Penfield's ceiling

Seeing brain injury through Galen's eyes

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ABSTRACT

The cathedral ceiling located in the entrance hall of the Montreal Neurological Institute, planned by its founder Wilder Penfield, has intrigued visitors since it was erected in 1934. Central to its charm is a cryptic comment by the ancient physician Galen of Pergamum, which refutes a dire Hippocratic aphorism about prognosis in brain injury. Galen's optimism, shared by Penfield, is curious from a fellow ancient. In this article, we use primary sources in Ancient Greek as well as secondary sources to not only examine the origins of Galen's epistemology but also, using a methodology in classics scholarship known as *reception studies*, illustrate how an awareness of this ancient debate can illuminate contemporary clinical contexts. While Galen based his prognostications on direct clinical observations like the Hippocratics, he also engaged in experimental and anatomic work in both animals and humans, which informed his views on neurologic states and outcomes. Penfield's memorialization of Galen is representative of the evolution of the neurosciences and the ongoing importance of evidence-based prognostication in severe brain injury. ***Neurology*®** **2017;89:854–858**

GLOSSARY

MNI = Montreal Neurological Institute.

When the Montreal Neurological Institute (MNI) opened its doors in 1934, the institute's founder, neurosurgeon and neuroscientist Wilder Penfield (1891–1976), planned a ceiling in the building's entryway that would embody his vision for the institute.[1] Penfield was a pioneering researcher in the surgical treatment of epilepsy, functional cortical mapping, and localization of memory.[2] Influenced by Osler, Cushing, Sherrington, Whipple, and Ramon y Cajal, Penfield was committed to using neuroscience to advance neurosurgery early in the 20th century.[3] The MNI, which sought to "minimize the schisms that impede learning and patient care," was the embodiment of Penfield's aspirations to integrate research and clinical care and served as an inspiration for the National Institute of Neurological Disorders and Stroke in the United States.[3,4]

Designed by architect Barnet Philips, the ceiling features several artistic elements that hearken back to some of the first theorizations on the brain and brain injury (figure). Etched around the hieroglyphics and the head of Aries are the words of Galen (131–200 CE), a Greek physician from Pergamum. As translated by Dr. William Francis, the nephew of Sir William Osler, Galen's sentence reads, "But I have seen a severely wounded brain healed."[5] In this short sentence, Galen contests the widely known Hippocratic aphorism that "a wound involving the brain…is fatal."[6]

Penfield's decorated ceiling taps into a divide in antiquity that has stretched into modernity, one that concerns a particular nihilism towards recovery from brain injury. The 2 physicians involved in this debate are Hippocrates, a Greek physician from the island of Cos, whose school dominated medical thought circa late fifth to early fourth century BCE, and Galen, a trained philosopher and physician who practiced and taught in Rome during the height of the Roman Empire.

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Figure Penfield's 1934 cathedral ceiling located in the entrance hall of the Montreal Neurological Institute

Modeled after drawings by Camillo Golgi, the ceiling's background features 3 patterns of neuroglia cells, which correspond to their appropriate layers within the cerebellum. These different neuroglia cell patterns frame "the head of Aries the Ram, which in astrological terms presides over the brain."[5] Galen's refutation of the Hippocratic aphorism encircles the head of Aries: ἐγκέφαλον δὲ τρωθέντα εἶδομεν ἰαθέντα ("But I have seen a severely wounded brain healed").[5] The ceiling also displays 4 hieroglyphic figures around the head of Aries, which, in the Edwin Smith papyrus from 3000 BCE, are thought to symbolize the brain. The ceiling's border illustrates a repeating "outline of the fluid-filled cavities within the brain," also known as the cerebral ventricles.[5] The cerebral ventricles were at the center of Galen's theories and experiments on brain states. Image courtesy of the Montreal Neurological Institute.

These differing ancient perspectives extend into our contemporary moment, and have affected how the medical community views and treats those with severe brain injury.[7–11] Penfield's decision to showcase Galen's refutation in the MNI entryway is illustrative of Galen and Penfield's shared faith in the brain's resilience to heal itself and in healers to heal the injured brain.

Whatever one's views are about the futility of severe brain injury, how can we explain the source of Galen's optimism? Why did his views so contrast with those of the Hippocratics? To answer these questions, we will use a methodology in classics scholarship known as *reception studies*, which reconsiders ancient texts to inform modern thinking. One of the goals of reception studies is to investigate how "Greek and Roman material has been transmitted, translated, excerpted, interpreted, re-written, re-imaged and represented" over time.[12] We use this methodology to explore ancient views on brain injury and their relevance to contemporary issues in neurology. By examining Hippocratic and Galenic texts in the original Greek, we will illustrate how differing views on recovery from brain injury in antiquity can illuminate issues in modern practice.[7,12]

GALEN AND THE HIPPOCRATICS Galen was a contemporary of the Second Sophistic class, a group of scholars who considered the knowledge of Greek literature, language, and philosophy from the Classical Period to be essential if one wanted to join "the (Roman) empire's urban intellectual and cultural elite."[13] Galen wrote in Attic Greek instead of Latin, and considered Aristotle, Plato, and the Hippocratics to be "the authoritative sources of medical tradition."[13]

In contrast to his Hippocratic predecessors, Galen performed vivisections and anatomical demonstrations in front of public audiences in the form of "competitive displays," a practice never carried out in Classical Greece for religious reasons.[13] Furthermore, there is little evidence of neuroanatomical inquiry in the Hippocratic Corpus; the Hippocratics relied almost exclusively on their understanding of humoral theory and clinical observations.[14] Thus, the Hippocratic school failed to create "an anatomical research methodology of their own."[14]

Despite their differing approaches to biology, the Hippocratics and Galen shared an encephalocentric orientation, viewing the brain—rather than the heart—as the primary modulator of sensation, thought, and emotions.[15,16] In addition, both the Hippocratics and Galen possessed an Aristotelian inductive sensibility; the Hippocratics were among the first to establish the clinical encounter as a primary form of experiential knowledge, thus distinguishing the field of medicine as a novel discipline.[13,16] Galen was a refiner of Hippocratic technique, adding experimental rigor to ancient clinical medicine. Galen studied the Hippocratic Corpus extensively and wrote several commentaries on Hippocratic treatises, including the *Aphorisms*, of which he was antiquity's foremost expert. Mattern[13] comments that Galen "frequently claimed his professional success rested on nothing other than his superior knowledge and

understanding of Hippocratic writings." Throughout his oeuvre, Galen exhibited tremendous respect for his master.

Aphorisms were not only central to Hippocratic medicine, but also functioned as tenets of medical education in the West until the mid-19th century.[17] The Hippocratic aphorisms (422 in total) are distinct in narrative style; they lack an authorial voice and offer neither nuance nor concrete observations, yet their brevity and declarative force make them rhetorically strong. Commenting on the Hippocratic aphorisms, Nuland[18] observed, "An aphorism should stand by itself…and it must express a timeless truth…[it requires] no editorializing, interpretation, or further comment." As assertions of "fact," aphorisms were imbued with "a confident authority that seemed to be the product of long experience."[17] Perhaps due to these characteristics, the Hippocratic aphorisms, or "the physician's bible," left an enduring legacy, playing a crucial role in medical training centuries after publication.[18]

Although Galen was dedicated to upholding aspects of the Hippocratic tradition, he was a harsh critic of the aphorisms, and refuted those with which he disagreed.[17] He was especially critical of the Hippocratic prognostication about the injured brain.

Beyond substance, Galen's writings also differed in their expression of science through prose. While the Hippocratics wrote hundreds of treatises (including one on the surgical management of brain injury titled *On the Injuries of the Head*, c. 400 BCE) and a book of aphorisms, Galen only wrote treatises. Longer-form treatises allowed Galen to document his observations, expound on theories, and make empirical conclusions, all elements of expository writing that would not fit within the rhetorical confines of the pithy aphorism.

GALEN'S REFUTATION Though a scholar of the Hippocratic tradition, Galen staunchly opposed these views on brain injury through a distinct rhetoric that emphasized clinical observation and evidence. His refutation, "But I have seen the wounded brain healed" [ἐγκέφαλον δὲ τρωθέντα εἴδομεν ἰαθέντα], directly opposes the Hippocratic aphorism "A wound involving the brain is fatal." Galen's use of the particle "but" [δὲ] sets up an emphatic refutation, and the verb εἴδομεν ("I have seen") gives the sentence an evidentiary or empirical tone. To the ancient Greeks, the verb "to know" [οἶδα] has an etymologic root that means "to see." Specifically, οἶδα ["I know"] is the perfect tense of εἶδον ["I saw"]. In Greek, the perfect tense is used to express the *present* effects of a *past* action. "To have seen" [εἴδομεν] in the *past* is "to know" (about what was observed) in the *present*. Thus, Galen could only *know* that a brain had recovered if he had previously *seen* healing occur. As we shall see, he had in fact observed this in his experimental work on ungulates. This practical demonstration is representative of a larger Galenic epistemology, which called for conclusions from "empirically testable" observations, not unsubstantiated theory.[14]

While the relationship between seeing and knowing in antiquity could be understood as a larger epistemic question, it is important to note that both the Hippocratics and Galen followed the Aristotelian tradition of inductive reasoning, where there was a relationship between physical forms, perception, and cognition.[19] Thus, the question here is not their mode of reasoning, but rather the *content* of what they perceived and thereby what they *came to know*. Unlike the Hippocratics, who pioneered observational clinical medicine, Galen's work exhibits an experimentalist quality that did not exist in the prior historical and scientific contexts of the Hippocratics. While the physicians' intellectual traditions were similar, the methods and thus the content of their observations varied, thus prompting each to draw different conclusions. Nonetheless, their shared method was observational.

In his refutation, Galen's use of the first person bestows additional credibility. Unlike anonymous Hippocratic aphorisms, Galen puts himself in the center of his statement, declaring, "I have seen [εἴδομεν] the wounded brain healed." While Hippocratic aphorisms only seem to be true due to their brevity and implied experience, Galen's rebuttal is strengthened by his observations. As a physician–author, Galen attests to having evidence—to have *seen* a recovery—and thus, holds himself responsible for his claims. Similarly, when Galen discusses neuroanatomy, he often employed the verbs "to give proof" [ἐνδείκνυσθαι] and "to demonstrate or show" [ἀπόδειξις] in reference to experimentation and dissection.[14]

GALEN'S NEUROLOGY In addition to a new rhetoric of medicine, Galen also brought an emerging science to his views on the brain, most notably that of dissection and experimentation. In both humans and animals, Galen witnessed the brain's capacity to recover, drawing upon his pioneering knowledge of neuroanatomy. This was his "chief weapon against his opponents," and it laid the groundwork for studies on cerebral localization.[14] Galen wrote 5 neurologic treatises, which used anatomical evidence to substantiate his more abstract theories on the brain.

He made major discoveries. Through dissection, he proved the hegemonic theory of the brain, which asserted that nerves originated in the brain, and not in the heart, as Aristotle had proposed.[14,16] More

importantly for our consideration of Penfield's ceiling, Galen asserted his *pneumatic theory of ventricular control*, which postulated that the cerebral ventricles were the primary modulators of conscious awareness and contained psychic pneuma [πνεῦμα ψυχικόν].[14,20] Through a series of complex interactions between the external environment and the body, the psychic pneuma—thought to be "responsible for all nervous activities"—was created and subsequently stored in the ventricles.[14] Movement and sensation could only occur if nerves in the brain "took up" this psychic pneuma.[20] Galen predicted that the cerebral ventricles, and the psychic pneuma stored within them, played a key role in how the brain responded to and recovered from trauma.

While inaccurate by modern standards, Galen's ventricular theory represents a novel theorization in antiquity, requiring "experimental proof" to be rendered conclusive.[14] To test his theory, Galen decided that he would systematically disrupt ventricular function in an animal model: if the ventricles—which contained this psychic pneuma—were injured, would death always result? Or could the brain exist in multiple states with differing degrees of sensation and movement depending on the severity of the perturbation?

Book IX ("On the Brain") of Galen's surgical treatise, *De Anatomicis Administrationibus* (*On Anatomical Procedures*) (129–198 CE), details vivisection and dissection procedures, specifically concerning the third, fourth, and lateral ventricles, optic chiasma, pituitary gland, and cranial nerves.[21] Our consultation of the primary source material, specifically chapter 12 of Book IX, "Experiments in Brain Surgery," reveals Galen's manipulation of the ventricles of living ungulates.

After Galen instructs readers on how to "detach the dura mater" from the skull, he states, "…you can…press down upon the brain on each one of its 4 ventricles and observe what derangements have afflicted the animal."[21] While direct incisions to the ventricles often caused immediate death, pressure to the anterior and posterior ventricles resulted in a "slight" and "pronounced" stupor [κάρος, or "heavy sleep, torpor"], respectively.[14,21,22] Some animals could even recover to a "normal state" after having experienced trauma to their ventricular system.[21]

Galen continues, concluding that "[the] return to the normal condition follows more easily and more quickly, should the incision be made upon the 2 anterior ventricles."[21] In distinguishing this differential effect between the anterior and posterior chambers, Galen made one of the first attempts to localize cerebral function, establishing an early nosology. The degrees of stupor Galen observed not only supported his pneumatic theory of ventricular control, but also illustrated that trauma to the brain did not always result in death. Thus, these experimental observations informed Galen's views and turned the Hippocratic aphorism on its head.

At the end of chapter 12, Galen definitively summarizes his findings, reinforcing the key role that the ventricles play in modulating awareness. He writes:

> Should any person consider that there still remains something for us to say…he should know…when one pierces or incises the thin meninx, [the animal] sustains no derangement as a result, just as none such befalls it if the brain should be incised without the incision reaching as far as to one of its ventricles.[21]

In this passage, Galen emphasizes that trauma to brain regions other than the ventricles does not result in behavioral change. Galen's closing comment illustrates a systematic approach—though he disturbed various brain regions, none elicited changes in the animal's "respiration, voice, movement or sensation…" except for the ventricles.[21]

In addition to experimentation on ungulates, Galen drew conclusions about prognosis and brain injury from his clinical encounters with brain-injured humans who received trepanation. During this surgical procedure, Galen would press on both anterior ventricles and induce "a slight stupor."[21] As in ungulates, he observed a differential effect when he disturbed the posterior ventricles. These patients would lose their ability to sense their surroundings, move, and speak. Rocca[14] writes:

> [Galen's] results showed that definite and repeatable clinical symptoms could be elicited from pressure applied to the anterior part of the brain [in humans via trepanation]…and that this clinical state should be regarded as a close approximation of the experimental result of pressure applied to the anterior ventricles [in animals].

Thus, Galen's theory of ventricular control applied to both animals and patients who sustained neurologic injury.

PAST IN CONTEXT Penfield's invocation of Galen's refutation in the MNI embodied his aspirations for his young institute and continues to speak to neurology today. The schism between the Hippocratics and Galen has its modern parallel in divergent attitudes toward disorders of consciousness and competing views about nihilism, resilience, and neuroscience's potential to heal the severely injured brain.[7,23] Like the evolution of thought from the Hippocratics to Galen, and the latter's understanding of gradations of brain states, our era is marked by an emerging nosology that has further characterized disorders of consciousness[24,25] and nascent efforts to promote recovery from these conditions.[26–28]

Reception studies can help us place our era into a deeper historical context and better understand why Penfield saw Galen's refutation as a statement worthy of the MNI. As importantly, it reflected his own deeply felt ethical obligation to meet the needs of neurologic patients through the advance of translational science.[3] As such, Galen's message, memorialized through Penfield's ceiling, speaks to both antiquity and modernity.

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Zoe M. Adams: conception, writing, editing, interpretation, and translation of Ancient Greek. Joseph J. Fins: conception, writing, editing.

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