How Mad Cow Disease Works

Introduction to How Mad Cow Disease Works
To the cattle industry, an outbreak of mad cow disease is an ever-looming nightmare. In the 1980s and '90s, the brain disorder infected 180,000 livestock in Europe and claimed dozens of human lives, devastating the British cattle industry. Britain, the United States and most other major cattle-producing nations have imposed stringent measures to control the disease, but another outbreak is a very real possibility.

In this article, we'll discuss what mad cow disease is, how it works, what the consequences for humans are and what is being done to control and prevent its occurrence.

Mad Cow Disease = BSE
Mad cow disease is more correctly referred to as bovine spongiform encephalopathy, or BSE. In this article, we will use BSE to designate mad cow disease.

Origins of BSE
BSE is thought to have come from a similar disease in sheep called scrapie. In the 1980s, producers of cattle feed (which often included ground meat and bone meal by-products from sheep) changed the way they processed feed. The change somehow allowed the scrapie disease agent to survive the cattle feed production process. Thus, contaminated food was fed to cattle, which then came down with BSE.

At the time, neither scrapie nor BSE were thought to affect humans. So, meat (nervous tissue) from BSE-infected cows made it into the food supply. Humans who ate the infected meat (probably hamburger or other processed meats) contracted the BSE-causing agent and developed nvCJD.

What is Mad Cow Disease?
Mad cow disease, or bovine spongiform encephalopathy (BSE), is a fatal brain disorder that occurs in cattle and is caused by some unknown agent. In BSE, the unknown agent causes the cow's brain cells to die, forming sponge-like holes in the brain. The cow behaves strangely and eventually dies. The connection between BSE and humans was uncovered in Great Britain in the 1990s when several young people died of a human brain disorder, a new variation of a rare brain disorder called Creutzfeldt-Jakob Disease (CJD), which typically strikes elderly people. The new variation was called new variant Creutzfeldt-Jakob Disease (nvCJD), was similar to BSE and its connection to BSE was based on the following findings:

- The nvCJD victims had lived in areas where outbreaks of BSE had occurred in cattle years earlier. No victims were found in areas without BSE outbreaks.
- The brains of nvCJD victims had proteins called prions (pronounced "pree-ahnz") that were similar to those from the brains of BSE-infected cows, but different from those found in victims of classic CJD.
- The time between the BSE outbreaks and the deaths of the victims was similar to the time that it takes for Creutzfeldt-Jakob disease to develop.
- Brain tissue from BSE-infected cows caused experimental animals to develop symptoms and brain tissue disorders similar to those of the nvCJD victims.

The British government concluded that BSE was probably the cause of nvCJD, and that the victims contracted the disease probably by eating meat from BSE-infected cows.

How BSE Works
BSE is spread by contact with brain or other nervous-system tissue from an infected individual. Contact can be from eating food or food by-products that have been contaminated with nervous tissue, or from instruments that have contacted diseased nervous tissue. Once the infectious agent enters the brain, it can lie dormant for several years (even as long as 10 to 15 years). When activated, the agent kills brain cells, leaving large areas of spongy holes. Also, large clumps of abnormal prion proteins (plaques) are found in brain cells. Once the agent is activated, the disease runs its course in less than one year, and ultimately results in death.

We don't know the agent that causes BSE, but we do know the following:
The agent must be small - The agent's size must be as small or smaller than a virus.
You can't kill it by cooking or freezing - Much higher temperatures than those used in cooking or sterilizing are required to kill it.
Disinfectants don't work - Normal chemicals that you would use to disinfect surfaces for bacteria and viruses (Lysol, Betadine) are not effective.
It does not appear to have genetic information (nucleic acids) - This finding has been questioned.

Secret Agent
Research into BSE and similar diseases (nvCJD, CJD, scrapie) have provided three theories about the agent that causes BSE. These theories lead us to believe that it is:

- **An unidentified virus or virus-like particle** - Although the size of the agent is right, the resistance to heat and chemicals, as well as the absence of any nucleic acids, would make it unlike any known virus.
- **A mobile bacterium** (Spiroplasma) - Many of the features of Spiroplasma infections are similar to BSE, but there is no direct evidence to tie it to BSE.
- **An abnormal protein (prion)** - Abnormal prions are found throughout the brains of BSE-infected cows, nvCJD victims, CJD victims and scrapie-infected sheep. The protein is smaller than a virus and not changed by heat or by disinfectants. This hypothesis is the most prevalent in the media, but goes against many accepted theories of biology.

Foot-and-Mouth Disease
In addition to hearing about mad cow disease, you may have also heard about foot-and-mouth disease, also commonly referred to as hoof-and-mouth disease. Read more about it in this Question of the Day.

The Prion Hypothesis
Prions are proteins that are found in the nerve cells of all mammals. Numerous prions are in each nerve cell, but no one knows for sure what the prion protein does. As mentioned above, many abnormally-shaped prions are found in the brains of BSE-infected cows and humans afflicted with nvCJD or CJD. So, the prion hypothesis goes like this:

1. An person ingests an abnormally-shaped prion from contaminated food.
2. The abnormally-shaped prion gets absorbed into the bloodstream and crosses into the nervous system.
3. The abnormal prion touches a normal prion and changes the normal prion's shape into an abnormal one, thereby destroying the normal prion's original function.
4. Both abnormal prions then contact and change the shapes of other normal prions in the nerve cell.
5. The nerve cell tries to get rid of the abnormal prions by clumping them together in small sacs that merge with its "stomach" (lysosome).
6. Because the nerve cells cannot digest the abnormal prions, they accumulate in the lysosomes.
7. The lysosomes grow and engorge the nerve cell, which eventually dies.
8. When the cell dies, the abnormal prions are released to infect other cells.
9. Large, sponge-like holes are left where many cells die.
10. Numerous nerve cell deaths lead to loss of brain function, and the person eventually dies.

Animal and Human Consequences
Cows infected with BSE lose weight, show abnormal behavior (skittishness), may become paralyzed and die. Humans afflicted with nvCJD begin with psychiatric problems (paranoia) or perhaps problems with their senses. They later develop problems in muscle coordination (balance, speech), muscle spasms, problems with their senses (hearing, vision) and memory loss. They may finally lapse into coma and die.

Tests for BSE
To test for BSE, brain tissue from a suspected animal is injected into an experimental animal. Scientists then observe the experimental animal for signs of BSE. With the advent of the prion hypothesis, molecular tests are being developed to detect abnormal prions in suspected animals. One company, Prionics Inc., has marketed diagnostic tests for BSE.
Control and Prevention

In 1988, the UK government banned using any ruminant (cattle, sheep, goats) or ruminant by-products in animal feed. Later, they banned exports of cattle to other countries. They have destroyed BSE-infected cattle and monitored herds for signs of BSE. In addition, the medical community has monitored the general population and reported any cases of nvCJD. These steps have contributed to a steady decline in BSE since 1992.

The U.S. government has instituted the following policies regarding BSE:

- The U.S. Department of Agriculture (USDA) has prohibited imports of live ruminants or ruminant products (meat, feed, by-products) from Europe.
- The USDA has tested any cattle showing abnormal behavior for BSE.
- The USDA inspects all cattle used for food for signs of neurological diseases. Cattle with unidentified neurological disorders are rejected.
- The U.S. Food & Drug Administration (FDA) has prohibited using mammalian proteins in making animal feeds for ruminants.
- The FDA has recommended that pharmaceutical companies should not use animal tissues from countries with BSE in making drug products (vaccines).
- The FDA has asked blood centers to exclude potential blood donors who have spent six or more consecutive months in the UK between 1980 and 1986.
- The Centers for Disease Control (CDC) regularly monitors the U.S. population for signs of nvCJD.
- The CDC has issued guidelines to travelers in Europe -- 1. Avoid beef and beef products altogether. 2. If eating meat, then select beef or beef products that have less opportunity for contamination from nervous tissue (solid muscle cuts vs. processed sausages or hamburgers. 3. Milk or milk products are not believed to pose any risk from the BSE agent.
- The National Institutes of Health (NIH) conducts research on BSE, CJD, nvCJD and related nervous system diseases.

Several U.S. government agencies (FDA, USDA, CDC) monitor the meat supply in the United States as well as imports from other countries. European countries have instituted similar guidelines.