September 13, 1848, was a momentous day for Phineas Gage, a young man who worked in Vermont evening out terrain for railroad tracks. To blast away rock, he would drill a hole, fill it with gunpowder, cover that with sand, insert a fuse, and then press down with an iron rod called a tamping iron. The explosion would go down into the rock.

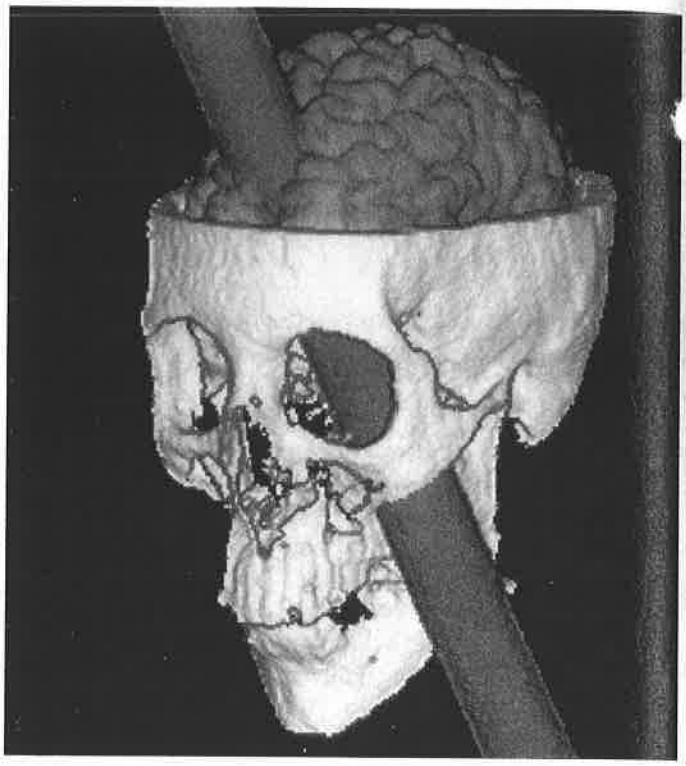
But on that fateful September day, Gage began pounding on the tamping iron before his coworker had put down the sand. The gunpowder exploded outward, slamming the inch-thick, 40-inch-long iron rod straight through Gage's skull. It pierced his brain like an arrow propelled through a soft melon, shooting out the other side of his head. Curiously, Gage stood up just a few moments later, fully conscious and apparently unharmed by the hole just blasted through his head.

As it turned out, Gage was harmed by the freak accident, but in ways so subtle that they were not at first evident. His friends reported that "Gage was no longer Gage." Although retaining his intellect and abilities to move, speak, learn, and remember, Gage underwent a profound personality transformation. Once a trusted, honest, and dedicated worker, the 25-year-old became irresponsible, shirking work, cursing, and pursuing what his doctor termed "animal propensities."

Researchers as long ago as 1868 hypothesized that the tamping iron had ripped out a part of Gage's brain controlling personality. In 1994, computer analysis more precisely pinpointed the damage to the famous brain of Phineas Gage, which, along with the tamping iron, wound up in a museum at Harvard University. Researchers reconstructed the trajectory of the tamping iron, localizing two small areas in the front of the brain that control rational decision making and processing of emotion.

More than a hundred years after Gage's accident, in 1975, 21-year-old Karen Ann Quinlan drank alcohol after taking a prescription sedative, and her heart and lungs stopped working. When she was found, Karen had no pulse, was not breathing, had dilated pupils, and was unresponsive. Cardiopulmonary resuscitation restored her pulse, but once at the hospital she was placed on a ventilator. Within 12 hours, some functions returned—her pupils constricted, she moved, gagged, grimaced, and even opened her eyes. Within a few months, she could even breathe unaided for short periods.

Because Karen's responses were random and not purposeful, and she was apparently unaware of herself and her environment, she was said to be in a *persistent vegetative state.* Her basic life functions were intact, but she had to be fed and given water intravenously. Fourteen months after Karen took the fateful pills and alcohol, her parents made a request that was to launch the right-to-die movement. They asked that Karen be taken off of life support. Doctors removed Karen's ventilator, and a nursing home accepted her, where she lived for 9 more years before dying of infection, never regaining awareness.



A rod blasted through the head of a young railway worker has taught us much about the biology of personality.

Throughout Karen and her family's ordeal, researchers tried to fathom what had happened to her. A CAT scan performed 5 years after the accident showed atrophy in two major brain regions, the cerebrum and the cerebellum. But when researchers analyzed Karen Ann Quinlan's brain in 1993, they were surprised. The most severely damaged part of her brain was the thalamus, an area thought to function merely as a relay station to higher brain structures. Karen's tragic case revealed that the thalamus is also important in processing thoughts, in providing the awareness and responsiveness that makes a person a conscious being.

The cases of Phineas Gage and Karen Ann Quinlan dramatically illustrate the function of the human brain by revealing what can happen when it is damaged. Nearly every aspect of our existence depends upon the brain and other parts of the nervous system, from thinking and feeling; to sensing, perceiving, and responding to the environment; to carrying out vital functions such as breathing and heartbeat. This chapter describes how the billions of neurons comprising the nervous system interact to enable us to survive and to enjoy the world around us.