Cells called osteoclasts break down bone by producing an acidic environment that dissolves the bone’s mineral foundation. Cells called osteoblasts build the bone back up, and their activity slows down as people get older.

Only recently have researchers shown that nociceptors penetrate bone as they do internal organs and skin. Most experts thought that pain from broken bones originated from nerves in the outermost layer of the skeleton. But work published in *Neuroscience* this summer challenges that notion (32). Mantyh’s group sliced mouse femurs into thin sections and identified all of the pain transmitters snaking about. In addition to the nerves they expected in the external sheath, they found a large number in the marrow. “A good number of papers have looked at nerves in human bones,” says Mantyh. “But those bones have spent months or years in demineralizing solutions” used to prepare tissues for analysis; such chemicals destroy nerve fibers, he points out. The results help explain the origins of the agony experienced by people with maladies such as bone cancer or thinning bones.

Most bone cancers arise when metastases infiltrate the skeleton, such as in advanced breast, lung, and prostate cancer, some of the many cancers that plague the older population disproportionately (see “Dangerous Liaisons”). Constant pain arises from tumor-induced bone destruction. Mantyh has learned from his mouse model of bone cancer that tumors stimulate osteoclast activity (27, 28). “The osteoclasts are hijacked [by the cancer],” he says. “Instead of three in an area, you have 300.” These demolition cells pump acid into the local environment, which probably stimulates acid receptors on bone neurons, he suggests.

To make matters worse, too few osteoblasts set the stage for pain associated with the bone-related problem of osteoporosis (see “The Plot Thickens on Thin Bones”). Women are most vulnerable to osteoporosis during the first few years after menopause, because estrogen no longer prods osteoblasts to construct skeleton. Bones that go unused after a paralyzing stroke are also susceptible to thinning. Osteoporosis develops inconspicuously, and most people don’t know that they have it until a bone fractures, sending shrieks of pain along the bone’s nerves. Due to the lack of bone building in these patients, osteoporotic bones take longer to heal than do healthy bones. To counteract flimsy skeletons, researchers are exploring a class of compounds known as bisphosphonates that inhibit osteoclasts; by quelling these bone destroyers, investigators give the diminishing osteoblasts a chance to do their thing, says Mantyh (33, 34).

Connections between bones also succumb to degradation over time. Two joint-wrenching arthritic conditions that strike people are often confused—with each other and with osteoporosis, which is unrelated to joints. One, rheumatoid arthritis, isn’t technically a disease of old age. It hits people while they’re young, usually before the age of 50. However, once it starts, it sticks around and worsens with time. In rheumatoid arthritis, a person’s immune system attacks the cushion that lines joints such as in wrists and hands, and it eventually damages the surrounding bones and cartilage. Using a mouse model of inflammatory arthritis, which mimics some aspects of rheumatoid arthritis, rheumatologist David Lee and colleagues at Harvard Medical School in Boston showed that antibodies that bind a protein in the joint lining solicit inflammatory cells that fire up an assault (35). After the immune system devastates the protective lining, nociceptors in raw bone wallow in the inflammatory soup. These results establish a connection between autoimmune reactions, inflammation, and pain. Reliable therapies to stop the relentless tissue destruction don’t exist, but patients can derive symptomatic relief with compounds that limit the production of inflammation-promoting molecules.

The other arthritis—osteoarthritis—does originate largely in the aged population. Some researchers estimate that almost 80% of people over the age of 65 have this condition, and it accounts for more than 70% of knee and hip replacements.
Marked by pain, stiffness, and loss of flexibility, it occurs because the spongy, protective cartilage in joints—usually the knees, hips, and spine—breaks down. Inflammation saturates the damaged cartilage, and the chronic pain associated with osteoarthritis might also contribute to tender muscles; affected people are more sensitive to muscle pain in both hands and legs, compared to healthy individuals (36, 37). The disease can be inherited, but obesity, overuse, and injury increase risk. Nonsteroidal anti-inflammatory drugs, including the COX inhibitors mentioned previously, can palliate osteoarthritic pain. Injecting a viscous compound called hyaluronic acid, normally found in healthy joints, into diseased knees also alleviates pain and stiffness (38), but the underlying cause of degeneration has yet to be elucidated and pharmacologically tackled.

An Unnecessary Evil
Although no magic tonic soothes all the discomforts of growing old, experts seem to agree that pain doesn’t have to go hand in hand with aging. Pain in the elderly must be assuaged, they say, because it can prevent people from staying active, which leads to weight gain, heart disease, diabetes, depression—and either early death or a long, miserable decline.

Much of the pain that the aged experience remains untreated. A quarter to a half of older people who suffer from maladies such as hip fractures or cancer do not receive enough treatment to waylay the pain (39-43). “The undertreatment of pain within the nation is an unmet health care crisis,” says geriatrician R. Sean Morrison of Mount Sinai School of Medicine in New York City. The problem, experts say, is a complicated mix: Older people are less likely to report pain, and an undeserved stigma about “drugging” the elderly plagues doctors and patients. Furthermore, doctors don’t always recognize pain, especially chronic pain, says geriatrician Jean Kutter of the University of Colorado Health Sciences Center in Denver. “A person in acute pain looks like they’re in pain,” she says. “But someone in chronic pain looks like the average person.” Also, due to the subjectivity of rating how much pain one feels, doctors, researchers, and patients have a hard time quantifying it (44).

Furthermore, people expect painful, aching joints and diseases to pester them as they get older, and they commonly think that pain is a normal part of aging, says Morrison: “Older people are less likely [than younger ones] to report pain, and they’re more willing to tolerate it” (45). Many people resign themselves to living with pain because they misunderstand the alternatives, worrying about the potential side effects of opioids, analgesics, and anti-inflammatory agents. They think that opioids are highly addictive, for example, whereas the actual incidence of addiction in the old is very low, according to Kutter. “We have really good medications,” she says, adding that she would count about 50 drug options off the top of her head. Untreated pain correlates strongly with a poor quality of life, says Kutter, and there’s no reason for it.

While clinicians spread the word about pain mitigation, researchers are pursuing new drugs and treatments. Perhaps by the time Generation X enters the claws of middle age, the most painful aspect of growing old will be their baby boomer relatives overstaying their visits.

Mary Beckman writes from southeast Idaho, where people tend to hunt and fish into their 90s. She finds it painful to watch an 80-year-old mountain woman butcher an antelope.

Glossary

- Acid-sensing ion channels ASICs: nociceptor channels that detect acidity.
- Axon: Projection of nerve cell that transfers information to another neuron.
- Bradykinin: A short protein that causes neurogenic inflammation.
- C fiber: Slow, unmyelinated nerve fibers.
- Calcitonin gene-related peptide (CGRP): a short protein that causes neurogenic inflammation.
- Capsaicin: The chemical that makes peppers hot. Triggers VR1 channel.
- COX inhibitors: “Cold and méthanol-sensitive receptor” channel protein that detects nocuous cold.
- Nonsteroidal anti-inflammatory drugs (NSAIDS): chemicals that interfere with the production of inflammatory prostaglandins.
- Cytokines: Secreted proteins that affect the behavior of immune and other cells.
- Dendrites: Nerve cell projections that receive input.
- Glutamate: A major neurotransmitter in the central nervous system.
- Inflammation: Cells and cellular factors that collectively cause heat, pain, redness, and swelling.
- Neuropathy: Pathological pain caused by damage to nerves.
- Nociceptors: Sensory nerves that transmit pain. From the Latin word that means “to do harm.”
- Nonsteroidal anti-inflammatory drugs (NSAIDS): chemicals that interfere with the production of inflammatory prostaglandins.
- Osteoarthritis: A disease that breaks down cartilage and affects joints in knees, hips, and spine; it affects the elderly disproportionately.
- Osteoblasts: Cells that build up bone.
- Osteoclasts: Cells that break down bone.
- Osteoporosis: A disease characterized by thinning of the bones.
- Pheromone: Secreted proteins that affect the behavior of immune and other cells.
- Postherpetic neuralgia: PHN; neuropathy that remains after shingles has cleared up.
- Rheumatoid arthritis: Autoimmune disease that ravages the cushion that lines joints; affects joints in wrists and hands; can strike people while they’re young but worsens with age.
- Substance P: A short protein that causes neurogenic inflammation, functions as a neurotransmitter, and is involved in chronic pain.
- Trigeminal neuralgia: Neuropathy of nerves that reside in the face.
- TRP channels: Molecules on nociceptors that sense temperature.
- VR1: “Vanilloid receptor 1”; main channel that responds to painful heat and chemicals.
- VR1-L: “Vanilloid receptor-like”; channel protein that responds to heat but not nocuous chemicals.

Further Reading


“Stop Pain” at Beth Israel Medical Center, a news and information site on pain and palliative care.

www.stoppain.org

International Association for the Study of Pain.

www.halcyon.com/iasp/journal.html

“Management of Persistent Pain,” from the American Geriatrics Society.

www.americangeriatrics.org/education/manage_pers_pain.shtml

The Harvard Center for Shingles and Postherpetic Neuralgia.

www.shingles.mgh.harvard.edu

References


