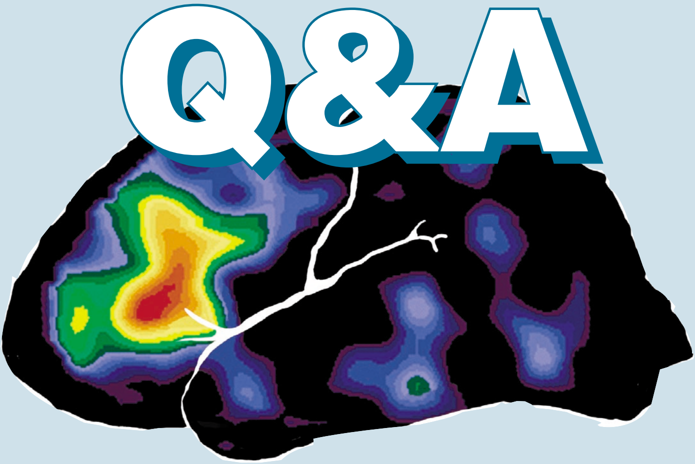
Answering Your Questions About Brain Research



The brain is our body's most vital organ. It is what makes us human. It defines who we are.

Advances in research are bringing us closer to understanding the brain in health and in disease. Learn more from the answers to some commonly asked questions about the brain.

Discover why neuroscience is one of the most exciting areas of scientific research.

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The Dana Alliance for Brain Initiatives is a nonprofit organization supported by the Dana Foundation.

Q. How can I become involved in supporting brain research?

A. Here are five ways you can support brain research:

- Donate your time and support to the brain organization or advocacy group of your choice.
- If you or someone you love has a brain disorder, stay informed of the latest developments in treatments and clinical trials, and ask your doctor about them.
- Write to your Congressional representatives to let them know that you think brain research is a good investment.
- Volunteer to be a research subject for a brain study at an accredited research institution. Studies about how the normal brain functions are crucial to finding the answers to brain disorders.
- Join in the activities of Brain Awareness Week. For news of dates and events in your area, check our Web site: www.dana.org/brainweek.

The Dana Alliance for Brain Initiatives *offers many resource materials for the public that provide general information about the brain, report advances in brain research, and track news coverage of brain topics. A pamphlet called* Brain Connections *lists nearly 300 organizations and advocacy groups devoted to specific brain disorders. The Alliance also sponsors public forums on topics such as depression and Alzheimer's disease, and publishes free companion booklets. The Dana Web site (www.dana.org) provides a wealth of information, news, and links to many other brain-focused organizations.*

THE HUMAN BRAIN.

It weighs a mere three pounds and is barely larger than an adult fist, yet it is our body's most vital organ. It is what makes us human. It defines who we are. That's why brain research is so essential.

Every day, scientists are making discoveries about the brain. The pace of discovery is accelerating as powerful new techniques allow us to see the inner workings of the brain and trace the molecular pathways that underlie brain function. Each new piece of the puzzle brings us one step closer to truly understanding the brain in health and in disease.

Neurological and psychiatric illnesses account for more disability worldwide than any other group of disorders. They cause immense suffering among individuals and place a great burden on society. A primary goal of neuroscience research is to find the answers that will lead to effective treatments for these devastating brain disorders and better strategies for maintaining a healthy brain.

The Dana Alliance for Brain Initiatives *is a group of neuroscientists—more than 200 of them, including nine Nobel laureates—who have a vision.*

They imagine a world in which the scourge of brain disorders is eventually alleviated through research aimed at prevention and treatment. While such a vision may seem optimistic, the Dana Alliance scientists know that these are exciting times for brain research. The advances in research in the past decade are unprecedented. We have expanded our understanding of how the brain works to a point where we can now begin to harness the healing potential of that immense knowledge.

In this brochure, we share with you some of that knowledge, in answers to a few of the most commonly asked questions about the brain. Explore with us the growing advances in brain research, and join us in envisioning a better world through brain science.

The Dana Alliance is a nonprofit organization committed to advancing public awareness about the progress and benefits of brain research and to disseminating information on the brain in an understandable and accessible fashion. Supported entirely by the Dana Foundation, the Dana Alliance does not fund research or make grants.

Q. How does the brain work?

A. That remains one of the greatest mysteries of science, but scientists are zeroing in on the answers. What we do know is that the brain's 100 billion nerve cells (neurons) communicate with one another primarily through biochemical signals (neurotransmitters) traveling at speeds up to 220 mph along a network that involves trillions of synaptic connections, which makes the LA freeway system seem like a mouse maze. These connections, which change as we grow and learn, form the basis of all brain function, from creating a memory to solving a math problem to walking the dog, and also underlie the personality traits that make us unique individuals. Research aimed at better understanding the processes involved in cell-to-cell communication in the brain has made tremendous progress; three leading investigators in this area—all Dana Alliance members—received the 2000 Nobel Prize in Physiology or Medicine for their work.

There are different kinds of cells in the brain, but the neurons are the real workhorses. They consist of a cell body, in which the nucleus is housed, and long processes called dendrites and axons. Neurons release various neurotransmitters, chemical messengers that connect—lock-and-key-fashion—with receptors on another cell's surface and deliver a set of instructions that tell the receiving cell what to do. What happens inside the cell beyond the receptor is an area of intense research.

Q. Can we see the brain at work?

A. Much of the recent progress in understanding brain function is the result of new imaging tools that let scientists observe the brain at work. The various techniques available, with names like fMRI, PET, CT and SPECT, have enabled scientists to see which areas of the brain are working when engaged in a task such as speaking, recalling a memory, or feeling pain.

Each uses a different method of noninvasive brain scanning, along with sophisticated computer programs, to take pictures of the living human brain. Brain imaging has propelled our understanding of many brain disorders by helping identify which parts of the brain are involved.

BRAIN FACT:

The "gray matter" of the brain is comprised of the bodies of nerve cells, where the nuclei are housed, and dendrites. The "white matter" is so named because of the fatty myelin sheath that encases the cells' axons.

Q. Is the brain fully developed at birth?

A. No. The brain develops over a longer period of time than any other system in the body. Though the brain reaches its full size by about age four and is believed to reach "maturity" in young adulthood, it continues to make new synaptic connections throughout life. The prenatal period, the first few years after birth, and adolescence are the periods of the most dramatic brain-building. In the womb, the brain of the fetus undergoes spectacular growth, at times adding new nerve cells at the rate of 250,000 per minute. After birth, the infant's brain continues to form a dense network of nerve-cell fibers, taking cues from the environment to guide development of movement, language, and other skills. Neuroscientists have recently discovered that another growth spurt in the brain occurs just before puberty, followed by an aggressive "pruning" of connections that are not sufficiently activated—as if the brain were remodeling itself in preparation for adulthood. The old adage, "use it or lose it," is particularly fitting to these post-birth periods of reshaping in the brain.

BRAIN TIP:

If you're pregnant, avoid alcohol, drugs, and smoking, which can impair the baby's brain development. Proper nutrition is also critical during pregnancy, and taking folic acid supplements reduces the risk of certain types of neural birth defects.

Q. Does the brain grow new nerve cells throughout life?

A. Apparently so. The discovery that even older adults are capable of creating new brain cells has turned long-accepted neuroscience dogma on its head and opened up new vistas in research. Neurogenesis, as the phenomenon is called, has been seen most convincingly in the hippocampus, a brain structure integral to forming new memories. There is some evidence to suggest that neurogenesis may also be happening in other brain areas, including the cortex, from which higher intellectual functions are orchestrated. These findings, however, are preliminary and need to be replicated. Scientists have also discovered an area of the brain that houses neural stem cells, immature cells that are capable of differentiating into neurons and other brain cells.

BRAIN FACT:

Enriching environments that provide lots of stimulation have been shown to increase the rate of neurogenesis in animal studies, while stress decreases new nerve-cell growth.

Q. What happens to the brain as we age?

A. Until recently, it was widely accepted that neuron death was an inevitable result of normal aging, which was a reasonable explanation for the so-called signs of brain aging, such as memory slippage or a dulling of our mental "edge." Now we know that the normal brain actually loses relatively few nerve cells, even into old age. In addition, the loss of nerve cells seems to be primarily restricted to regions of the brain that produce neurotransmitters such as dopamine, serotonin, and norepinephrine, which contributes to progressive alterations in the biochemical make-up of the aging brain. The incidence of a number of brain disorders, including depression, Alzheimer's, and Parkinson's, is considerably higher in older adults, but the reasons are not completely clear. The good news is that mental decline is not an inevitable part of aging, and there are a number of things we can do throughout life that may keep us "brain-healthy" in old age.

BRAIN TIP:

Experts say you can preserve mental sharpness in older age if you exercise your brain AND your body. Both help keep your brain "fit" as you age. Managing stress, avoiding excessive drug or alcohol use, and staying socially connected with friends and family may also help.

Q. Is the mind different from the brain?

A. Scientists and philosophers have wrestled with this question for centuries, but modern neuroimaging has brought a clear new view to the debate. Through sophisticated brain imaging devices such as fMRI, we can now see the mind at work—visual evidence that the mind and brain are one. It's possible to track which areas of the brain "light up" when we're thinking about certain things, indicating that neurons in those areas are being activated. Nurtured in part by the surge in imaging technology, the field of cognitive neuroscience, the study of the thinking part of the brain, has blossomed. These experts argue that "the mind"—the ability to plan, reason, feel emotions, and have a unique personality—is as clearly a function of the synapses in our brains as our ability to walk or talk.

Q. What has the human genome told us about the brain?

A. The sequencing of the human genome is destined to revolutionize much of medicine, but its impact on brain science and the treatment of brain disorders may be particularly great. Gene experts estimate that roughly half of the 30,000 plus genes scattered among the chemical code of our DNA are dedicated to the development, structure, and function of the central nervous system. These genes are what separates us from the rest of the animal kingdom.

Some cases of the most devastating brain disorders, including bipolar disorder, schizophrenia, depression, and Alzheimer's disease, appear to have an inherited component, which suggests a genetic root.

But, except for several genes associated with Alzheimer's, the search for the underlying genes for the most common brain conditions has so far not been fruitful, in part because many diseases probably result from an interaction of multiple genetic and environmental factors. As gene functions are revealed, so, eventually, will be the mechanisms by which they lead to disease. This is the next step in developing rational treatments that target disorders at their root.

BRAIN TIP:

The discovery of the gene for Huntington's disease is a good example of how genes can help us understand brain disorders and design treatments. Based on knowledge about how the genetic mutation in Huntington's leads to the disease's devastating movement problems, scientists are one step closer to developing new drug candidates.

Q. How is the brain involved in the immune system?

A. The immune system is the body's biological defense shield against infections and toxins. Immune cells have some important characteristics in common with nerve cells. Just like nerve cells, for instance, immune cells communicate with one another. And, like nerve cells, some immune cells have memory. This memory enables the immune cells to remember an infectious agent and identify and attack it every time it tries to invade the body. Additionally, as scientists recently have discovered, substances that have been thought to be important for nerve cell maintenance and survival also are necessary for immune cell functioning and survival. What, then, do these similarities mean for how the brain is involved in the immune system?

Scientists are still working to determine to what extent, and how, the brain influences or controls some immune system functions. Answers to these critically important questions are expected to have major implications for improving means to prevent and treat diseases that affect the nervous system. For instance, we know that the immune system helps to prevent diseases that can attack the brain, such as measles and encephalitis.

Surprisingly, the immune system in some instances also can cause harm to the brain and spinal cord. In degenerative diseases like Parkinson's or Alzheimer's disease or multiple sclerosis, immune cells misidentify the deteriorating nerve cells as "foreign" and attack them, which may worsen the disease. This also appears to happen in spinal cord injury, where immune cells travel to the site of injury and attack the damaged spinal cord cells.

Out of our increasing understanding of this harmful relationship, however, may come new therapeutic advances that target immune system dysfunction in brain diseases. For instance, scientists are currently determining if specific vaccines might arrest or slow the progress of brain tumor growth or Alzheimer's disease. Research exploring this brain-immune system relationship is moving to the forefront of important new directions in brain disease prevention and treatment.

Q. Can the brain repair itself after injury or cell death?

A. It has long been accepted that the central nervous system does not regenerate itself after traumatic injury or widespread cell death. This is evident from the fact that people with severe head or spinal cord trauma are generally not able to recover their pre-injury level of function. However, recent discoveries—including the revelations that adult brains can form new nerve cells and that immature neural stem cells can migrate to injured areas of animals' brains—have forced a reconsideration of this accepted principle.

In addition, improved understanding of how nerve cell connections are formed in early brain development has helped bring the sci-fi notion of nerve cell regeneration closer to reality. Still, more research is needed before we can successfully harness the brain's innate repair abilities to help victims of trauma or disease.

BRAIN TIP:

All the advances notwithstanding, safety is still the No. 1 rule of brain health. Wear a helmet to protect your brain in high-risk activities such as cycling, rollerblading, skateboarding, skiing, playing football, or riding an ATV or snowmobile. Don't dive in shallow water, and check first if you don't know the water's depth. Always fasten your seat belt.

Q. Why do some people become mentally ill?

A. For the same reasons that some people develop heart disease or diabetes: A combination of genetic predisposition (sometimes evident by family history of a disease) and environmental factors increase one's risk. Mental illnesses such as depression, bipolar disorder (manic-depressive illness), schizophrenia, and obsessive-compulsive disorder are medical conditions with a biological basis. Many are thought to be the result of imbalances in certain neurotransmitters, the brain's chemical messengers. For example, depression has been linked to low levels of the neurotransmitter serotonin, which regulates mood. People who are mentally ill cannot control their disease and they cannot just "snap out of it." In the hope that these misunderstood conditions might be prevented, brain scientists are trying to determine what environmental factors trigger mental illness in susceptible individuals. The role of stress is a primary target for research.

BRAIN TIP:

Having a mental illness is not something to be ashamed of. Many people can benefit from available treatments, and support groups can augment drug treatment by helping people learn to cope with their illness.

Q. **How effective are treatments for mood disorders such as depression, bipolar disorder (manic-depressive illness), obsessive-compulsive disorder, anxiety and panic attacks?**

A. As many as 80 percent of people with major depression can be effectively treated with a combination of antidepressant medications and "talk therapy"—if they get the proper medical attention. Many people with bipolar disorder, in which periods of depression alternate with manic episodes marked by sleeplessness and extreme behaviors, can also be effectively treated, as can those with panic, anxiety, or obsessive-compulsive disorders. Unfortunately, people with mood disorders or other psychiatric illnesses often do not seek help. Seeking—and getting—the right treatment is crucial to reducing disability and preventing suicide, a serious risk for people with depression or bipolar disorder. Studies have shown that consulting a psychiatrist with special training in such illnesses helps ensure better care.

BRAIN TIP:

Serious depression commonly co-occurs with many chronic illnesses, including heart disease, stroke, and diabetes. Be alert to signs of depression—excessive, persistent sadness; sleep problems, and loss of interest in usual activities—and seek medical care if these symptoms last two weeks or more.

Q. Do alcohol and illicit drugs really kill brain cells?

A. Excessive use of alcohol, and even moderate use of potent street drugs, can cause irreversible damage to nerve cells. For example, the club drug Ecstasy, the use of which has increased dramatically among young people, injures brain cells that produce serotonin, a neurotransmitter that regulates mood, emotion, learning, memory, sleep, and pain.

Researchers have now identified important brain circuits involved in every known drug of abuse, according to the National Institute on Drug Abuse, and have replicated the molecular structures of the nerve-cell receptors on which these drugs act. Through brain imaging, scientists have tracked the processes that turn a normal brain into an addicted brain. These advances are crucial to the development of therapies that can reverse or compensate for drug-induced brain changes.

BRAIN FACT:

Using illicit drugs—even if only as an experiment —can cause permanent changes to the brain.

Q. Is there any hope for people with Parkinson's disease?

A. Medications that act on the brain chemical dopamine have had significant success in treating the movement abnormalities of Parkinson's, but the benefits wear off in many patients after five to ten years. New drugs are being developed to prolong the action of these treatments and to slow the selective nerve-cell loss that causes the disease. For those in whom drug therapies fail, surgical approaches may be of some benefit, including deep brain stimulation, a therapy in which electrodes implanted in the brain mildly stimulate cells in an area that controls movement. There is also hope that gene therapy and cell-transplantation strategies may be useful in Parkinson's, though the best techniques for employing these futuristic treatments are not yet clear.

BRAIN TIP:

Caring for a person with a chronic brain disorder like Parkinson's can cause health problems in the caregiver. Support groups and caregiver networks can help caregivers learn coping strategies, and many groups also provide respite services.

Q. How is the brain involved in pain?

A. Oddly, the brain itself feels no pain directly, but it registers pain from everywhere else in the body. When pain is experienced, pain signals travel from peripheral nerves to the brain, initiating a torrent of biochemicals and hormones that orchestrate the body's reaction to pain. Chronic pain can occur when pain signals fail to switch off properly and become amplified, making even the slightest touch excruciatingly painful.

New understandings about the brain pathways underlying chronic pain have led to the development of a new class of pain relievers, called NMDA-antagonists, which work by blocking pain signals and interrupting the cascade of nerve-cell changes that lead to chronic pain.

Q. Is memory loss an early sign of Alzheimer's disease?

A. Brain scientists are working diligently to pin down where normal forgetfulness ends and early-stage Alzheimer's begins. Even though memory loss is one of the earliest symptoms of Alzheimer's disease, there are clear differences between what scientists call "age-related memory loss" and the dementia of Alzheimer's, both in the symptoms and the underlying biology. Alzheimer's involves a broad loss of cognitive abilities—thinking and reasoning in addition to memory, while normal memory loss is primarily a deficit of declarative memory—our memory for facts, people, places and things. Forgetting where the car is parked happens to us all occasionally, but forgetting that we drove the car to the store is cause for concern.

BRAIN TIP:

As we get older, it may take us longer to learn and store new information, so concentration becomes increasingly important. Try to reduce distractions and minimize interferences when learning new information. Write down and verbally repeat important things, and organize objects you use frequently (like car keys), so you'll always know where to look for them.

Q. Can stroke be prevented?

A. Brain experts are convinced that many strokes can be prevented with proper attention to factors that increase risk. Primary risk factors that can be managed with lifestyle modifications include smoking, obesity, excessive alcohol use, diabetes, high blood pressure, and physical inactivity. Stroke is the second leading cause of death and disability worldwide, so preventative measures could have a huge impact on public health. When a "brain attack" occurs, treatments must be administered within a few hours, so it's critical to get medical help immediately. Advances in rehabilitation therapy are now making it possible for many people to recover a considerable degree of function following a stroke.

BRAIN TIP:

Stroke, also known as a "brain attack," is a medical emergency, and should be treated with the same urgency as a heart attack. If you or someone you know experiences any of the following symptoms, seek help immediately: sudden numbness, paralysis or weakness in the face, arms, or legs; sudden difficulty talking or understanding speech; sudden confusion; vision disturbances; dizziness; or severe, unexplained headaches.

Q. What kinds of advances in treating brain disorders can be expected in coming years?

A. Harnessing the power of plasticity—the brain's ability to remodel and adjust itself—and applying the findings of genomic research are two areas that scientists believe will deliver profound therapeutic advances. Gene therapy—in which genes that produce specific proteins are transplanted into the brain to replace those lost in a disease—holds promise for the treatment of neurodegenerative diseases such as Alzheimer's and movement-related disorders (*i.e.* Parkinson's, Lou Gehrig's, and Huntington's diseases). Regenerative medicine, in which the processes by which the brain develops are simulated to induce regrowth of nerve cells, offers hope for the treatment of nervous system injuries like stroke and spinal cord trauma.

We are on the cusp of a new era in brain science in which the scourge of brain disorders may be eased through prevention, early recognition, and effective treatments.

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