

## Historical Vignette

## Phineas among the phrenologists: the American crowbar case and nineteenth-century theories of cerebral localization

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✓ In 1848, Mr. Phineas Gage suffered destruction of his left frontal lobe in a unique fashion: passage of a metal rod through his head after a freak explosion. His change in character after the accident is the index case for personality change due to frontal lobe damage. Yet, from 1848 to 1868, it was widely believed among American physicians that he was mentally intact. The case was used as evidence against phrenology, a crude precursor of modern cerebral localization theories.

The two original reports of the case by Drs. John Harlow (Gage's physician) and Henry J. Bigelow show subtle differences in attitude toward Gage's posttraumatic character change. In his 1848 report, Harlow promised a further communication that would address Gage's "mental manifestations." Bigelow's article portrayed Gage as fully recovered. Although delayed by 20 years, Harlow's second report rapidly changed the perception of the case in the medical community, as reflected by contemporary citations.

The educational backgrounds of Harlow and Bigelow are examined to explain their differing attitudes toward the case. Harlow's interest in phrenology prepared him to accept the change in character as a significant clue to cerebral function which merited publication. Bigelow had learned that damage to the cerebral hemispheres had no intellectual effect, and he was unwilling to consider Gage's deficit significant. Although Bigelow's paradigm was initially more influential, Harlow's more closely matched emerging theories of cerebral localization. His version of the case was used by David Ferrier as the keystone in the first modern theory of frontal lobe function, and this is how the case is remembered today.

**KEY WORDS** • Phineas Gage • Henry J. Bigelow • John M. Harlow • history of neurosurgery • frontal lobe • phrenology • historical vignette

**T**HE injury suffered by Phineas Gage in 1848 ranks as one of the most famous nonfatal brain wounds on record. While at work on the Rutland & Burlington Railroad, near Cavendish, Vermont, Gage was struck in the left cheek by a tamping iron propelled by an accidental gunpowder detonation. The rod, approximately 3 cm in diameter and over 1 m long, passed entirely through his head, entering under the left zygomatic arch and exiting in the midline just anterior to the bregma (Fig. 1). Gage was transported by wagon to Cavendish, where a young local physician, John M. Harlow, undertook his treatment (Fig. 2). Against expectation, Gage recovered fully, or nearly so. Harlow<sup>63</sup> reported the case briefly in 1848. The ensuing blast of skepticism from the medical profession prompted Henry J. Bigelow, a prominent Boston surgeon (Fig. 3), to examine Gage personally. Bigelow<sup>15</sup> reported his conclusions in 1850. There the case rested for two decades. Gage left New England and then the country; he resurfaced in San Francisco, where he died of an apparent seizure approximately 12 years after his injury. Harlow procured his exhumed skull in 1868 and

republished the case with extended follow up. He now first disclosed Gage's remarkable personality change, in short, that he was "no longer Gage."<sup>65</sup> Although the case was notorious for decades as an example of intact mental function despite a desperately severe cerebral injury, Gage is remembered today for the subtle change in personality that Harlow waited 20 years to report.<sup>36,52,76,100</sup>

Some aspects of this famous case have remained largely uninvestigated to date. Why, for instance, did Drs. Harlow and Bigelow find the case so important that they chased it across two continents for 20 years? Why did Harlow wait so long to report Gage's change in personality? And how did he explain it in an age when cerebral localization was essentially unknown?

**Dr. John M. Harlow**

When Phineas Gage arrived at the tavern where he was to remain for the weeks of his convalescence, Dr. John M. Harlow was a relative newcomer to the Vermont medical scene. He was 29 years old, just 4 years after his gradua-



FIG. 1. Woodcut depicting Phineas Gage's skull, with tamping iron shown in mid-flight. From Harlow.<sup>65</sup> The blocks from this illustration were sent by Harvard physiologist H. P. Bowditch to David Ferrier for use in his Goulstonian Lectures on cerebral localization.<sup>49</sup>

tion from Jefferson Medical College (JMC) in Philadelphia. Gage's open brain wound was almost certainly the first that had come his way. Harlow's treatment plan would be expected to rest entirely on his medical school training.

"No medical institution has a better reputation than the Jefferson," said the *Boston Medical & Surgical Journal* in 1844,<sup>7</sup> as it listed the names of the graduating class. Harlow was one of just three Massachusetts men out of the 114 graduates. His reasons for choosing JMC over the closer schools in Boston are unknown, but perhaps he was swayed by the reputation of the new JMC faculty; the famous "Faculty of '41." These seven worthies included J. K. Mitchell (S. Weir Mitchell's father), and Franklin Bache, the future coauthor of the first *United States Dispensatory*.<sup>112</sup> Most relevant to Gage's case, however, would be Harlow's recollections from classes in physiology (Prof. Robley Dunglison), anatomy (Prof. Joseph Pancoast), and surgery (Prof. Thomas D. Mütter).<sup>102</sup>

Robley Dunglison was the brightest star in Jefferson's firmament. Thomas Jefferson himself had personally recruited this staggeringly prolific physiologist from his native England in 1825 to be the sole professor in the new Medical School at the University of Virginia. After serving as Jefferson's personal physician and attending at his deathbed, Dunglison moved north in stages seeking a more kindly climate, coming to rest at Philadelphia's JMC in 1836. Here he taught physiology for over 30 years. His textbook, *Human Physiology*, passed through eight editions between 1832 and 1856. This was just one of 11

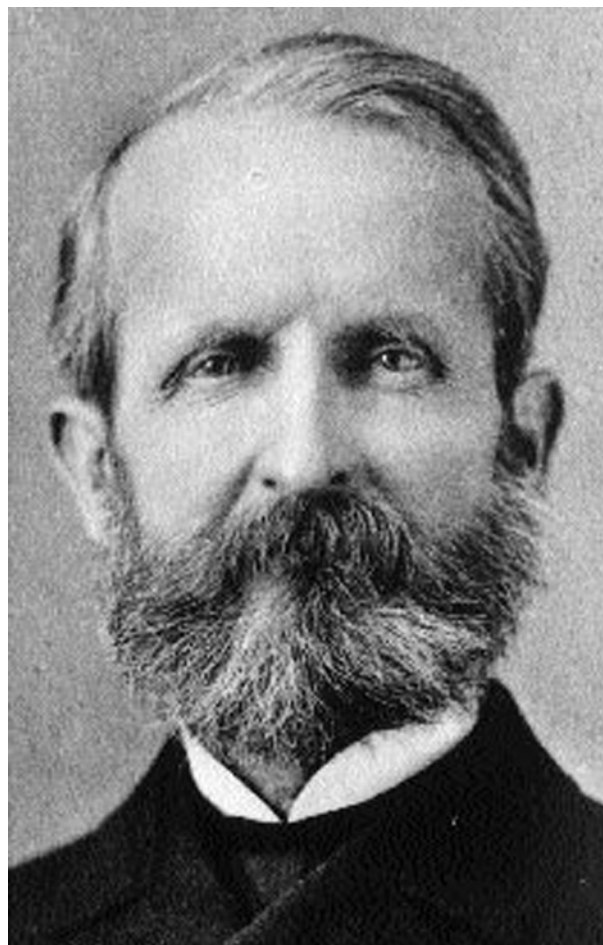


FIG. 2. Photograph of John M. Harlow, Gage's personal physician. Courtesy of Francis A. Countway Library of Medicine, Boston, Massachusetts.

books written by Dunglison, who also edited four journals.<sup>92</sup> Dunglison's physiology lectures at JMC, which would have formed Harlow's main knowledge base on the functions of the brain, have vanished without trace. His physiology textbook, letters, and unsigned editorial notices in his journals provide the only evidence of his lectures' probable content. Dunglison was educated in Edinburgh during the years 1815 to 1816, when the town was a hotbed of phrenological controversy. Phrenology, founded by Dr. Franz Joseph Gall in Vienna in the late 1790s, was the first theory of brain function that assigned a cognitive function to the cerebral cortex. Gall parceled the cerebral and cerebellar cortex into 27 "organs." Each was thought to control one aspect of character, such as courage, religious veneration, or love of children. The degree to which an individual expressed each trait was thought to reflect the size of the corresponding "organ," which would in turn cause a prominence, or "bump," in the overlying skull. A skilled "manipulator" could thus interpret a subject's character from his or her cranial contour.

The attention of English readers was first drawn to this "new science of the brain" by the *Edinburgh Review* in



FIG. 3. Photograph of Henry J. Bigelow, Professor of Surgery (Harvard Medical School), as a young man. The embroidered waistcoat is typical of Bigelow's flamboyant style of dress after his return from Paris.

1803.<sup>25</sup> In 1816 Dr. J. G. Spurzheim, phrenology's co-founder and future apostle to the New World, arrived in Edinburgh to promote his new doctrine in person. His advent triggered a cataclysm of debate that spread from medical circles into the town's quietest intellectual backwaters,<sup>95</sup> but physicians remained the strongest advocates of phrenology during Dunglison's years in Edinburgh. In age, social and academic standing, and in his liberal political leanings,<sup>92</sup> Dunglison closely resembled the typical early 19th-century Edinburgh phrenological convert.<sup>32</sup>

Having completed his medical education, Dunglison moved to London. During his years there, articles promoting phrenology appeared in many prominent medical journals, including the *Lancet*, the *Weekly Medico-Chirurgical and Philosophical Magazine*, and the *Medico-Chirurgical Review*.<sup>33</sup> It is thus unsurprising that Dunglison included a "head laid out according to Gall and Spurzheim's system" in a list of necessary anatomical preparations for the University of Virginia that he sent to Thomas Jefferson in 1825. A year later he requested that the University subscribe to the *Phrenological Journal*, which embodied the transactions of the Edinburgh Phrenological Society.<sup>40</sup> Indeed, had he neglected phrenology, a physiology professor between 1820 and 1844 would have had little to say about the higher functions of the human brain.

During the early 1830s, phrenology set fire to the highest intellectual circles of America,<sup>103-106</sup> particularly in Philadelphia and Boston. Although all varieties of American intelligentsia were intrigued, it was the physicians who were hardest bit by the phrenology bug, and they constituted a large fraction of the officers and membership



FIG. 4. Illustration of Gall's phrenological system, from Robley Dunglison's textbook *Human Physiology*.<sup>46</sup> Spurzheim's revised phrenological map was also included in the textbook.

of the phrenological societies which soon began to dot the landscape.<sup>56,105</sup>

Dunglison and his colleagues on the JMC faculty kept well abreast of the controversial new theory. Of the other six faculty members, two are known to have joined Philadelphia's Central Phrenological Society (the first phrenological society in the United States), and a third translated Pierre Flourens' classic antiphrenological work, *Phrenology Examined*.<sup>54,77,105</sup> Any discussion of the brain and its functions at JMC during this era would likely have reflected the controversy over phrenology's validity, and a JMC student seeking to read about the brain in Philadelphia's largest medical library would have had over 50 works on phrenology to choose from. These volumes comprised more than half of the library's holdings on the functions of the nervous system.<sup>53</sup>

Fully 60% of the 34 pages on "Physiology of the intellectual and moral faculties" in Dunglison's *Human Physiology* (1832 edition) were devoted to a discussion of phrenological theory. These pages remained substantially unaltered through the book's many revisions, and at the date when Harlow attended JMC, phrenology was still given a respectable hearing in his professor's textbook (Fig. 4).<sup>46</sup> Regarding the phrenological explanation of the effects of cerebral injury on higher cerebral function, Dunglison wrote,

... in many of the cases of severe injury to the brain, which are on record, but one hemisphere was implicated; and accordingly, the impunity of the intellectual and moral manifestations has been ascribed to the cerebrum being a double organ; so that, although one hemisphere may have been injured; the other, containing similar organs, may have been capable of carrying on the function. . . . [A case of injury to the left frontal lobe, in the area Gall thought responsible for language, is described, which was accompanied by aphasia.] . . . We cannot understand why, in particular cases, such serious effects should result from severe injury done to the brain; and, in others, the comparative immunity attendant upon injury to all appearances equally grave. . . . The views of Gall are by no means established. They require numerous and careful experiments, which it is not easy for every one to institute. . . .<sup>46</sup>

Editorial notices and reviews in the *American Medical Intelligencer*, of which Dunglison was sole editor, reflect further light on his feelings toward phrenology. In his editorial comment on the first article in the first issue of his new journal, he states, "It is well known, that, according to many eminent physiologists, the seat of the organs concerned in the intellectual and moral manifestations is the periphery of the brain . . ."45 In an 1839 review of an antiphrenological work, he wrote, "We strongly recommend its perusal to the phrenologist, as we do the standard phrenological works to those who are unbelievers. The truth or falsehood of phrenology is not to be established by angry declamation; but by calm and unprejudiced observation."43 In 1841, Dunglison professed to be surprised by an antiphrenologist's accusation that he was a supporter of phrenology, and again he stated his neutral position.<sup>42</sup> The 1844 edition of his *A Dictionary of Medical Science* explained Gall's system in detail, but expressed the opinion that the assignment of specific locations to the individual cerebral organs might be premature.<sup>44</sup> As late as 1850, Dunglison's early publications were still cited as support for Gall's tenets.<sup>92</sup> Overall, his attitude seems to have been one of cautious interest, rather than of partisanship either for or against phrenology's doctrines.

Of more practical import when Gage arrived on his doorstep would have been Harlow's recollection of the proper treatment of a brain wound. Such injuries, resulting from falls, horse kicks, and gunfire, were well known in pre-Civil War America.<sup>12</sup> Every contemporary course of lectures on surgery described the diagnosis and treatment of head injuries, and Professor Thomas Mütter's lectures were no exception. Mütter<sup>82</sup> published outlines of his lectures for his students' use, and manuscript sets of student notes from the lectures have also been preserved.<sup>80,81</sup> For penetrating wounds of the brain, Mütter recommended replacing any sizable fragments of displaced skull, allowing dependent drainage of the wound, and not exploring the brain for retained foreign bodies. He pointed out that consciousness was frequently preserved. When the patient was initially lucid, he stated, and then developed signs of compression ("aberration of mind . . . pulse slow and laboring . . . can't rouse the patient"), then pus was present and must be drained. The cornerstones of his treatment plan were bleeding and vigorous antiphlogistic measures (purging and cathartics).<sup>80,81</sup> Indeed, in 1846, Mütter<sup>74</sup> recommended nonoperative treatment with bleeding and antiphlogistics for the "vast majority" of cases in which the clinical diagnosis was epidural hemorrhage.

Less evidence exists for Professor Joseph Pancoast's lectures on anatomy, but through a happy coincidence, he performed his most celebrated operation for head injury before Harlow's medical school class during the winter between 1843 and 1844. He described the case in his *Treatise on Operative Surgery*.<sup>88</sup> The patient presented with delayed cerebral symptoms from the accumulation of intracerebral pus after a head injury; Pancoast trephined to drain the pus, resulting in temporary recovery. Unfortunately, symptoms recurred and the patient died. At autopsy, reaccumulated pus was found: granulation tissue had blocked the opening in the dura. Pancoast believed that this had caused the patient's death.<sup>88</sup> This operation

brought Pancoast a high reputation as a cerebral surgeon.<sup>89</sup> It may also have prompted him 6 years later to keep the wound open and draining for a month after an elective epilepsy trephination, lest the patient's seizures recur.<sup>86</sup> His nonoperative treatment of head injury, like Mütter's, was designed to combat brain inflammation: purging, moderate bleeding, "but a few ounces of blood," and opiates to calm the mind. Blisters applied to the back of the neck and the extremities were also recommended, to draw off excess cerebral blood.<sup>87</sup>

Harlow was well prepared, then, to grapple with Gage's staggeringly severe brain injury. In addition, he must have seen the case as a rare opportunity for physiological "experiment," as Dunglison had described, perhaps even as the cerebral equivalent of Beaumont's<sup>13</sup> famous observations of digestion on Alexis St. Martin's gastric fistula.

### Gage's Treatment and Harlow's First Report

Harlow first reported Gage's case in December 1848 as a letter to the *Boston Medical & Surgical Journal*,<sup>62,63</sup> although newspaper accounts of the injury had already appeared.<sup>77</sup> His initial treatment consisted of shaving the scalp, removing small bone spicules and replacing larger pieces, and approximating the wound edges with strips of tape, leaving an opening for drainage. Over the next 2 weeks, he ordered vinum colchicum (a sedative for brain and nerves which also purged the bowels<sup>112</sup>) and three other purgatives: magnesium sulphate, calomel, and rhubarb. When a hernia cerebri developed, Harlow responded by applying silver nitrate crystals to the protruding brain and ice water to the rest of the head. Gage initially improved, only to lapse again into coma. His family prepared his coffin and begged Harlow to let him die, but instead he boldly amputated the protruding brain fungus and laid open the skin from the exit wound to the root of the nose with scissors, draining "eight ounces of ill-conditioned pus," or approximately 250 ml.<sup>65</sup> Harlow considered that it was "due in great measure to the free outlets through the skull below and above that the man Gage owed his life."<sup>84</sup> He had not repeated Professor Pancoast's mistake.

Two weeks later Gage was convalescent. Harlow left town for a week, but found on his return that Gage had been "in the street every day except Sunday, during my absence." The result was a chill, rigors, a pulse of 120, and lancinating pain in the left face and head. Treatment was venesection (approximately 500 ml) and another deluge of purgatives and cathartics. After 2 hectic days Gage returned to health.

Harlow took obvious interest in studying Gage's exposed brain. He noted its pulsations and confirmed the lack of pain when its depths were probed.<sup>63,65</sup> Aside from the cryptic promise of a "future communication" on the "mental manifestations of the patient," Harlow mentions only one observation on Gage's cognitive function. Although memory was "as perfect as ever," he "does not estimate size or money accurately . . . would not take \$1000 for a few pebbles which he took from an ancient river bed where he was at work." Why did Harlow mention this idiosyncrasy in his brief initial communication?

The answer may lie in a desire to interpret Gage's case

as useful data on phrenology. Harlow thought the case “exceedingly interesting to the enlightened physiologist and intellectual philosopher.”<sup>63</sup> In addition, he appears to have been on a local committee to organize a course of phrenological lectures in the early 1840s.<sup>96</sup> (Such phrenological activities, as a means of bolstering income, are known for at least one other rural physician who was a JMC graduate.<sup>111</sup>) Had Harlow consulted the diagram of Gall’s phrenological system in Dunglison’s physiology textbook, he would have found several mental functions in the path of Gage’s tamping iron: poetical and musical talent, language, color discrimination, acquisitiveness, “comparative sagacity,” and the sense of relations of numbers.<sup>46</sup> At a loss to demonstrate any musical, poetical, or language deficiency in this patient, Harlow interpreted Gage’s mental imbalance as a disorder of “comparison and number,” that is, an inability to estimate monetary worth or size.

### Henry J. Bigelow and the Revision of Phineas Gage

Harlow’s letter was widely disbelieved, for obvious reasons. After all, it was a considerably more severe brain injury than any American had ever survived.

Henry J. Bigelow, the new Professor of Surgery at the Harvard Medical School, was “at first wholly skeptical.” He noted that the accident was the “sort . . . that happens in the pantomime at the theatre, but not elsewhere . . . A physician who holds in his hand a crowbar . . . will not readily believe that it has been driven with a crash through the brain of a man who is still able to walk off, talking with composure and equanimity of the hole in his head.”<sup>75</sup> Yet Bigelow presented the case to the Boston Society of Medical Improvement on December 11, 1848, before its actual publication. He stated that he had “had some details of the case . . . from the consulting physician,” and that “the patient is now well.”<sup>22</sup> He then contacted Gage and paid him to come to Boston for confirmation of the report. Bigelow presented him to the Society for Medical Improvement<sup>23</sup> and to the class of the Harvard Medical School. He also sought testimonials to the details of the accident from the clergyman and the Justice of the Peace at Cavendish, as well as from approximately a dozen other prominent local figures.

Unlike Harlow’s report of the case, Bigelow’s presentation consistently underlined Gage’s intact mental condition: “now well,”<sup>22</sup> “inconsiderable disturbance of function.”<sup>15</sup> Most telling is this paragraph:

Little need be said of the physiological possibility of this history. It is well known that a considerable portion of the brain has been in some cases abstracted without impairing its functions. Atrophy of an entire cerebral hemisphere has also been recorded.<sup>15</sup>

Although extensive portions of Harlow’s article were quoted verbatim by Bigelow, the promise of a future report on the “mental manifestations” was not.

Who was Bigelow, and where did he get these notions? Today he is remembered as a heavily bewhiskered surgical giant, who first reported the use of ether in 1846,<sup>17</sup> then revolutionized the reduction of hip dislocations<sup>19</sup> and became Professor of Surgery in Harvard Medical School,

a post he held for 33 years.<sup>21</sup> In 1849, however, nearly all of this still lay in the future.

As the only son of Jacob Bigelow, Boston’s most famous physician, young Henry was slated for medical prominence from the start. Medicine ran in families in Boston in those days: Jacksons, Warrens, and Bigelows dominated every aspect of the medical scene.<sup>99</sup> Henry entered Harvard College at age 15 as a matter of course. He specialized in making loud noises, joining drinking clubs, playing the French horn, and manufacturing nitrous oxide for the customary annual binges of the chemistry class.<sup>21</sup> Halfway through Bigelow’s senior year, Harvard’s president, a personal friend of Jacob Bigelow, had the painful duty of ejecting young Henry from college. Pistol practice in his dormitory room had been too much for the trustees, who considered the offense “as unprecedented as it was criminal.”<sup>91</sup> Bigelow was banned from the town of Cambridge for the remainder of the year, but despite his rustication he managed to graduate on schedule.

Bigelow’s father found it expedient to send him to Dartmouth Medical School in New Hampshire. There he continued his experiments with nitrous oxide to the point of endangering his health. Having gained his M.D., he spent a year as House Pupil in Medicine at the Massachusetts General Hospital (MGH), directly under his father. He then traveled to Paris for postgraduate work, an increasingly popular step for young physicians interested in an academic career.<sup>70,71</sup> Unlike most of his American contemporaries in Paris, who viewed the emerging statistical studies of Pierre Louis with little less than awe,<sup>29</sup> Bigelow scorned this tedious collection of facts because of its “failure to make any special demand upon the reasoning powers.”<sup>21</sup> On his return to Harvard he delivered an address criticizing the method.<sup>16</sup>

Little else is known of Bigelow’s stay in Paris, except that he attended the lectures of Professor F. A. Longet, the famous neurophysiologist. Although Bigelow’s lecture notes reflect mainly neuroanatomy,<sup>18</sup> Longet’s views on cerebral physiology are more interesting today. Longet was perhaps the most influential antilocalizationist of his time.<sup>30</sup> Having conducted exhaustive experiments on the cortex in dogs, he had concluded that “the cerebral hemispheres can be irritated mechanically, chemically, galvanically . . . without giving rise to convulsive tremors.”<sup>75</sup> Drawing on post mortem evidence of pathological lesions in man, he also concluded that there was no special cerebral locale for speech.<sup>30,75</sup>

With Harlow’s manuscript before him, Bigelow might well have turned to Longet’s 1842 neurophysiology textbook for parallel cases. Consulting the chapter on the cerebral hemispheres, he would have found from the headings of the chapter sections that Gage’s case was not unique: “One healthy cerebral hemisphere may suffice for the exercise of intelligence . . . observations of severe wounds of the brain: loss of cerebral substance affecting various regions of the cerebrum, with intact intelligence.”<sup>75</sup> Longet adduced reports of 16 severe brain wounds to prove that intellectual function was unaffected by injury to the cerebral hemispheres.

But Paris was not Bigelow’s first introduction to the localization debate. In Boston, as in Philadelphia, the 1930’s saw a rage for phrenology—if anything, an even

## Phineas Gage and cerebral localization

more severe one.<sup>103,104</sup> The Boston Phrenological Society, composed to a large degree of physicians, was founded in 1832 and remained active for a decade. No list of members of the society has survived. But one piece of evidence confirms Bigelow's early exposure to phrenology: he owned the complete works of F. J. Gall, the founder of the science. The six volumes, almost unmarked except for Bigelow's signature, are now housed in the Harvard College Library, to which he donated them during his junior year.\*<sup>57</sup>

In the forefront of the Boston phrenological movement was John Collins Warren, surgeon to the MGH and a family friend of the Bigelows. In 1848, Bigelow was 30 years old and had been Professor of Surgery for just 1 year. Warren had resigned the professorship in 1847, having held the post for 40 years. Friction between the grave and cautious Warren and the flamboyant Bigelow, who drove about town in a flashy cabriolet, with monogrammed harness for his horses, was almost inevitable. Soon Bigelow was caricatured in local broadsides as "Festinans Bigblow, equal to two surgeons," who "after about only one year's arduous practice, is already made one of the Surgeons of the principal Hospital in New England, having a father, two or three uncles, and several influential friends connected with that institution . . . and through whose interest [he] hopes to fill [and did] the Professorship . . . in the Medical School."<sup>21</sup> Clearly a man in such a position would gain from pointing out the latest advances in medical science at every turn, thereby capitalizing on his recent first-hand experience in Paris. Gage's case was a perfect opportunity to flaunt the latest antilocalizationist theories of cerebral function, tacitly condemning phrenology as fit only for those with more antiquated ideas, such as John Collins Warren. This is just what Bigelow did. When added to his rapid publication of an article about the first public use of ether, beating both the inventor of the method (Morton) and the surgeon who allowed him to use it (Warren), a picture of a man very anxious to make his mark emerges. Bigelow's own role in the ether demonstration seems to have been strictly that of a spectator.<sup>72</sup> Certainly Dr. Warren might be forgiven for viewing such a man with "distaste," or even something stronger.<sup>14</sup>

A second potential ideological difference between Bigelow and Harlow (again paralleled by a difference between Bigelow and Warren) was in therapeutic practice. Harlow's training in the vigorous Philadelphia school has already been mentioned. Henry Bigelow had been exposed to a diametrically opposite therapeutic style during his early years. His father was America's leading therapeutic conservative: in his celebrated 1835 presidential address to the Massachusetts Medical Society, he had argued that most diseases would heal themselves if the physician could refrain from vigorous bleeding and purging.<sup>20</sup> Oliver Wendell Holmes<sup>66</sup> later referred to this address as a stronger influence on medical practice than any other publication of the century: it had "given the keynote to the prevailing medical tendency of this neighborhood [Boston], at least, for the quarter-century since it

\* Widener Library, Harvard University, Cambridge, Massachusetts; Shelfmark Phil 5926.1.6. with signature in vol 1, "H Bigelow / Class 1836" and donation bookplate, "The gift of Mr. Henry J. Bigelow, of Boston." (H.U. 1836) 10 Sept., 1836.

was delivered." (Philadelphians, in turn, thought Holmes a rather "nampy pampy" sort of physician.<sup>107</sup>) Henry Bigelow must have absorbed some of this conservative Bostonian philosophy during his year as Medical House Pupil under his father at the MGH. This would only have been reinforced during his year in Paris, where a radically skeptical attitude toward therapeutics, bordering on nihilism, held sway.<sup>107</sup>

As Bigelow perused Harlow's litany of cathartics, he might well have considered his treatment outdated, despite its success. Bigelow's own choice of regimen in a patient trephined for epilepsy at MGH in 1851 (one dose of opiate, no venesection, no cathartics)<sup>24,78</sup> forms a sharp contrast both with Harlow's treatment of Gage in 1848 (venesection and multiple cathartics) and with Warren's regimen for a trephined epileptic in 1831 (500 ml venesection twice, enemas, five different cathartic prescriptions, and an epigastric blister).<sup>108</sup> A logistic regression analysis of 170 published cases of open brain wounds treated in America between 1810 and 1880 shows that physicians were rapidly discarding venesection as a therapy for brain injury at the time of Gage's accident; in 1848, only 30% of physicians would have used venesection in the treatment of an open brain wound.<sup>12</sup> From Bigelow's newfangled, Parisian point of view, Harlow would have appeared closer to Warren's outdated style of medicine than to his own.

### Orthodox Medical Versions: 1848 to 1868

Twenty years passed, and Harlow's promised communication on Gage's "mental manifestations" did not appear. The startling nature of the case guaranteed immediate notoriety, and citations by other authors soon began to appear. Almost all early references to the case, however, were to Bigelow's version, not to Harlow's. Not surprisingly, given Bigelow's care to present Gage as mentally intact, citations of the case during these 20 years laid emphasis on the "perfect" recovery of Harlow's patient. Of 14 comments on Gage's case located in American medical journals before 1868, 11 refer explicitly to, or quote directly from, Bigelow's version; none of the 11 mentions any mental deficit.<sup>4,11,27,28,41,69,85,90,94,97,101</sup> One report described Gage as well but was too sketchy to determine which version of the case was being quoted.<sup>93</sup> One editorial comment implied that Harlow had been deceived and that the rod had not passed through Gage's brain.<sup>5</sup> Only one report of the case, probably written before the publication of Bigelow's article, explicitly quoted Harlow and an unnamed "friend."<sup>98</sup> This is the only report of the 14 to mention Gage's "deficiency of mental powers."

In Bigelow's version, the case offered the antiphrenologist an unusually conclusive triumph. One journal commented,

. . . as portions of the brain to which are allotted different functions, passions, &c., were entirely destroyed, phrenology would teach that these functions would be entirely annihilated. This, however, was not the case, for 'the man was still able to walk off, and talked with composure and equanimity of the hole in his head,' and has never been . . . other than a rational man.<sup>11</sup>

(The quote is from Bigelow.) One 1856 author<sup>41</sup> quoted

Bigelow's case as an "exemplification" of injury which would "demolish, at once, as with a 'knock-down argument,' the scull-bump psychology." All agreed that Gage was "quite"<sup>74,85</sup> or "perfectly"<sup>78</sup> "recovered," retaining "in a perfect degree his mental powers."<sup>27</sup>

The case undoubtedly gained its widest publicity through its appearance in some of the most popular textbooks of the day: as late as 1890, a physician discussing a case of thoracic impalement cited the "celebrated 'crowbar' case of Maine [sic], which was formerly classical in all the standard works on surgery."<sup>31</sup> Many of the nation's medical students encountered the case in J. C. Dalton's physiology textbook. In the context of an attack on phrenology, the first five editions of this work (1859–1871) described Gage as "in perfect health . . . with the mental and bodily functions entirely unimpaired."<sup>35</sup> Dr. S. D. Gross's influential 1859 surgical text commented, "Notwithstanding this horrible mutilation, enough, one might imagine, to kill a dozen ordinary men, the patient made an excellent recovery, completely regaining his mental and physical faculties. . . ."<sup>58</sup> (This assertion, based on Bigelow's article, was not revised until the textbook's 5th edition in 1872). Still more young physicians would have met with Gage's story in F. H. Hamilton's popular 1861 handbook for Union Army surgeons.<sup>60</sup> Here Gage is found "in 1860 . . . still living, and in the enjoyment of good health, with no impairment whatever of his mental faculties." Complete recovery was also cited in Hamilton's larger postwar textbook, through editions as late as 1886.<sup>61</sup> Dr. P. F. Eve's *A Collection of Remarkable Cases in Surgery*, a Ripley's believe-it-or-not compendium of interesting surgical cases which also recorded an amputation of the head with survival for 36 hours, quoted from Bigelow's version that Gage was "quite recovered in his faculties of body and mind."<sup>47</sup> The common denominator in these accounts is the use of Bigelow's article as source, and not Harlow's. The pervasiveness of Bigelow's influence over the public image of the case is reflected in its universal citation as the "crowbar case": Harlow always refers to the bar by its proper title, as a tamping iron. Bigelow's reference to a crowbar, quoted above, gave the case its nickname, which is still encountered today.

In addition to acting as a counterargument to phrenology, the case served a second function for contemporaries, as a *ne plus ultra* for the survivability of cerebral injury. As such it was widely quoted.<sup>55,67,69,90,101</sup> As years passed, the case took on a life of its own, accruing novel additions to Gage's story without any factual basis. One doctor pictured Gage as being under "surveillance" until he died.<sup>59</sup> Another remembered Gage returning home with the bar still lodged in his head: "some force was required to extract the bar."<sup>79</sup> Still another reported in 1869, when Gage had been 9 years dead, that he had had "no aphonia or dysphagia [sic], no loss of memory, reasons correctly, judgment unimpaired, and at the present time is a prosperous farmer in the state of Virginia."<sup>67</sup> (This report is the more remarkable for containing, on the next page, an account of Gage's intellectual decline and death.)

### Phrenological Views

Although the medical community did not hear of

Gage's mental change until 1868, America's many amateur phrenologists could have read about it as early as 1851. In that year, the eccentric Joseph Buchanan reprinted Bigelow's article in his *Journal of Man* with editorial comment. Noting that the phrenological organs affected by Gage's injury included number, form, and size (according to Buchanan's idiosyncratic maps of the skull), he drew attention to Gage's "inaccurate ideas of quantity and number, of which his physician speaks."<sup>26</sup> But Buchanan had no independent information about the case.

Much more in the mainstream of popular phrenological thought was the *American Phrenological Journal (APJ)*, which had one of the largest circulations of any American magazine in 1851, 35,000 avid readers.<sup>37</sup> This lively journal was always on the lookout for interesting material of any type, and spectacular brain injuries were attention grabbers, then as now. The *APJ* quoted Gage's case from a newspaper account based in turn on Bigelow's article; the newspaper claimed that "though he lost a considerable portion of his brains he exhibited no difference in mental perceptions and power."<sup>10</sup> The *APJ* editors, however, had different information:

We have been informed by the best authority that after the man recovered, and while recovering, he was gross, profane, coarse, and vulgar, to such a degree that his society was intolerable to decent people. Before the injury he was quiet and respectful. If we remember correctly, the iron passed through the regions of the organs of BENEVOLENCE and VENERATION, which left these organs without influence in his character, hence his profanity, and want of respect and kindness; giving the animal propensities absolute control in the character.<sup>10</sup>

This is the first published account of Gage's frontal lobe syndrome, preceding Harlow's own by 17 years. An 1882 memoir<sup>96</sup> indicates that Nelson Sizer, an itinerant phrenological lecturer, probably obtained the information on Gage's mental state directly from Dr. Harlow, supplied the phrenological interpretation himself, and composed the article for the *APJ*.<sup>77</sup> Sizer even claimed to have lodged while giving his phrenological lectures in the same Cavendish hotel room that Gage later occupied during his convalescence.<sup>77,96</sup>

This version of Gage's story remained part of the stock-in-trade of phrenologists for decades. In 1879 we find Gage cited (in a distorted fashion) by an antiphrenologist: "At one fell swoop there must have been a considerable destruction of the phrenological organs. Yet he suffered from no deprivation of intelligence; and few would dream of associating the drinking habits which finally beset him with his accident and the loss of his brains, or otherwise maintain that he was less rational before than after the accident [sic]."<sup>110</sup> But phrenologist W. M. Williams replied that Gage's profanity resulted from the destruction of the organ of veneration, which was in the midline at the coronal suture.<sup>109</sup> The use of a single case to prove opposing views on phrenology was not uncommon: in 1857 Dr. L. N. Dimmick, of Freedom, Illinois, was surprised to find that his patient's loss of both frontal lobes after a horse kick had been reported in the *APJ*. He supplied a prompt and spirited reply in a standard medical journal.<sup>6,39</sup>

### Personality Change and the Orthodox Medical World

From Harlow's 1868 article, it is clear that he recognized Gage's mental change as early as 1849. During that year, Gage applied to regain his former job as foreman, but "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 . . . his friends and acquaintances said that he was 'no longer Gage.'"<sup>65</sup> Gage soon left New England for New York City, where he joined P. T. Barnum's freak show, and then traveled to Chile, where he drove a stage coach. Harlow maintained some form of contact with Gage until he left Chile for San Francisco in 1860.<sup>65</sup>

This tenuous follow-up information somehow leaked into general circulation in 1860 or 1861. In the latter year (as noted above) F. H. Hamilton described Gage as alive and mentally unimpaired in 1860.<sup>60</sup> Between the first edition of his textbook in 1859 and the second in 1862, S. D. Gross added, "When last heard from, twelve years after the receipt of the injury, he was perfectly well" to his description of the case.<sup>58</sup> This assertion was repeated in an 1866 article, probably derived from either Hamilton or Gross.<sup>93</sup> The ultimate source of the information must have been Harlow, who by 1861 was residing just outside of Boston.<sup>9,83</sup> The emphasis on Gage as "perfectly well," however, suggests that it had been filtered through Bigelow, who would certainly have been better known to Hamilton and Gross than Harlow would have been.

Gage died in 1860, but Harlow did not acquire his skull and tamping iron until after 1866. He presented the entire history of the case to the Massachusetts Medical Society in 1868. This was the first formal report of Gage's mental aberration to an orthodox medical audience. But Bigelow now reappeared on the scene in an unexpected manner. Immediately following Harlow's presentation, which concluded with the demonstration of the tamping iron and the exhumed skull, Bigelow made an unannounced addition to the program: the actual victim of a brain transfixion even more colossal than Gage's.<sup>21,69</sup> Bigelow had imported the patient and his physician from Ohio for the purpose.<sup>68</sup> The patient, with the gas pipe which had pierced his head from right forehead to left occiput, and the hat he had been wearing (with entrance and exit holes), made the expected impression on the audience.<sup>2</sup> This *coup de théâtre* must have been a painful coda for Harlow, eclipsing the pinnacle of his medical career.

Harlow's address was published in a journal of limited circulation.<sup>65</sup> Abstracts of the address appeared in several other journals,<sup>2,8,77</sup> but these failed to carry Harlow's description of Gage's mental state. Only one abstract that mentioned the personality changes was found.<sup>3</sup> The full address was reprinted in pamphlet form in 1869.<sup>64</sup>

Despite this obscure method of publication, the case itself was so well known that knowledge of the sequel spread quickly among American surgeons. Horner,<sup>67</sup> in 1869, knew that Gage's "intellectual faculties" had been "impaired but not totally lost, nothing like dementia, but they were enfeebled in their manifestations." The 1870 descriptive catalogue<sup>68</sup> of the Warren Museum, where Gage's skull was deposited by Dr. Harlow, noted that

Gage was "very fitful and vacillating . . . and . . . very profane, though never so before the accident." A Buffalo physician<sup>34</sup> wrote in 1871 that "in all severe injuries of the brain the mind is more or less impaired . . . contrary to all the reports which have circulated, [Gage's] mind was much impaired." Dr. Gross revised his textbook<sup>58</sup> for its fifth edition in 1872, describing Gage as "ever after fitful, irreverent, vacillating [sic], and impatient of restraint," clearly an account based on the Warren Museum catalog. Agnew's<sup>1</sup> 1878 textbook stated that Gage "suffered from mental peculiarities which rendered him unlike his former self." Despite some exceptions,<sup>38,79,89</sup> American physicians had finally been adequately informed of the true result of Gage's injury.

The rapid acceptance on the part of the medical profession in 1868 of personality change as a result of cerebral injury reflects a change in attitude toward the entire question of cerebral localization. Although Broca's speech center had not yet gained complete acceptance, physicians were again ready to consider localization of cerebral functions to a single portion of the brain. Phrenology was no longer a powerful juggernaut, demanding staunch medical opposition, but was clearly on the wane among educated circles. In 1868 the climate was right for Harlow's presentation of ideas which, in 1848, would have savored too much of phrenology to have compelled widespread belief.

Abroad, however, the image of Gage's recovery still remained that promulgated by Bigelow. David Ferrier, the English pioneer in cerebral localization, stated in 1874<sup>51</sup> and again in 1876<sup>48</sup> that Gage had suffered "no very obvious symptoms of loss of intellectual power." When the case was used by a French antilocalizationist to prove the absence of aphasia after left frontal lobe damage, however, Ferrier fought back.<sup>77</sup> In a letter to H. P. Bowditch, Harvard's Professor of Physiology, Ferrier<sup>50</sup> requested further details: "Is there any further account of this case, with post mortem & beyond that given by Bigelow? I have an idea there is, but I cannot find any reference to it." Bowditch sent an offprint of Harlow's 1868 paper. Ferrier, thrilled, wired for copies of Harlow's woodcuts to illustrate his upcoming Goulstonian Lectures on cerebral localization:<sup>49</sup> "I did not know of their existence till you sent me Harlow's paper which has been of the greatest value to me . . . I think your proposal to imitate the lesion with the brain in situ would be a most desirable experiment."<sup>50</sup> In an 1879 letter that accompanied the return of the woodcuts, he wrote: "I hope—Bigelow notwithstanding—that Putnam & you will really carry out your proposed investigation. I can do no experimental work now. . . . All that is done away with as I cannot work under the accursed antivivisection laws. . . ." <sup>50</sup> Bigelow was a prominent antivivisectionist, which suggests that the hindered "investigation" may have been an "imitation of the lesion" in an experimental animal. This appears to have been Bigelow's last, ineffectual attempt to sabotage the use of the crowbar case by cerebral localizationists.

### Conclusion

Thus ended the first 30 years of Gage's story, with Ferrier's incorporation of his behavior into the first modern theory of frontal lobe function. Gage was lucky to encounter Dr. Harlow when he did. Few doctors in 1848

would have had the experience with cerebral abscess with which Harlow left JMC and which probably saved Gage's life. Even fewer would have persisted in investigating the mental effects of the injury; here, Dunglison's interest in phrenology seems to show through. Perhaps fewer still would have tracked Gage to the grave and brought back the skull to grace the local medical museum. These remarkable occurrences, combined with good luck, resulted in the publication of the two articles which appear to constitute Harlow's entire published output. In 1974, a survey found that the second of these articles was still the most frequently cited 19th-century paper in modern textbooks of abnormal psychology.<sup>73</sup> Gage's case informs neuropsychological debate even today; a recent reconstruction of his brain injury, based on his preserved skull, has allowed investigators to extend their arguments on the function of the ventromedial structures of the frontal lobe.<sup>36</sup>

Certainly Harlow has earned our thanks for his persistence. To Dr. Bigelow, who did not possess our advantage of hindsight, the case appeared in a different light. In the search for the function of the cerebral hemispheres, Harlow saw the case as a positive datum, whereas Bigelow's education under Longet taught him to see it as a negative one. The tension between the two very different physicians was described by Harlow in 1868:

The case . . . was attended and reported by an obscure country physician, and was received by the Metropolitan Doctors with several grains of caution, insomuch that many utterly refused to believe that the man had risen, until they had thrust their fingers into the hole in his head, and even then they required of the Country Doctor attested statements, from clergymen and lawyers [as published in Bigelow's article], before they *could* or *would* believe. . . .<sup>65</sup>

Some of Harlow's paranoia must surely be forgiven, in view of the universal citation of his case for two decades to prove the silence of the cerebral hemispheres, when he knew that the truth was very different. The evidence cited above shows that it was Harlow's own second report, despite its obscure publication and Bigelow's distracting stage maneuvers, which transformed the American public image of the case, even before Ferrier built it into a modern paradigm of frontal lobe function. The checkered history of the case may serve today as a cautionary whisper. As Ferrier wrote to Bowditch in 1877,

In investigating the reports on diseases and injuries of the brain I am constantly being amazed at the inexactitude and distortion to which they are subjected by men who have some pet theory to support. The facts suffer so frightfully that I feel obliged always to go to the fountain-head—dirty and muddy though this frequently turns out.<sup>50</sup>

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