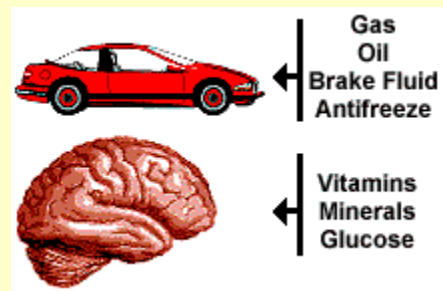




## Nutrition and the Brain

Your brain is like a car. A car needs gasoline, oil, brake fluid and other materials to run properly. Your brain also needs special materials to run properly: glucose, vitamins, minerals and other essential chemicals. For example, the fuel (energy) for your brain is glucose. You can get glucose by eating carbohydrates or other foods that can be converted to glucose.

Your brain must manufacture the right proteins and fats to do things such as grow new connections or add [myelin](#), the fatty sheath to axons. You do this by digesting proteins and fats in food and using the pieces, that is, the amino acids and fatty acids, to make the new brain proteins and fats. Without the correct amount and balance of particular building blocks, your brain will not work properly. Too little (deficiency) or too much (overabundance) of the necessary nutrient can affect the nervous system. (For a table that shows the effects of too little or too much of specific nutrients, please see [Nutrient Effects on the Nervous System](#).)



### Vocabulary

**Amino Acid:** building block of proteins; an organic compound

**Protein:** a large molecule made from amino acids. Examples of proteins are enzymes and hormones.

**Essential Vitamin or Mineral:** vitamins and minerals that are needed by the body but are not produced by the body. Therefore, these materials must be taken in as part of the diet.

**Lipids (fats):** not all fats are bad for you. In fact, some fats are essential for proper brain function. Two lipids important to the brain are the n-6 and n-3 fatty acids. Low levels of n-3 fatty acids in a diet can cause visual problems especially by affecting the retina. Studies in animals have shown that diets without n-3 fatty acids cause learning, motivation and motor problems and may affect systems that use the neurotransmitters dopamine and serotonin in the frontal cortex. The n-6 fatty acids are also important in proper brain function because they affect

**Vitamin:** substance from food that is necessary for the proper function of the body. Many vitamins assist in enzymatic processes.

neurotransmitter release and they also influence the ability of neurons to use glucose.



## Diet and the Neurotransmitters

Certain foods contain precursors (starting materials) for some [neurotransmitters](#). If a diet is deficient in certain precursors, the brain will not be able to produce some neurotransmitters. Neurological and mental disorders may occur when the balance of neurotransmitters is upset. Examples of neurotransmitter precursors include:

### Aspartic Acid

Used to make aspartate; found in peanuts, potatoes, eggs and grains.

### Choline

Used to make acetylcholine; found in eggs, liver and soybeans.

### Glutamic Acid

Used to make glutamate; found in flour and potatoes.

### Phenylalanine

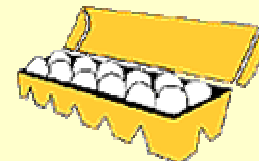
Used to make dopamine; found in beets, soybeans, almonds, eggs, meat and grains.

### Tryptophan

Used to make serotonin; found in eggs, meat, skim milk, bananas, yogurt, milk, and cheese.

### Tyrosine

Used to make norepinephrine; found in milk, meat, fish and legumes.



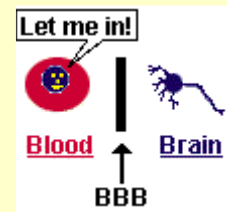
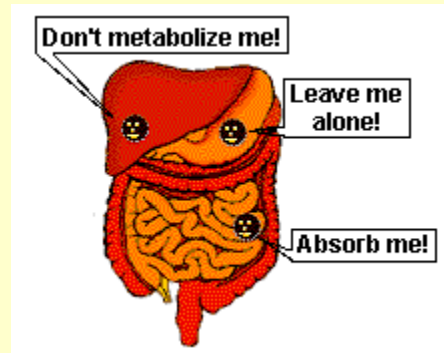
## The Journey Into the Brain

Nutrients must follow a tricky pathway to your brain and overcome several challenges:

1. They must gain entry to your body: if you don't eat them, they will not be available to



- your brain.
2. Once in your stomach, they must survive an attack by acid that breaks some foods down.
  3. Further along the digestive tract, they must be absorbed through the cells lining the intestine and transported through blood vessel walls into the bloodstream.
  4. Traveling in the blood through the liver, nutrients need to avoid being metabolized (destroyed).
  5. Once in the bloodstream, nutrients must cross small blood vessels into brain tissue. This transport from the blood to neurons is restricted by the blood brain barrier.



## The Blood Brain Barrier (BBB)

The [blood brain barrier \(BBB\)](#) keeps many substances out of the brain, but it also must let nutrients into the brain. You might think of the BBB as a wall between the bloodstream and neurons. A substance must cross through this wall from the blood to reach neurons. The BBB can be crossed in three ways:

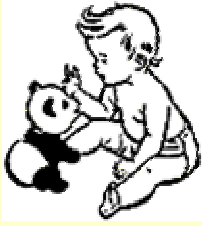
1. Some materials can fit through "holes" in the BBB.
2. Substances can be transported through the BBB by special carriers.
3. Some materials can break down the BBB.



## Malnutrition and the Brain

Vitamin and mineral deficiencies can be caused by:

1. Starvation
2. Poor diet
3. Poor absorption of vitamins and minerals
4. Damage to the digestive system
5. Infection
6. Alcoholism



The brain of a human fetus grows rapidly from the 10th to 18th week of pregnancy, so it is important for the mother to eat nutritious foods during this time. The brain also grows rapidly just before and for about 2 years after birth. Malnutrition during these periods of rapid brain growth may have devastating effects on the nervous system and can affect not only neurons, but also [glial cell](#) development and growth. Effects on glial cells may change myelin development especially because myelin continues to form around axons for several years after birth.

Babies born to mothers who had poor diets may have some form of mental retardation or behavioral problems. Also, children who do not receive adequate nutrition in their first few years of life may develop problems later. Often the effects of malnutrition and environmental problems, such as emotional and physical abuse, can combine to create behavioral problems. Therefore, the exact causes of behavioral disorders are difficult to determine.

Some effects of malnutrition can be repaired by a proper diet, so not all of the effects of poor diets are permanent. Researchers believe that the timing of malnutrition is an important factor in determining if problems will occur. This means that missing out on a particular nutrient at the time when a part of the brain is growing and needs that nutrient will cause a specific problem there.



## Studying the Nutrition-Brain-Behavior Connection

The study of how nutrition affects the brain and behavior is relatively new. Scientists have just begun to understand how changes in particular nutrients alter the brain and how these neural changes then affect intelligence, mood, and the way people act. Experiments that investigate this nutrition-brain-behavior interaction, particularly those that study the effects of malnutrition, are difficult for several reasons:

1. There is a link between poor nutrition and environmental factors. Therefore, changes in behavior may not be due to poor nutrition only. Other factors such as education, social or family problems may affect behavior.
2. It is difficult to alter only one substance in the human diet. Therefore, it is difficult to determine if a particular vitamin or mineral has a certain effect on behavior. For ethical reasons, experiments in which a person is not allowed to eat a particular nutrient cannot be done, so much of the data come from animal experiments. Studies in humans are generally limited to examining the effects of famine and starvation, situations where many nutrients are missing.
3. People respond to different diets in different ways. In other words, there is a large individual variation in the body's response and need for different nutrients.
4. A change in diet may have a **placebo effect**. The placebo effect occurs because a

- person **thinks** something will have an effect. In other words, if a person thinks a change in diet will affect behavior, it may actually affect behavior even if the nutrients are not causing the change. Therefore, experiments must have a placebo control and be performed in a **double-blind manner** where neither the experimental subject nor the experimenter know who has received an altered diet.
5. The definition of intelligence is controversial. For example, some people do not believe that IQ tests accurately measure intelligence so it is difficult to use an IQ test to claim that intelligence has been affected by diet.

**WARNING:** Always consult with a health care professional before starting a diet or nutritional supplement program, such as taking high doses of vitamins or minerals. Small changes in diet can have large effects on your health.



For more information on nutrition and the brain, see:

1. [Child Malnutrition](#)
2. [Iron Deficiency](#)
3. [Dangers of Lead Still Linger](#) - US FDA
4. [Dietary Guidelines for Americans](#)
5. [FDA Guide to Dietary Supplements](#)
6. [RDAs](#)
7. [Staking a Claim to Good Health](#) - US FDA
8. [Mercury in Fish](#)
9. [Lead in food](#)

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