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The Brains of Geniuses
On the History of Elite Brain Research

Translated by Philip Schmitz

After Elite Brain Research

The Cybernetic Brain

> Have you ever realized that virtually everything mankind still thinks today, everything called thought, can already be thought by machines, generated through cybernetics, the new science of creation? And these machines actually outperform human beings, their valves are more precise, their fuses are more precise than in our dilapidated wrecks […] Thus, thought processes are transferred to robots that satisfy our needs. What remains are the rudiments of volcanic antecedents, and where they emerge they already seem inhuman and derelict. (1)

Only 17 years after characterizing progressive cerebration as the “fundamental concept for the entire incipient epoch,” Gottfried Benn bid farewell to the brain as the organ which would render mankind capable of dealing with the future. “Races and brains have been totally emptied,” he commented in a footnote to the poem *Quartär* (Quaternary) shortly after the end of the war. Regardless of what one may think about Benn’s defiant adherence to worn-out concepts and the lack of ability to make political differentiation expressed here, his annotation nevertheless marks the departure from a conception of history based on organicism and racial hygiene. If brains have now been emptied, then there is nothing more to be expected from elite brains either. As if all the attempts undertaken since the late 18th century to freight the brain with values and meaning had rendered themselves obsolete; as if all self-attributions of genius or membership in an elite had erased themselves of their own accord, and all that remains is to note the presence of a great void. The promises held out by a new science of creation, which in fact Norbert Wiener intended, were effortlessly assimilated into this vacuum. (2) The brain as control center was replaced by the computer as control center.

Benn’s diagnosis is not the isolated doomsday sentiment of a controversial intellectualist who was engaged in securing his place as a writer in postwar Germany. In a much more comprehensive sense than Benn may have envisioned, a new dispositif in brain research developed during the 1940s. In well-nigh every respect it represented the opposite of the structural-morphological approach pursued by anatomically oriented scientists from Flechsig and Retzius to Vogt and Economo.

This dispositif can be described as a transition from an organicistic to a technicistic view of the brain. It had not set its sights on cerebral structure but rather on function. It was not interested in individual characteristics but in the general principles of cognition, perception and behavior. It did not pin its hopes on questions of proportion or even on topographical constellations, but on dynamic conditions, on wiring and circuitry, whereby it was immaterial whether these were actualized by organic substances such as neurons and nerve tissue or by machines. The size and number of nerve cells were irrelevant. Instead, the focus shifted to their activation status. The brain no longer represented an organ into which intelligence and emotions, thinking and instincts were inscribed at various locations, but rather a functional unit with problem-solving capability. This cognitive turn transformed the brain into a computer. The central questions now became: Which algorithm determines how the brain functions and how can we simulate brain functions electronically? Research to date has not even begun to examine the extent of the ramifications of the post-World War II upswing in cybernetics, computer science and brain research. But there is no question that the brain as a “computational device” was a trend-setting research category that blurred the distinction between brain and machine, at least for some time.

It is equally clear that cybernetics did not completely reinvent the technicistic brain. Even in the 1920s behavioristic machine models of the brain were circulating, primarily in the USA. Granted, they were at a disadvantage because as yet no machine existed with the ability to simulate even the simplest cognitive functions. Nevertheless, the parallels were so strong that Fritz Kahn outfitted his popular illustrations of the brain cavity with technical and electronic equipment to depict the various functional elements of the act of vision (Fig. 66). (3) Paul Valéry noted in his *Cahiers* at the time that “functionally speaking, the nervous system represents a totality of transformations and substitutions” and embarrassed brain anthropologists by claiming that the “schematic of a radio […] [reveals] more about the life and functioning of a sentient being than any histological section.” (4) He could find no better visual representation for this than the work of Kahn, who portrayed radio wiring in modern high-rise architecture as identical with the sensory pathways in the body (cf. Color Plate VIII). In addition, Valéry was at least assured of the agreement of those brain scientists who viewed anatomical localization attempts with great skepticism. For example, in his only publication on the brains of scholars Henry Donaldson, a former member of the *American Anthropological Society*, dismissed the morphological approach by stating that a post mortem brain represented a “crude machine without power or control.” Donaldson was no physicalist, which explains why he attributed the unknown forces regulating the brain less to electrical processes than to the chemistry of nerve tissue, the connections between nerve cells, and to blood supply. (5)

Other anatomists joined the critique of morphology and the exaggerated demands of cytoarchitectonics. Both scientific as well as ideological concerns played contributing roles. Raffael Lorente de Nó, who had actually spent time conducting research with the Vogts in Berlin, was able to point out several inconsistencies: cortical layers which should actually have been similar sometimes differed significantly from each other in origin and structure, and fields which formed a functional unit according to the architectonic method produced entirely different results when Camillo Golgi's silver nitrate staining technique was employed. While Lorente de Nó had no doubt that two morphologically different fields also had different functions, Karl Lashley as well as Gerhardt von Bonin and Percival Bailey generally viewed the architectonic results as artifacts. Lashley viewed the structural differences of individual fields as an expression of varying developmental processes within the cerebral cortex, while Bailey and Bonin saw structural differences as the result of individual variation and insisted that the brain is essentially the same in all people – a decidedly anti-racist interpretation of brain anatomy. This accorded with the1950 and 1951 UNESCO Statements on Race and the assertion that the concept of race was no more than a myth. (6) With that, cytoarchitectonics too had acquired a reputation, at least in the USA, as a science that had been contaminated by Nazi barbarism, and this undoubtedly contributed to the supersession of the organicistic view of the brain by a technicistic perspective.

Frustration with the anatomical approach is also evident in Norbert Wiener's *Cybernetics.* In the chapter entitled "Cybernetics and Psychopathology" he writes that mental illnesses are functional in nature and that it is impossible to identify the brain of a schizophrenic or a depressive. Using more precise terms, he reiterates Donaldson's opinion that a post mortem brain is of no value in determining activity within a living one. In the cadaver "there is no way we can trace out the chain of neurons and synapses communicating with this, and determine the significance of this chain for the ideational contents which it records."[1] Based on this Wiener offers an explanation of psychopathological processes which he characterizes, entirely in keeping with the terminology of communications engineering, as "secondary traffic jams," as an "overload of the remaining part of the nervous system and the rerouting of information." (7) In other words the usual pathways of the information flows circulating through the brain are disrupted, which can happen just as readily in a computing machine.

Wiener suffered several emotional breakdowns which rendered him incapable of work for a period of time, and it would be worth examining in its own right how far his notions of overload and traffic collapse in either cerebral or electronic computing machines reflected a generalizing projection of his own unstable health. (8) The fact remains that the convergence of nervous system and computers occurred from both sides. According to Wiener, the latter could fall ill and even exhibit conditioned reflexes. The brain, by the same token, had properties which in principle rendered it compatible with computers. The nerve cells or neurons, those smallest functional units of the brain, acted like relays in the sense that their physiological functioning was based on two states: active or inactive. (9) The concept of the so-called "on-off" principle was not bestowed upon neurophysiology as the gift of theoretical computer science. Instead, it was a genuinely physiological theory that proceeded from the all-or-nothing principle of nerve activation and had already been formulated at the beginning of the century by E. D. Adrian. The theory became a mathematical and media event in 1937 the moment Alan Turing evolved the thesis that both machines and mental states could be understood in like manner according to logical principles. A few years later Warren McCulloch and Walter Pitts went one step further by attempting to characterize processes in the nervous

[1] Wiener, Norbert. *Cybernetics; or, Control and Communication in the Animal and the Machine*. Cambridge: M.I.T. Press, 1962. p. 147.

system as logical operations during which the activation status of a single neuron corresponded to the simplest mental act. Information theory as applied to the nervous system concerned itself with the smallest units, in order to nail down the common denominator of intelligent operations. (10)

For Wiener, Turing and an entire group of cyberneticists and later AI-researchers it was an established fact that a computer and a brain did not have to involve the same morphological, chemical and physical processes in order to speak of a functional identity of both systems. Turing, for example, saw no problem in the fact that the nervous system is not a machine with discrete states. (11) Rather, the identity was assumed as axiomatic based on problem-solving behavior. The draining of symbols and values from the brain, better said, the demystification of brain hygiene through the catastrophe of National Socialism, hastened the ascendance of a perspective in which emotions and self-confidence, criminality and creativity were no longer relevant factors. Within this epistemic configuration the brain literally became disembodied and isolated. Disembodied, because morphological structure with all of its chemical substances and processes receded behind the digital on-off-principle to which the functioning of the nerve cells corresponded. Isolated, because the usual environment in which the brain functions as a whole, namely the body, was factored out either by ignoring it or through the deliberate exclusion of contingent and distracting physical processes. An entire generation of brain researchers, neurologists and cognitive scientists studied the hardware of the brain from an electro-physiological perspective and no longer devoted the same attention to its morphological structure as their predecessors during the first half of the 20^{th} century.

Two coincident factors were responsible for this. In addition to the invention of the cybernetic brain it became possible, thanks to technological innovations, to detect single neurons within the brain using an electrode. Optical, acoustic or other stimuli produced reactions in specific neurons, which could thereby be classified according to function. Nerve cells or their potentials, as the case may be, were identified in a purified state. Naturally, none of the studies insisted on examining the entire brain but focused on specific functional sequences such as the perception of color or form, the interaction of eye movement and balance and numerous other functions which were sufficiently complex in themselves to constitute an entire system and were modeled theoretically under the best of circumstances.

This brief and greatly simplified outline of some of the main directions within the cybernetically informed neurosciences is intended is draw attention to one point only: the computerization of the brain went hand in hand with a temporary departure from physiognomically oriented visual representations of the brain. I do not wish to claim that no illustrations of the brain were to be seen in the 50s and 60s of the 20th century, but that representations of relevant mental processes drew on entirely different imagery. The schematic diagrams of individual neurons used by McCulloch and Pitts are almost emblematic in character. Their triangular shapes are even slightly reminiscent of pyramidal cells (Fig. 67). By the 1950s, however, cybernetic illustrations no longer showed any similarities with nervous systems. The insight into *The Living Brain* offered by British neurologist Grey Walter in his widely read book amounts to a confirmation of Paul Valéry’s comment that the circuit diagram of a radio has greater bearing on the nervous system than a histological section. Among the book’s 22 Illustrations there is not one picture of the brain, although several figures depict circuit diagrams, for example of a nerve model which cannot – and is not intended to – be distinguished from that of a machine (Fig. 68).

Such iconoclasm is taken even further in the publications of John Eccles, of which his collaboration with Karl Popper, *The Self and Its Brain*, may someday be viewed as the terminal point of brain research in the 20th century. The book contains not a single photograph. (12) In my opinion, this is not merely a case of the aesthetic taste of book designers. Instead, it reflects an antiphysiognomic tendency and the deliberate asceticism of brain researchers when dealing with representations of the brain that create a realistic effect. The visual design of the brain is modeled on the design of symbolic operations within a computer and no longer on the so-called wetware. Even if Eccles certainly did not inhabit the Turing-galaxy of his own free will, his view of the brain is abstract and functional. Naturally, for Eccles the brain is physical and belongs to *World 1*,along with all other material substrates, organic or inorganic. But the brain is isolated and disembodied in the sense that it is understood as a functional machine which is connected to other, equally abstract physical systems. Under no circumstances, however, do these functions contain any reference to the person to whom the physical body belongs. According to Eccles's metaphysical outlook it cannot be otherwise because the assumption of reciprocal relationships between the three worlds only makes sense if each has its own clearly defined properties as distinct from the others. When images of the brain emerge in the works of Eccles and other brain researchers they are schematic in form (Fig. 69), merely suggesting the brain within the head. The focus is not on the abundance let alone the variability of the brain convolutions and fissures, but on certain orientation points where the names of the various functions are subsequently entered. This type of illustration, still very common in the 1980s, is a far cry from our visual conceptualization of the brain today, although they are separated only by the decade of the brain, during which computer images virtually inundated the public. The antiphysiognomic and deindividualized approach to the brain spanned roughly 40 years. During that period virtually no elite brain research was conducted; if it was, it played only a marginal role.

In an apparent contradiction to these findings, the brain of Albert Einstein had already become the focus of public attention even before his death. Einstein's brain, however, is not a singular phenomenon with respect to either its electrophysiological features or its morphological structure. Rather, it was treated as a cult object from the start without ever becoming the object of research. This dissociation was only resolved with the advent of new imaging technologies.

Einstein's Brain

"Einstein's brain is a mythical object." This is the opening sentence of Roland Barthes's famous essay in which he explains how Einstein's brain was used to retell yet again the myth of mankind's unlimited power over nature. Barthes continues, "Paradoxically the greatest intelligence of all provides an image of the most up-to-date machine, the man who is too powerful is removed from psychology, and introduced into a world of robots. . ." (13)[2] Thus, the myth of Einstein's brain rests on the fact that there are no secrets. Einstein's thought processes are thereby reinterpreted as a kind of functional labor which, according to Barthes, is no different than making sausages. This functionalistic interpretation meshes perfectly with the computer dispositif of the 1950s. The

[2] I was able to find the Barthes essay in an English translation from the French and have quoted directly from that edition. Thus, the author's footnote is no longer valid. Barthes, Roland. *Mythologies*. Selected and translated from the French by Annette Lavers. New York: Hill and Wang, 1972, p. 68.

physiognomic equivalence between the structure of a brain and the person to whom it belongs is irrelevant. All that matters is the “cybernetic complexity” (“complication cybernetique”) of the organ. In the sense of an organ, the brain disappears amidst the connections between brain function and mechanics, between computers and cybernetics. Even if Barthes criticizes the instrumentalization within in the public prattle about Einstein’s brain, he is still operating entirely within the intellectual framework of a deindividualized and disembodied understanding of the brain.

The absence of Einstein’s brain is informative in another respect as well. Barthes was primarily interested in the commotion about Einstein’s brain in 1955 essentially boiling down to a phenomenon based on a public personality cult. Of course, Einstein himself was not entirely uninvolved with the course of events. Several years before his death he had made himself available for an EEG in Princeton. It did not reveal any electrical brain waves indicative of genius, although it did produce the famous photograph of Einstein hooked up to electrodes, an image that integrated seamlessly with the iconography of an exceptional figure who was breaking with the conventions of academic demeanor (Fig. 70). Einstein’s brain had become a cult object even before its owner was deceased. Anatomically oriented elite brain research had exhausted itself, and in spite of some optimism around 1950 the decoding of genius using electrical current in the brain hardly achieved an impressive rank as a research goal at any time. Nevertheless, the memory of pre-war elite brain research was still sufficiently salient in the collective memory to sustain fascination with the cerebral uniqueness of the genius of the century for a short time – as opposed to interest in the brain researchers themselves. It is only speculation, of course, but even if one of the leading neuroanatomists at the time had had Einstein’s brain at his disposal the result would hardly have been a revival of elite brain research. In 1966, when the elderly Walther Riese drew a balance on elite brain research and regretfully concluded that there was no longer any interest in it, he didn't even find Einstein's brain worth mentioning. (14)

For decades the most famous brain of the 20th century was little discussed. Even the journalists who occasionally set out in search of it made no headway. Their investigations, however, do yield information about the ongoing saga of Einstein's brain, a story that revolves almost equally around Thomas Harvey and object responsible for this pathologist's somewhat dubious renown. (15) It could also be told as the tale of a clueless man who inadvertently gains possession of a treasure which completely exceeds his competence. Princeton Hospital, where Harvey was employed and Einstein died, was not a research institution despite its illustrious name. It was a regular hospital where doctors had no great interest in conducting research. The same held true for Harvey who was a well-trained pathologist but entertained no academic ambitions and commanded no particular expertise in the anatomy of the brain.

Harvey removed the brain in the presence of Otto Nathan, Einstein's close confidante and soon-to-be almighty executor of the Einstein estate. It is unclear whether it was Einstein's wish that his brain should be subjected to scientific study; at any rate his son Hans Albert and Nathan were agreed that the organ should remain with Harvey for the time being. (16) There is no point in speculating why Nathan, who had a keen hagiographical interest in the outcome of an examination of the brain, made no attempt to place it in the hands of a well-known neuroanatomist. Harvey, for his part, sought contact with several leading brain anatomists, but deluded himself into thinking that they would agree to collaborating with him while he himself continued to hold the reins. Correspondingly frigid was a meeting in Philadelphia attended among others by Webb Haymaker, who had examined Mussolini's brain, and – of all people – Gerhardt von

Bonin, one of the most vehement critics of Vogt's elite brain research. Other than Harvey's recollection no further record of this meeting appears to exist. In any event he left without having achieved anything, and none of the brain anatomists present expressed an interest in Einstein's brain during the following years. This is entirely congruent with opinion in brain research at the time, namely, that studying elite brains was a lost cause.

As if rejection by the brain authorities amounted to carte blanche, Harvey proceeded with the brain as he saw fit. True, he did use Bailey and Bonin's atlas as an orientation, but his procedure makes it fairly clear that he had absolutely no idea what kind of research he wanted to perform on the brain. To begin with he had it photographed from several angles. Next, he dissected it into 240 cube-shaped blocks from which he subsequently prepared 2,000 microscope slides. It would be misleading to view this procedure as following Constantin von Economo's small-block method. First, Economo provided far more complex and meticulous instructions for preparing and preserving elite brains, which included taking a paraffin cast of the intact brain hemispheres as a matter of course. Second, there is no indication that Harvey had plans of conducting a cytoarchitectonic study.

Instead, Harvey began to distribute individual brain sections to experts for examination. Best known among them was Percival Bailey, who politely expressed his gratitude for the present and was never heard from again. Harvey's hope that the microscopic examination of several brain slides could produce meaningful results actually amounts to an unintentional satire on earlier, far more elaborate and more competent efforts to induce elite brains to speak. Conducting an anatomical examination in accordance with anatomical standards of roughly the year 1900, not to mention the rules of Economo or Vogt, had become impossible after Harvey's intervention.

In the following decades Einstein's brain was enveloped by silence. When Harvey was more or less forced to resign his position at Princeton Hospital in 1960, he took along the formalin-preserved brain cubes. This only underscores that nobody was interested in the brain any longer, not even Otto Nathan. As Harvey gradually lapsed into social decline over the further course of his life, Einstein's brain remained his most loyal companion. At some point he dropped out of sight, and considerable journalistic investigation was required to rediscover his whereabouts. The bizarre fate of Harvey and Einstein's brain found an appropriate narrative genre: the road movie. One journalist detailed her trip to the village of Weston, population 1267, where Harvey lived in 1985. Another reporter wastes an entire book recounting the tale of an aged Harvey crisscrossing the USA by car to find Einstein's granddaughter – with the brain in his baggage. Stories of this type can be viewed as crude by-products of investigative journalism. The question "Where is the genius in Einstein's brain?" has been replaced by the more banal question "Where is Einstein's brain?" To which we would have to reply: sitting on Harvey's shelves, for the most part. The rest of it has been scattered to far-flung places, for over the course of time Harvey also parceled out pieces of the brain to admirers, for example a Japanese Einstein aficionado at Kinki University. In the meantime, it has at least been determined in which laboratories and collections pieces of the brain now reside. Several years ago the aged Harvey allowed himself to be persuaded to hand over the brain blocks remaining in his possession to Princeton Medical Center, where they are currently stored. (17)

Since the 1980s the brain sections that Harvey continued to make available led to several marginal publications. One study claimed that Einstein’s cerebral cortex was thinner than those of a small control group. Another discovered that in Einstein’s brain the proportion of neurons to glial cells – at least in one Brodmann’s Area – was significantly lower than in an equally small control group. Not exactly promising findings that were accordingly met with silence or harsh methodological criticism within the neurosciences. (18) Only in the year 1999 did a publication truly reverberate. This comes as no surprise, for at the end of the often-cited decade of the brain Sandra Witelson, a Canadian neuroscientist, acted as if she had achieved a breakthrough in the study of Einstein’s brain.

“The development of computer-assisted imaging technologies has made it possible to undertake in vivo, quantitative measurements of brain anatomy using magnetic resonance tomography. This has focused […] renewed attention on the relationship between structure and function.” (19) With this quote Witelson introduces her study of Einstein’s brain into mainstream brain research at the turn of the millennium. While there is no doubt that computer imaging has taken the relationship between anatomical structure and function to a new level, the author is still constrained politely to conceal the irreparably fragmented condition of Einstein’s brain. Witelson had no choice but to make do with macroscopic measurements and to base her calculations primarily on photographs. True, she writes that in addition to the photographs she also had the brain itself before her, but the question arises as to what she was actually able to do with it, faced with 240 brain cubes. Even if Witelson does have extensive experience pertaining to the anatomy of brain convolutions, her actual measurements of the proportions of the four major brain regions lead directly back into the 19th century.

The findings, namely that Einstein's inferior parietal lobes, i.e. the region surrounding the end of the Sylvian fissure, are especially well-developed, were passed off as sensational, but fit perfectly within the conceptual framework of a Gustaf Retzius or Paul Flechsig. Witelson observes a confluence of the Sylvian fissure with the post-central sulcus, which produces a significant widening of the inferior parietal lobe. This indeed represents an anatomical rarity, but we can safely question whether this feature is unique to Einstein's brain and thereby provides a clue to his genius. Even in the late 19th century there was debate about whether peculiarities in the pattern of brain convolutions, no matter how rare, were anomalies or merely expressions of a wide range of variation – not to mention the question of attributing functional significance to them.

What Witelson describes as the "unique morphology" of Einstein's brain was seen in almost all of the brains examined, as the present study may have demonstrated. Lombroso and the educated engineer studied by Meynert exhibited a major simian fissure, while in Italian anatomist Giacomini the Rolando's fissure was doubled. In politician Gambetta the left third frontal convolution was doubled at the tip, while in brain researcher Constantin von Monakow the entire second frontal convolution was doubled on the left. (20) In Helmholtz the parietotemporal transition zone is as highly developed as in Bach. Retzius found a shortened Sylvian fissure and a thickened supramarginal gyrus in Sonja Kovalevsky and Hugo Gyldén. In Lenin layer III of the cerebral cortex was exceptionally pronounced. Haeckel exhibited an unusual cortex layer II. The confluence of two fissures pointed out by Witelson was interpreted entirely differently in the 19th century. Moritz Benedikt saw it as a typical feature of a criminal brain.

Finally, if one searches through history for brains which were described as extraordinary at the time and exhibited a widening of the inferior parietal lobe similar to Einstein's brain, one finds oneself in thoroughly illustrious company: Polish Marshall Josef Pilsudski, who was not reputed to have any special mathematical ability; a mathematical prodigy from Budapest; and finally a senior government official who was completely unremarkable both mathematically and musically, but had achieved fluency in nine languages. (21) Einstein’s brain is not as unique as Witelson may have hoped, and even if it were, the question of how to evaluate such a finding is highly contentious. What Witelson considers to be the path to Einstein’s genius, French neuropathologist Olivier Robain views as a grave malformation which, if discovered in a fetus today, would at least raise the question of an abortion. (22) With regard to the highest intellectual capabilities, it is virtually impossible to express in clearer, more drastic terms that interpreting the relationship between structure and function, between the immediate appearance of a brain and its life history, still poses similarly difficult questions today as it did 100 years ago.

Knowledge of the relevant literature protects one from making new discoveries. Apparently, this axiom applies not only in the liberal arts but also to brain research, and the knowledge has a particularly protective effect when it comes to misinterpretation. As deeply as some genius seekers may regret it, we must proceed from the assumption that the future does not look hopeful for Einstein’s brain, and probably not for any brain preserved in glass, when it comes to localizing the cause of a special ability within a specific area of the brain. Researchers in Göttingen had the same experience. After the brain of Carl Friedrich Gauss had languished unnoticed in a neuropathologist’s cabinet for decades, scientists there conceived the idea of examining it using magnetic resonance tomography. Astonishingly, the undertaking was legitimized on the grounds of data protection. As if the organ floating in formalin were threatened by destruction, the computed tomography images would be archived prophylactically as digital documentation. Whether such data can even be put to use, however, is another question which was presumably not under discussion. Apparently, the primary purpose was to refocus local awareness on one of “the greatest treasures of the Göttingen University Clinic.” The precise minutes that record the course of the procedure reflect the reverence in which the object is held. November 25, 1988, 8:40 a.m.: the brain is transported from one institute to another where it is first cleaned and then transferred to a new container. 1:15 p.m.: the specimen is advanced into the tomograph. Shortly after 4:15 p.m.: the brain has been returned to its original glass container and traditional location in the museum. (23)

The tomography of Gauss’s brain has more to do with preserving a specific tradition in Göttingen than with ambitious neuroscientific research. It demonstrates yet again how the brain and its processing with advanced technology are incorporated into hagiography. Thus, the re-emergence of Einstein’s and Gauss’s brains from obscurity is related to the new imaging technologies and the promise they hold for defining mental states as conditions within the brain, even though in one case as well as the other the validity of 19^{th} century parameters remains intact. In addition, there are also significant differences between the two brains, although these tend to reflect cultural rather than neuroanatomical factors. Gauss has long ceased to be a national hero who could be harnessed for achieving any large-scale political or commercial objectives. Gaussian mathematics is and will continue to be known globally, but Gauss’s brain is a local phenomenon. It is, so to speak, an expression of a certain traditional sense of academic identity in Göttingen which is based primarily on history. Einstein’s brain, however, has global dimensions entirely in keeping with his status as a 20^{th} century cult figure. Einstein’s brain offers more than the mere potential of gaining fame and a source of income. His cult status simultaneously raises the brain to a level approaching Christian relics, particularly since fragments of it are spread all over the world. Fingernails, hair and bones were the actual sacred substances which endowed an altar with numinous legitimacy. Certainly, no research institute that owns a specimen of Einstein's brain has yet to exploit it for publicity purposes, but it may be only a question of time until a piece of the brain is exhibited in some show, to be marveled at like a magic cube.

Fig. 66: Fritz Kahn, processes in the brain and in the sensory-motor organs upon optical presentation of a key

Fig. 67: W. McCulloch and W. Pitts, diagram of neurons as logical circuitry

Fig. 68: William Grey Walter, circuit diagram depicting a nerve model

Fig. 69: John C. Eccles, schematic representation of the brain

Fig. 70: Einstein during the administration of an EEG