



“Horrible Accident” in Vermont

T

he most unlucky/lucky moment in the life of Phineas Gage is only a minute or two away. It's almost four-thirty in the afternoon on September 13, 1848. Phineas is the foreman of a track construction gang that is in the process of blasting a railroad right-of-way through granite bedrock near the small town of Cavendish, Vermont. Phineas is twenty-six years old, unmarried, and five feet, six inches tall, short for our time but about average for his. He is good with his hands and good with his men, “possessing an iron will as

well as an iron frame,” according to his doctor. In a moment, Phineas will have a horrible accident.

It will kill him, but it will take another eleven years, six months, and nineteen days to do so. In the short run, Phineas will make a full recovery, or so it will seem to those who didn't know him before. Old friends and family will know the truth. Phineas will never be his old self again. His “character” will change. The ways in which he deals with others, conducts himself, and makes plans will all change. Long after the accident, his doctor will sum up his case for a medical journal. “Gage,” his doctor will write, “was no longer Gage.” Phineas Gage's accident will make him world famous, but fame will do him little good. Yet for many others—psychologists, medical researchers, doctors, and especially those who suffer brain injuries—Phineas Gage will become someone worth knowing.

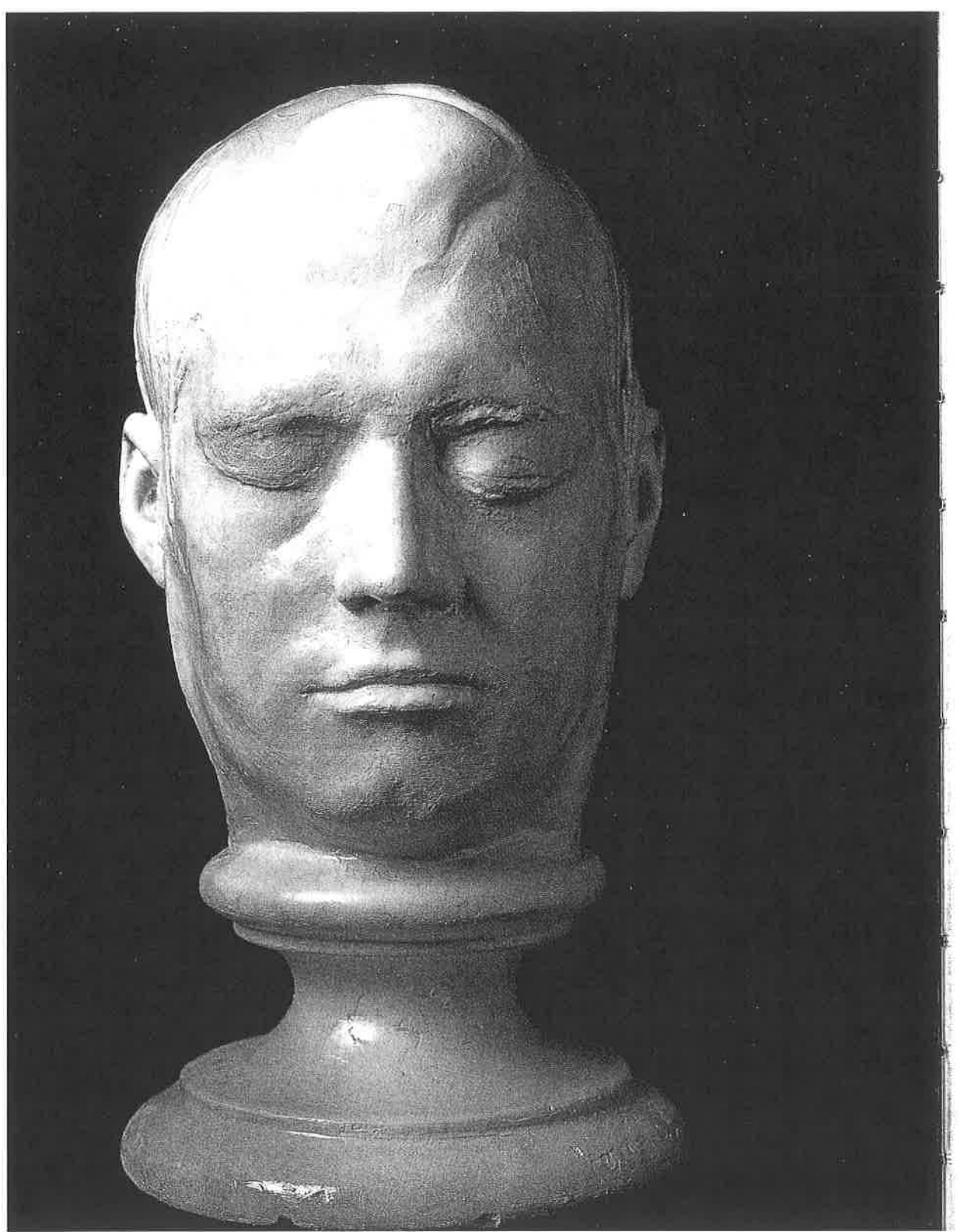
That's why we know so much about Phineas. It's been 150 years since his accident, yet we are still learning more about him. There's also a lot about Phineas we don't know and probably never will. The biggest question is the simplest one and the hardest to answer: Was Phineas lucky or unlucky? Once you hear his story, you can decide for yourself. But right now, Phineas is working on the railroad and his time has nearly come.

Building a railroad in 1848 is muscle work. There are no bulldozers or power shovels to open a way through Vermont's Green Mountains for the Rutland & Burlington Railroad. Phineas's men work with picks, shovels, and rock drills. Phineas's special skill is blasting. With well-placed charges of black gunpowder, he shatters rock. To set those charges, he carries the special tool of the blasting trade, his “tamping iron.” Some people confuse a tamping iron with a

crowbar, but they are different tools for different jobs. A crowbar is for lifting up or prying apart something heavy. A tamping iron is for the delicate job of setting explosives. Phineas had his tamping iron made to order by a neighborhood blacksmith. It's a tapering iron rod that is three feet, seven inches long and weighs thirteen and a half pounds. It looks like an iron spear. At the base, it's fat and round, an inch and three quarters in diameter. The fat end is for tamping—packing down—loose powder. The other end comes to a sharp, narrow point and is for poking holes through the gunpowder to set the fuse. Phineas's tamping iron is very smooth to the touch, smooth from the blacksmith's forge as well as from constant use.

His task is to blast the solid rock into pieces small enough for his crew to dig loose with hand tools and haul away in ox carts. The first step is to drill a hole in the bedrock at exactly the right angle and depth, or the explosion will be wasted. All day, Phineas must keep an eye on his drillers to make sure they stay ahead. All day, Phineas must keep an eye on his diggers to make sure they keep up. All the time between, Phineas and his assistant are working with touchy explosives.

They follow a strict routine. His assistant "charges" each new hole by filling the bottom with coarse-grained gunpowder. Phineas uses the narrow end of his iron to carefully press the ropelike fuse down into the powder. The assistant then fills up the rest of the hole with loose sand to act as a plug. Phineas will tamp the sand tight to bottle up the explosion, channeling the blast downward into the rock to shatter it. While his assistant is pouring the sand, Phineas flips his tamping iron around from the pointy end to the round end for tamping. Black powder is ticklish stuff. When it's damp, nothing will set it off.



When it's too dry or mixed in the wrong formula, almost anything can set it off, without warning. But Phineas and his assistant have done this a thousand times—pour the powder, set the fuse, pour the sand, tamp the sand plug, shout a warning, light the fuse, and run like mad.

But something goes wrong this time. The sand is never poured down the hole; the black powder and fuse sit exposed at the bottom. Does his assistant forget, or does Phineas forget to look? Witnesses disagree. A few yards behind Phineas, a group of his men are using a hand-cranked derrick crane to hoist a large piece of rock. Some of the men remember seeing Phineas standing over the blast hole, leaning lightly on the tamping iron. Others say Phineas was sitting on a rock ledge above the hole, holding the iron loosely between his knees.

There is no argument about what happens next. Something or someone distracts Phineas. Does he hear his name called? Does he spot someone goofing off? Whatever the reason, Phineas turns his head to glance over his right shoulder. The fat end of his tamping iron slips down into the hole and strikes the granite. A spark flies onto the exposed blasting powder. Blam! The drill hole acts as a gun barrel. Instead of a bullet, it fires Phineas's rod straight upward. The iron shrieks through the air and comes down with a loud clang about thirty feet away.

This is what happens. Imagine you are inside Phineas's head, watching in

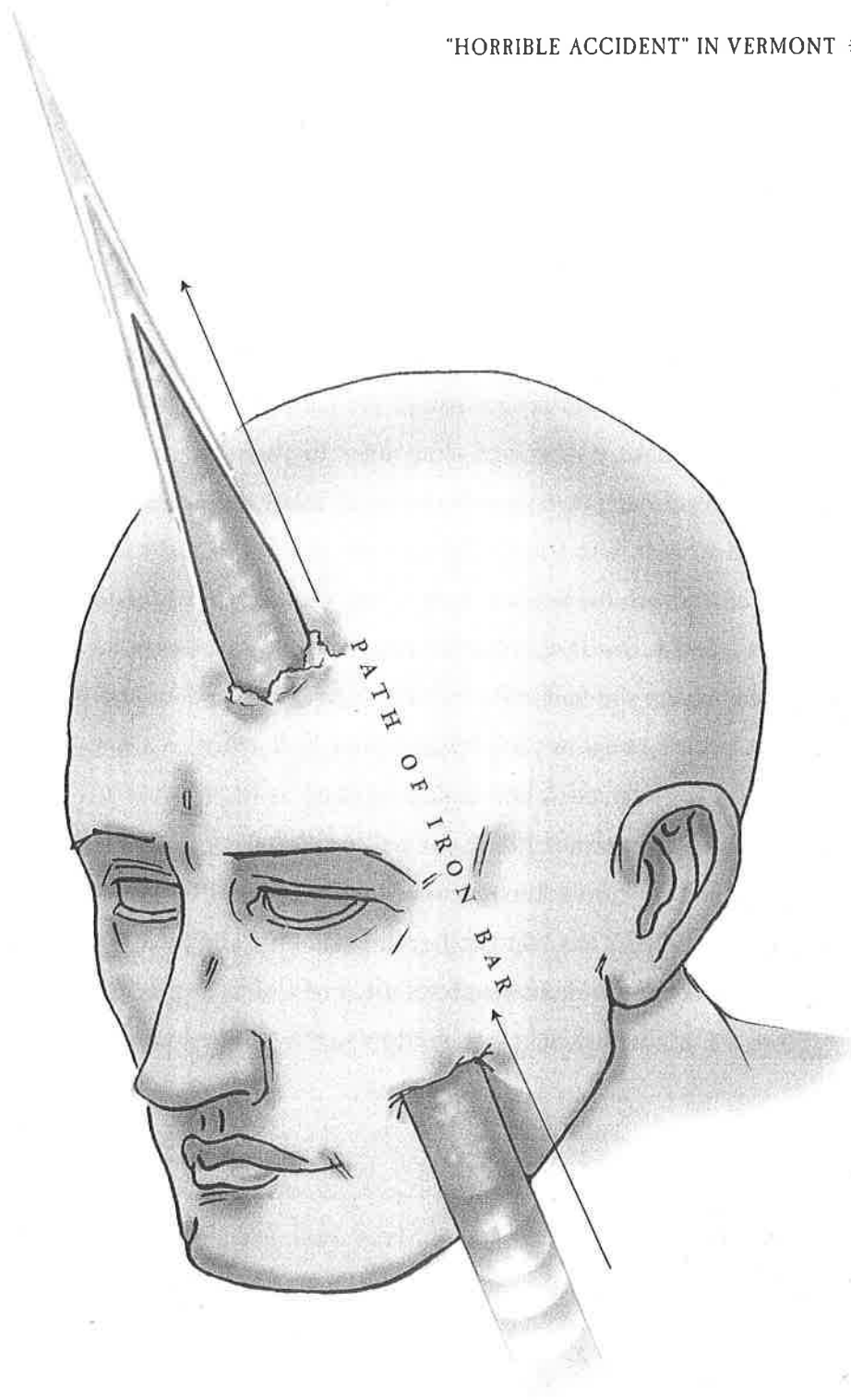
This is the face of the man with a hole in his head. It's a plaster life mask of Phineas Gage made in Boston after his accident, and it shows exactly what the "recovered" Phineas looked like a year after his accident. He was twenty-seven. Notice the big scar on his forehead. To see what lies beneath the scar, compare this to the picture of his skull on page 62. *Photograph by Doug Mindell; life mask courtesy of the Warren Anatomical Museum, Countway Library of Medicine, Harvard Medical School*

extreme slow motion: See the pointy end of the rod enter under his left cheekbone, pass behind his left eye, through the front of his brain, and out the middle of his forehead just above the hairline. It takes a fraction of a fraction of a second for the iron rod to pass from cheekbone to forehead, through and through.

Amazingly, Phineas is still alive. The iron throws him flat on his back, but as his men come running through the gunpowder smoke, he sits up. A minute later, he speaks. Blood is pouring down his face from his forehead, but Phineas is talking about the explosion. His men insist on carrying him to an ox cart for the short ride into town. They gently lift him into the back of the cart so he can sit up with his legs out before him on the floor. An Irish workman grabs a horse and races ahead for the doctor while the ox cart ambulance rumbles slowly down the half-mile to Cavendish. Phineas's excited men crowd alongside, walking next to their injured boss. Still acting as a foreman, Phineas calls out for his time book and makes an entry as he rolls toward town.

Something terrible has happened, yet Phineas gets down from the cart without help. He climbs the steps of the Cavendish hotel, where he has been living, and takes a seat on the porch beside his landlord, Joseph Adams. A few minutes earlier, Adams had seen the Irishman ride past shouting for Dr. Harlow, the town physician. Dr. Harlow was not to be found, so the rider was sent

Lucky or unlucky, the sharp angle of the tamping iron made all the difference to Phineas. It entered just under his left cheekbone, passed behind his left eyeball, and continued on upward through his frontal lobes. It exited his forehead between the two hemispheres of the cortex. The iron's passage left him alive and conscious but forever changed. *Illustration by Jerry Malone*



on to the next village to fetch Dr. Williams. Now Phineas takes a neighborly seat on the porch and tells his landlord what happened to him.

That's how Dr. Edward Williams finds Phineas nearly thirty minutes after the accident. Dr. Williams pulls up in his buggy at the hotel porch, and there is Phineas, talking away. Friends, workmates, and the curious crowd around as Dr. Williams climbs down from his carriage. "Well, here's work enough for you, Doctor," Phineas says to him quite cheerfully.

Dr. Williams examines Phineas's head. He can't believe that this man is still alive. His skull is cracked open, as if something has popped out from the inside. Accident victims are often too shaken to know what happened, so Dr. Williams turns to Phineas's workmen for the story, but Phineas insists on speaking for himself. He tells Dr. Williams that the iron went right through his head.

Dr. Williams does not believe him. "I thought he was deceived," Dr. Williams writes in his notes. "I asked him where the bar entered, and he pointed to the wound on his cheek, which I had not before discovered. This was a slit running from the angle of the jaw forward about one and a half inch. It was very much stretched laterally, and was discolored by powder and iron rust, at least appeared so. Mr. Gage persisted in saying that the bar went through his head. An Irishman standing by said, 'Sure it was so, sir, for the bar is lying in the road below, all blood and brains.'"

It's now an hour after the accident. The town's regular physician, Dr. John Martyn Harlow, finally arrives at the hotel. The two doctors confer, but Dr. Harlow takes over the case. Phineas is a gruesome sight. Bleeding freely from his forehead and inside his mouth, Phineas looks to Dr. Harlow like a wounded man just carried in from a battlefield. Yet Phineas is alert, uncomplaining, and

still telling anyone who'll listen about the accident. Dr. Harlow wants Phineas to come in off the porch so he can treat his wound. Phineas gets up and, leaning only lightly on Dr. Harlow's arm, climbs up a long flight of stairs to his room. He lies down on his own bed so Dr. Harlow can shave his head and examine the wound more closely. What the doctor sees is terrible. Something has erupted through the top of Phineas's head, shattering the skull in its path and opening the brain to plain sight.

Dr. Harlow does what he can. He cleans the skin around the hole, extracts the small fragments of bone, and gently presses the larger pieces of skull back in place. He looks inside Phineas's mouth. He can see the hole where the iron passed upward through the roof of his mouth. Dr. Harlow decides to leave the hole open so the wound can drain. Then Dr. Harlow "dresses" the wound, pulling the loose skin back into position and taping it in place with adhesive strips. He puts a compress bandage directly over the wound and pulls Phineas's nightcap down tightly over it. Finally he winds a roller bandage around his forehead to hold all the bandages securely. Only then does he notice Phineas's hands and forearms, which are black with powder burns. Dr. Harlow dresses the burnt skin and has Phineas put to bed with his head elevated. He gives strict orders that his patient is to remain in that position.

Phineas should have been dead long before this. A thirteen-pound iron rod through the head should kill a person instantly. Surviving that, he should have died of shock soon after reaching Cavendish. He's lost a lot of blood, yet he remains awake and talkative. Even surviving the loss of blood, Phineas should have died of brain swelling. Any hard blow to the body causes injured tissue to swell. The brain is soft, and the skull is hard. A hard blow to the head can rat-

tle the brain around inside like a BB in a tin can. The rattling bruises the brain, and bruised tissue swells. The brain swells, but the skull stays the same size; a swollen brain can jam itself so tightly it will cut off its own blood supply. This swelling can choke off oxygen to parts of the brain long enough to cause permanent damage. It can also cause death.

That's a "closed brain" injury (sometimes called a concussion). The possibility of a closed brain injury is why doctors fuss if you bang your head falling off a bicycle or crashing a car or getting hit hard in the head with anything. (To prevent closed brain injuries, you should wear a helmet when bicycling, driving a race car, fighting in the infantry, playing tackle football, parachuting, exploring a cave, working on a construction site, or doing just about anything where you could strike your head hard. In Phineas's case, however, a helmet would not have helped.)

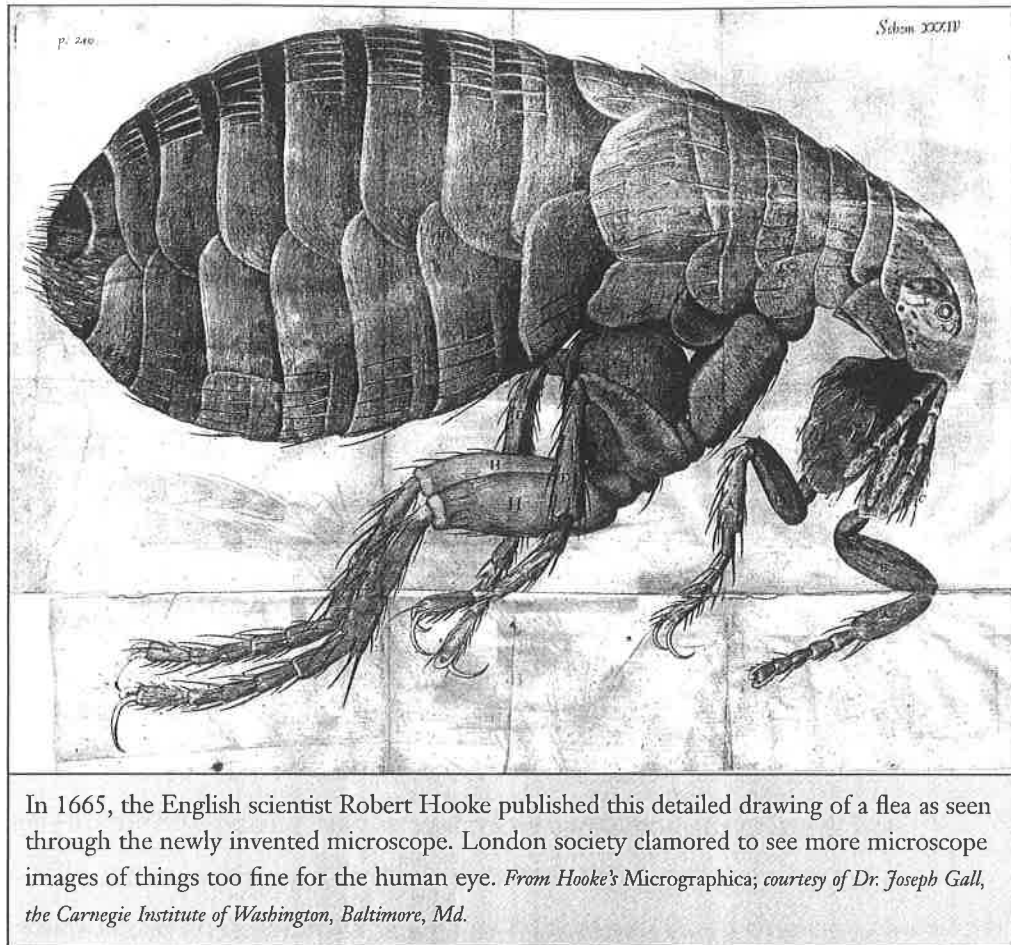
Here Phineas has a stroke of luck. His is an "open brain" injury. The hole on top of his head gives his battered brain swelling room. The bad news is that his brain is open to infection. At first, though, he does remarkably well. The bleeding from his forehead slows and then stops within twenty-four hours. He remains cheerful and tells Dr. Harlow that he "does not care to see his friends, as he shall be at work in a few days." The morning after the accident, however, he is glad to see his mother and uncle when they arrive from New Hampshire. Two days after the accident, he takes a turn for the worse. He develops a fever and begins to have delirious spells. His wound is leaking a foul-smelling liquid, a sure sign of infection. His death seems just a matter of time now.

More than any other organ, the brain is sealed off from the outside world and from the rest of the body. There are many layers of tissue, bone, and skin to

keep it protected from the outside, but there's also a "blood-brain barrier" that keeps out many substances circulating in the blood. Oxygen and nutrients can cross the blood-brain barrier, but many dangerous substances like bacteria cannot. With his skull fractured, Phineas's exposed brain is wide open, making him an ideal candidate for a fatal infection. No one in Cavendish in 1848, no scientist in America or Europe, has the slightest notion that bacteria cause infection.

Medical science in 1848 knows very little about bacteria, even though they were first seen through microscopes nearly two hundred years before. Today we are used to seeing the microscopic world, but when the microscope was invented in the middle of the seventeenth century, it caused a sensation. The microscope became a new kind of "high-tech" entertainment for cultured gentlemen, and in 1665 an Englishman named Robert Hooke came up with a microscopic "hit." He showed off a slide he'd made of an extremely thin slice of cork. Under the microscope lens, Hooke saw that the tissue inside a cork tree was made up of rows of tiny, boxlike structures. They reminded him of the bare rooms used by monks in a monastery. Hooke called them "cells." His cork cells, though, were empty because they were dead and dried out. It would take two centuries to figure out that it's the living stuff inside cells that makes them the fundamental unit of life.

While Hooke was showing off his "cells," a sharp-eyed Dutch merchant named Anton van Leeuwenhoek was making more powerful microscopes. Leeuwenhoek took a single drop of water from a rain barrel and turned his microscope on it. In that drop of water, Leeuwenhoek found a whole new planet of very, very small life forms. "Animalcules," he called them. Leeuwenhoek was the first to see single-celled microorganisms, tiny plants and tiny ani-



mals, including bacteria. Yet Leeuwenhoek never had the faintest suspicion that some of his “animalcules” caused humans to sicken and to die.

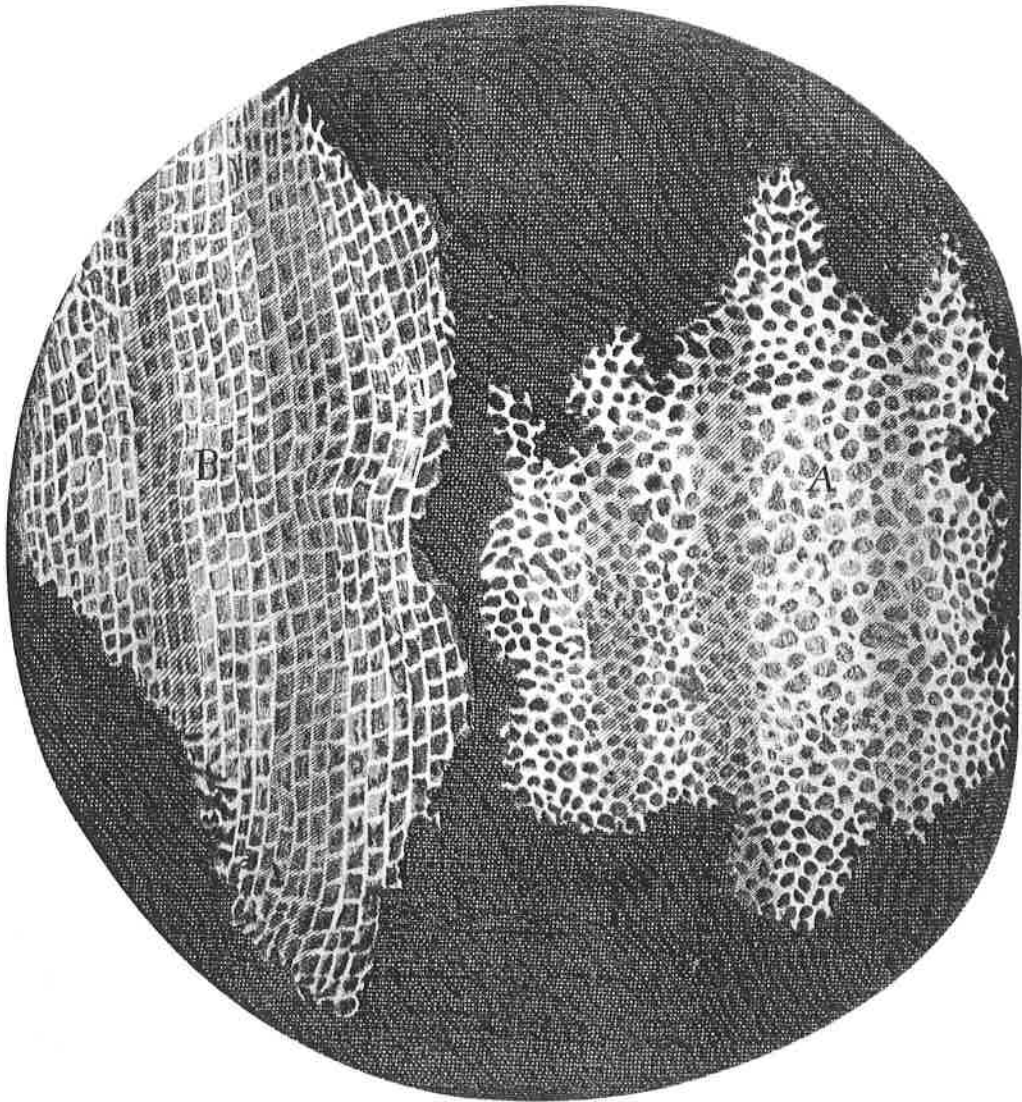
That’s more or less the state of knowledge in 1848. Few doctors have ever used a microscope, because it is not considered a medical instrument. These microscopic animals might be marvels of nature, but no doctor suspects that they have anything to do with disease, let alone infections. Doctors in 1848

don't use the word *infection*, but they know its symptoms well. They call it "sepsis," and they know from bitter experience how quickly a "septic" wound can go from slight redness to gross swelling to a fatal condition called gangrene.

The doctors of 1848 don't realize that gangrene is the end result of bacterial infection. They don't realize that floating in the air on dust particles, lurking on fingertips, or growing on the shiny steel blades of their unwashed surgical scalpels are single-celled bacteria and other microscopic life forms. On the smallest surface, there are hundreds of millions of them. They represent thousands of different species; there are tiny plants, tiny fungi, tiny viruses, and tiny animals. Among the microanimals are two particularly dangerous families of bacteria—streptococci and staphylococci ("strep" and "staph," for short). What doctors don't know in 1848, strep and staph do: that the broken head of Phineas is an ideal location to land.

A wound is an open door. A cut or break in the skin lets staph and strep bacteria colonize the warm, wet, nutrient-rich cells inside. Once these bacteria get established in the body, they reproduce wildly. The body's immune system tries to kill the invading bacteria with an array of special immune cells, while the bacteria try to protect themselves against immune cells by cranking out toxic chemicals. That's an infection. The site of this biological battle between the immune system and bacteria swells up and turns red.

In 1848, science is still twenty years away from figuring out that infections are the work of living—that is, "biotic"—things. It will take nearly a century for science to develop the first "antibiotic," penicillin, to counter infections. In 1848, a young Frenchman named Louis Pasteur is still studying chemistry in Paris. Eventually, Pasteur will unravel the three great biological mysteries of

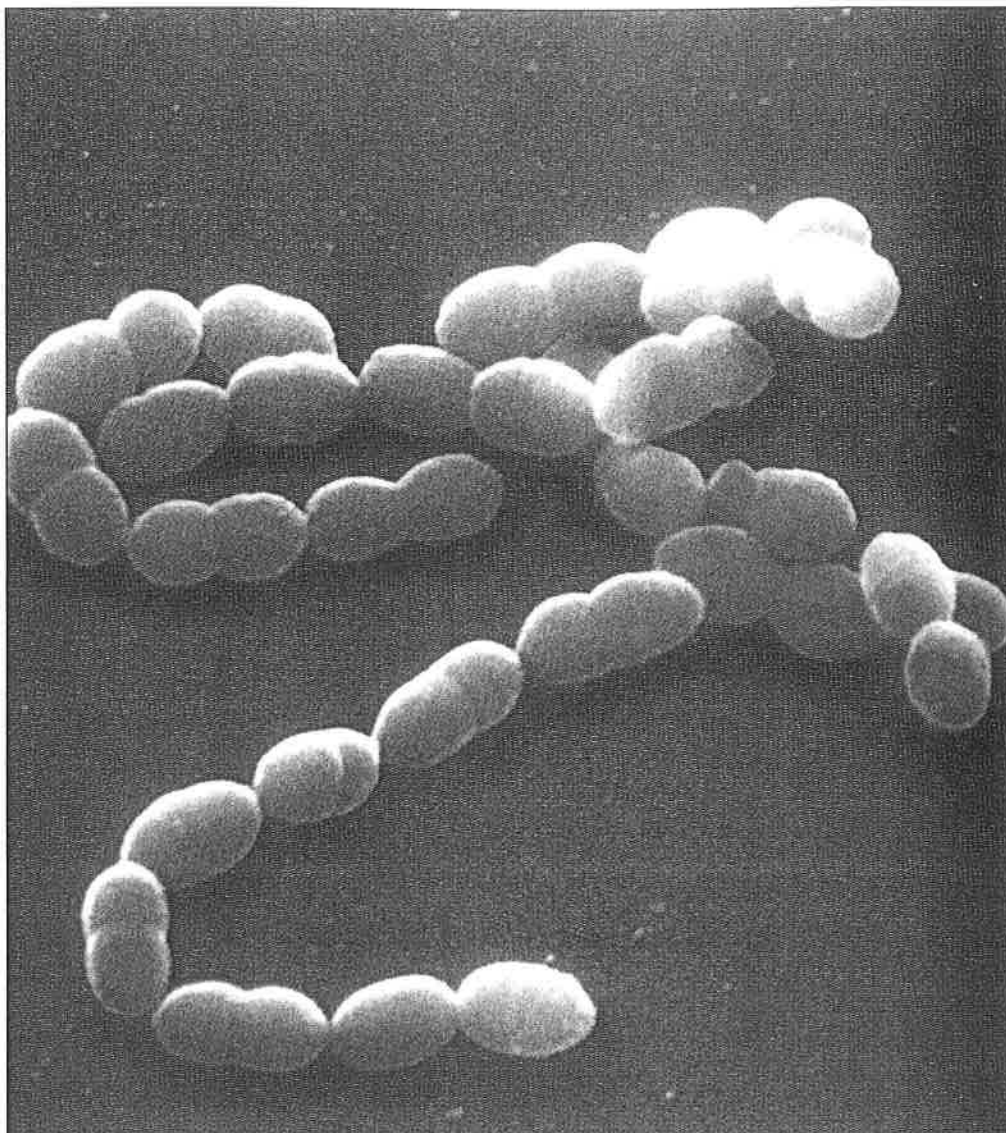


Hooke called the microscopic boxes that he saw in the bark of a cork tree "cells." Compared to his flea pictures, Hooke's cells attracted little notice in 1665. Two centuries later, his "cells" turned out to be the fundamental unit of all life. *From Hooke's Micrographica; courtesy of Dr. Joseph Gall, the Carnegie Institute of Washington, Baltimore, Md.*

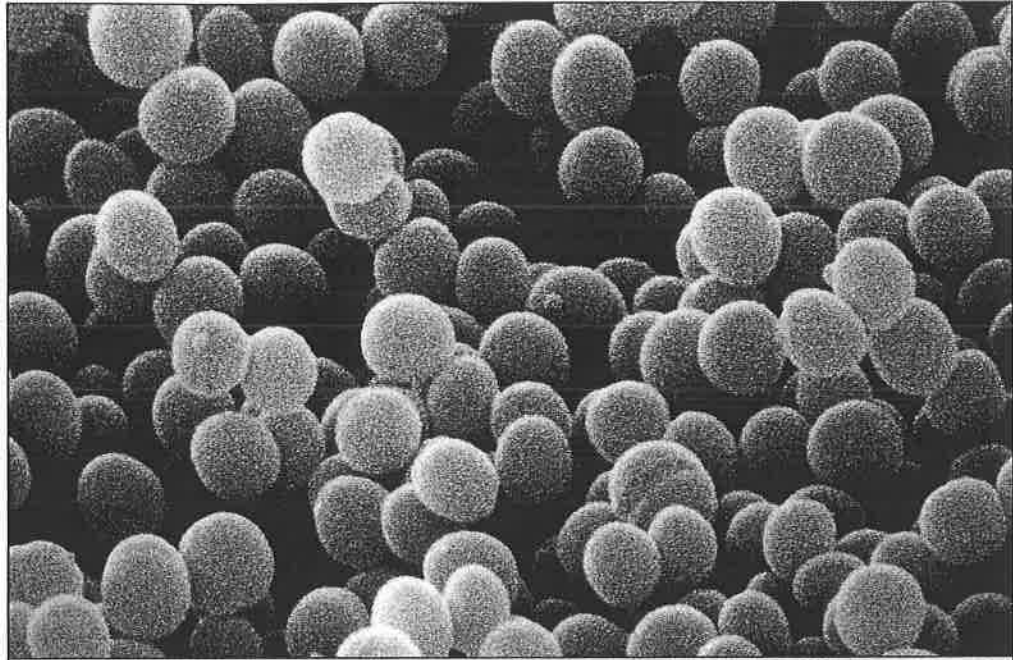
his time—fermentation, decay, and infection. All three processes are the work of living microorganisms; Pasteur will call them "germs." Pasteur's "germ theory" will lead to a revolution in medicine. It will inspire an English surgeon named Joseph Lister to try performing surgery in sterile conditions that exclude or kill all microorganisms. Lister will scrub his hands almost raw before operating, he will boil surgical clothing and instruments, and he will set up a machine to spray carbolic acid in the operating room to kill germs in mid-air. Lister's first sterile operations in 1868 will cut the number of deaths from infection after surgery by 90 percent. For the first time in history, doctors will help more patients with surgery than they harm with postsurgical infections.

None of this progress to come will do Phineas a bit of good back in 1848. Instead, Phineas is saved by good luck and good care. Dr. Harlow follows the best medical advice of his time—keep the wound clean but covered and watch for inflammation. A sign of infection is a fluid called "pus" (it's actually dead white blood cells, a sign that the body's immune system is attacking bacterial invaders) that collects in pockets to form abscesses. Fourteen days after the accident, Phineas develops a huge abscess under the skin just above his eyes. Phineas is feverish, losing his appetite, and sinking fast. Dr. Harlow lances (punctures) the abscess. He drains the pus and dresses Phineas's forehead again. The fever abates. His scalp begins to heal. Phineas is saved by his youth, his iron constitution, and Dr. Harlow's good nursing. Dr. Harlow will always be modest about his role in saving Phineas. "I dressed him," Dr. Harlow will say. "God healed him."

The patient gains strength. Too much strength, in his doctor's opinion. Dr. Harlow is called out of town for a few days, and when he comes back he finds



Under the microscope, streptococci bacteria have a distinctive beads-on-a-string appearance. "Strep" bacteria live on nearly everything people touch but are only dangerous if they can penetrate the body's defenses and overpower the immune system. *Microphotograph by H. Morgan, Photo Researchers Inc.*



Staphylococci bacteria are the other half of the deadly duo of opportunistic bacteria. Infections by "staph" and "strep" were a leading cause of death before the discovery of antibiotic medicines. Somehow, Phineas's immune system beat off their attack. *Microphotograph by Dr. Tony Brain, Photo Researchers Inc.*

Phineas out of his sickbed. His head still heavily bandaged, Phineas is roaming about Cavendish in the rain with no coat and thin shoes. He is eating unwisely, refusing nursing advice, and ignoring doctor's orders. Phineas says he wants to go home to his mother's house in Lebanon, New Hampshire, twenty miles away. He intends to walk. According to the best medical theories of his day, Dr. Harlow diagnoses an imbalance of bodily "humors." This theory, which goes back to the ancient Greeks, declares that health is maintained by a balance of four liquids, or humors, in the body—blood, phlegm, yellow



bile, and black bile. To bring them into balance, Dr. Harlow prescribes two powerful drugs—an "emetic" to make Phineas throw up and a "purgative," a powerful laxative, to evacuate his bowels. Phineas is knocked flat by the medicines and spends the next two weeks in bed, where Dr. Harlow keeps him on a "low," or bland, diet. His humors may or may not be in balance, but Phineas is resting quietly at last.

Ten weeks after the accident, Dr. Harlow declares Phineas fully recovered from his wounds. He puts Phineas in a closed carriage and sends him home to his mother in New Hampshire. Phineas is very weak, but he can walk short distances. He can count, feed and dress himself, and sing. He can speak clearly and make sense of what he hears. Yet there is something odd about the "recovered" Phineas. Just before he leaves Cavendish, Dr. Harlow gives Phineas a little test. The doctor offers Phineas \$1,000 for the pocketful of pebbles that Phineas has collected walking along the Black River near town. Dr. Harlow knows that Phineas can add and subtract, yet Phineas angrily refuses the deal. Dr. Harlow tells himself that a man who was so badly hurt is going to need time to regain his full powers.

As soon as Phineas leaves for home, Dr. Harlow writes a short report for the *Boston Medical & Surgical Journal*. Most doctors ignore Dr. Harlow's article. The few who read it don't believe it. How could a man survive such an

Four hundred years ago, this was an up-to-date medical book illustration. It shows a half-man, half-woman surrounded by the signs of the zodiac and the four "humors" that for centuries doctors believed controlled health—blood, phlegm, black bile, and yellow bile. Balancing the sanguine, or blood, humor was the "reason" for bleeding the sick. *Photo Researchers Inc.*

injury, let alone make a “complete recovery”? But one Boston doctor is intrigued. He writes to Harlow for information and urges the Vermont doctor to back up his case by collecting formal statements from eyewitnesses in Cavendish. The letter is from Henry J. Bigelow, professor of surgery at the Harvard Medical College.

In the spring, Phineas is back in Cavendish, carrying his tamping iron. He never goes anywhere without it these days. Phineas has come for a final examination by Dr. Harlow and to reclaim his old job on the railroad. His left eye looks intact, but the vision has gradually faded away. Phineas has a huge scar on his forehead and a small scar under his cheekbone, but otherwise he is physically healed. Yet Dr. Harlow has private doubts about Phineas’s mental state. Phineas is just not his old self.

His old employers on the railroad quickly come to the same conclusion. The new Phineas is unreliable and, at times, downright nasty. He insults old workmates and friends. He spouts vulgar language in the presence of women. He changes his mind and his orders from minute to minute. The railroad contractors let him go. Dr. Harlow, who is keeping confidential notes on Phineas, sadly writes, “His contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again.”

When he was an old man, Dr. Henry J. Bigelow wore a long beard and sober clothes, befitting one of Boston’s senior surgeons. But when he was a young man studying medicine in Paris, Bigelow was a snappy dresser. *From a daguerreotype by Leon Foucault, Paris, 1841; courtesy of Countway Library of Medicine, Harvard Medical School*



Phineas's old friends also wash their hands of him. Dr. Harlow writes: "He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires." Phineas comes up with all sorts of new plans, the doctor writes, but they are no sooner announced than he drops them. Phineas is like a small child who says he is running away from home after lunch and then comes up with a new idea over his sandwich. Dr. Harlow writes, "A child in his intellectual capacities and manifestations, he has the animal passions of a strong man." A doctor is bound by his oath not to reveal the details of a patient's condition without permission, so Dr. Harlow will keep his observations to himself for twenty years.

Meantime, Dr. Harlow has another letter from Dr. Bigelow at Harvard, who thanks him for collecting the eyewitness statements about the accident. Would Mr. Gage consider coming to Boston at Dr. Bigelow's expense so his case could be presented at the medical school and before the Boston Society of Medical Improvement? Dr. Harlow and Dr. Bigelow make arrangements.



What We Thought About How We Thought

I

n the winter of 1850, Phineas goes to Boston so the doctors there can see for themselves. What are doctors like in 1850? They look like gentlemen, or at least they do in the oil portraits that they have painted of themselves to boost their social status. If you lined up a gallery of these doctors' portraits, you'd see a long row of wise faces, satin waistcoats, gold watch chains, and side-whiskers. By 1850, there are photographs of doctors, showing wise faces, satin waistcoats, and whiskers. Photographs of doctors at work,