In the centenary year of his birth, the work of Sir Geoffrey Jefferson (1886-1961) is reviewed with special reference to his views on the seat of consciousness and on the application to medicine of the scientific method.

**KEY WORDS** • history of neurosurgery • Sir Geoffrey Jefferson • seat of consciousness • frontal lobe function • philosophy in medicine

“...The centenary of a great man’s birth affords an opportunity to survey not only his own works, but the after histories of the fields in which he spent his energies and won his fame.”

WITH these words Jefferson, in 1948, opened a lecture on William Macewen, whom he greatly admired not only for Macewen’s technical achievements in brain surgery but much more for the grasp of neuroanatomy and neurophysiology that enabled him to diagnose and localize the lesions which he was the first to successfully relieve. It is no less fitting that Jefferson’s own centenary should not pass unmarked.

The obituary by Botterell dealt admirably with Jefferson’s career and achievements, and his son Antony, himself a neurosurgeon, has provided a more personal memoir, but neither of these fully assessed his influence as a thinker. Before him, Macewen and Horsley had gained the special accolade that is reserved for pioneers, and in Jefferson’s own professional lifetime Cushing certainly, and Dandy and Olivecrona possibly, attracted more attention and (in the case of Cushing and Olivecrona) influenced a larger circle of pupils. But in a pragmatic profession, Jefferson stands out as a man of ideas. His gift of being able to detach himself from the details of everyday clinical care and to survey the larger medical and scientific scene with equal measures of authority and humility was a rare one. This tribute to the Master, as he was known to his pupils, will attempt to indicate the areas of Jefferson’s main interest, and to make some assessment of his impact upon these areas, as it appears 25 years after his death.

**Education and Training**

It is natural to enquire how Jefferson’s learning and culture came to be as great as they were. The son of a well-respected general practitioner in the industrial North-West of England, Jefferson attended Manchester Grammar School which was, and still is, recognized as one of the finest academic centers at the high-school level in all England. But his recollections of the experience, some 45 years later, were unfavorable: “I was not an ardent admirer of my teachers and some of them I cordially detested. ... The school rooms [had] neither the charm of respectable antiquity nor the lacquer of newness. ... The [Latin and Greek] texts that we read were ill-chosen and, worse still, the characters and purposes of the writers were veiled from us. ... The idea that any of those men had personal histories would indeed have surprised us.” But he did not lack a solution: “It might be possible to put off education altogether till the age of 15, for I believe that a boy could learn between 15 and 18 all that comprises an ordinary school education. I pass over the difficulty of occupying our children until the age of 15 in ways neither illegal nor immoral.” Here Jefferson touches playfully on a point — the education of the gifted child — from which he himself must have suffered deeply and which we may hope has advanced significantly since his time. At any rate, however little Jefferson enjoyed his studies, he profited sufficiently from them to be accepted as a medical student at Manchester University, where, in his own words, “The only prizes I won were the tops! The Sidney Renshaw Exhibition (in physiology), the London University Scholarship in...
Anatomy ... I got first-class honours in the M.B.,B.S. of course [author's italics] and distinction in Surgery." (Letter to Sir Ernest Finch, October 26, 1954, unpublished.)

On graduating from medical school, Jefferson became house surgeon to a competent but undistinguished general surgeon, George Arthur Wright, at Manchester Royal Infirmary, and later took up resident appointments in London at the Victoria Childrens Hospital in Chelsea (next door to Whistler's studio) and at the Royal Marsden Cancer Hospital. Had he wished to continue in general surgery he would surely have risen high, for at this stage he passed not only the Fellowship of the Royal College of Surgeons of England, but also the even more demanding Master of Surgery degree at London University, gaining another "top" — the Gold Medal.

In Jefferson’s time, surgeons in training often spent a year or more in the anatomy department at their parent universities, and it is there, he tells us, teaching medical students and studying under the eminent anatomist and anthropologist Sir Grafton Elliot Smith, that he "first got infected with the brain." (Letter to Sir Ernest Finch, see above.) Of formal neurosurgical training Jefferson had none, telling the present writer that, although he had learned from Cushing’s papers, he considered himself self-taught. William Thorburn (whose description of the clinical features of traumatic lesions of the spinal cord is a classic) was a surgeon at Manchester Royal Infirmary in Jefferson’s time and undertook most of the neurosurgery, but Jefferson saw little of him, considering Thorburn "not ... a very fine technician ... [with] a sarcastic tongue and a ... chilling and unfriendly manner. He was by no means a man to whom the young could turn for sympathy and guidance."18

Early Career

Antony Jefferson has described his father’s career between 1913 and 1918.5 It is sufficient to note here that following a period in Canada as a general surgeon he saw military service in World War I, first in the Anglo-Russian Hospital in Tsarist Russia and later in France, where he treated a considerable number of patients with head wounds. Doubtless because of this experience, head injuries remained one of Jefferson’s abiding interests, through which he would later come, as we shall see, to develop his attitude to the problems of the higher functions of the brain and of consciousness. In 1920 he published a long and reflective paper with the provocative title "Gunshot wounds of the scalp, with special reference to neurological signs presented," in which he described a group of soldiers in whom, thanks to the low velocity of rifle bullets in World War I and to the wearing of steel helmets, such wounds had not led to an underlying skull fracture, but had nonetheless been accompanied by focal neurological deficits and variable periods of unconsciousness. At a time when the severity of head injuries was believed to depend almost exclusively on the presence or absence of a skull fracture, Jefferson showed his quality as an interpreter of clinical phenomena by noting "the neurological signs of underlying cerebral mischief in scalp wounds have been greatly neglected in the past; the eye has seen only the wound of the scalp and the mind has travelled no further."

In 1920 Jefferson also published his observations on four cases of fracture of the atlas vertebra (later to be known as the “Jefferson fracture”) with an analysis of the mechanics of this condition which is still accepted as valid. He would eventually write 10 papers on spinal injury, one of which predicts, as improved radiology would later verify, that besides the increased frequency of injury at the lower end of the cervical spine a second peak frequency would be found at its upper end. Jefferson’s insistence on trying to analyze the mechanical forces involved in craniospinal trauma was ahead of his time. It also exemplifies the restless but always sharply focused curiosity, concealed behind a placid and equable disposition, which brought him acceptance among scientists of world standing. No honor later gave him
more pleasure than his election to the Fellowship of the Royal Society, in the footsteps of Harvey Cushing.

At the height of his renown, Jefferson would write "A [medical man's] position in a competitive world depends on ability to combine originality in science with enterprise and speed in its application to human needs," but frenetic activity was never his method. From Elliot Smith, who had inspired him to study neurology, Jefferson also cultivated, he tells us, the ability to "work hard with intense concentration and then relax for long periods while some idea was germinating." "Perhaps" he adds "I learned then the great good that one could do by wasting one's time talking to associates, to the team. It is an important duty for seniors," and one which his own clinical teachers had evidently neglected. It was during one of these sessions that the present writer dared to remind him of an appointment for which he was late, and was met by the disconcerting rejoinder "A man who is always punctual for his appointments cannot have been very interested in what he was doing before."

The Seat of Consciousness

In his career up to 1930 Jefferson had shown himself an accurate observer and an excellent diagnostician who had also developed a supremely gentle and meticulous surgical technique. Now he would show that he was capable of more than that. He continued to be interested in the neurological phenomena of the acute head injury, and in 1933 he published some thoughts on the matter, arising from his own growing experience. At that time Wilfred Trotter's view that unconsciousness in concussion was due to a sudden anemia of the cerebral cortex held sway in Britain. Trotter was no mean controversialist, but Jefferson was ready to challenge him. He writes that Trotter's doctrine "has been widely received but ... it may not be a complete explanation ... for we know trauma may paralyse nervous tissue (cf peripheral nerves) without ... [understanding] the exact physiological processes involved."

A more subtle point was the relationship between mental symptoms and increased intracranial pressure. Gordon Holmes, referring to brain tumors, had suggested that increased pressure in itself might be responsible for mental symptoms and disturbance of consciousness, regardless of the situation of the causative lesion. There was obviously a measure of truth in this since relief of pressure (such as by the then fashionable operation of subtemporal decompression) could be followed by a return to normality, even if the tumor was not removed. But Jefferson saw a possible fallacy: "It is very commonly assumed" he wrote "that prolonged unconsciousness is the result of raised intracranial pressure. This seems logical ... since Nature produces a human experiment for us in the shape of a middle meningeal haemorrhage. ... But is it the clot by reason of its size or the clot by reason of its position which leads to stupor? Evidence ... can be drawn from experience with intracranial tumors. ... The intracranial pressure in cerebellar tumors, for instance, exceeds any so far recorded rise in trauma, yet these patients are never ordinarily unconscious." At this stage, having observed that prolonged stupor had occurred in several head-injured patients later found to have severe frontal lobe contusions, he was tempted to conclude that therefore these contusions were the cause of the stupor. It is a mark of his greatness that he would shortly accept the necessity to change his mind completely.

In 1937 Jefferson reported the results of six patients surviving after frontal lobectomies, of which three were left-sided and three right-sided. Noting that neither group showed more than trivial alteration of intellect or behavior and that the side of the lobectomy made little difference, he proceeded to a remarkable generalization. "[The idea] that distinctive histological structure [in the cerebral cortex] portended distinctive and discoverable activities was, and still is, an irresistible one. We have become so deeply impressed with the importance of local areas, especially the motor, that we ... assume that function is equally local in the silent areas and that a small lesion of a frontal lobe will produce an equivalent paralysis [some aspect of] the intellect or of emotional control." But the relative normality of his patients after rather radical surgery showed that "mental activities have no closely packed, essential or solitary locus the withdrawal of which leads to ... dementia. The brain must function intellectually and emotionally as a whole. ... The frontal lobes cannot be regarded as the 'organ of mind.'"

But if not the organ of mind, could the frontal lobes nevertheless be the seat of consciousness? The observation that removal of a single frontal lobe from an otherwise normal brain could leave the subject mentally almost unchanged was not new, but in the minds of his contemporaries this fact had been regarded mainly as a stroke of luck for the patient. For Jefferson it was a fact of great significance. Forty years earlier Sherrington had written "Even the higher psychical events cannot truly be spoken of as functions of the cortex in the sense that they are simply the outcome of molecular changes in the grey matter; they are rather to be regarded as the outcome of complex processes in which the parts of the brain below the cortex play a part no less essential than that of the cortex itself. The fibres passing down from the cortex to the middle brain have probably functions by which they take part even in our psychical life." As time passed, von Economo and others began to postulate the existence of areas in the brain stem associated with sleep and waking.

By the 1930's, amid the enthusiasm resulting from the demonstration that the cortex could be successfully stimulated in both man and animals, as well as from the recent discovery of the electroencephalogram, Sherrington's message had been largely forgotten. In 1933 Jefferson had alluded to the probable importance of damage to the hypothalamus and other parts of the
"vegetative nervous system" in determining a fatal issue
in severe head injury.32 Later he had also become
interested in the tentorial pressure cone, and had con-
cluded that in fatal cases death was due to "interference
with the subthalamic autonomic vegetative centres."34
He also pointed out that some of these patients exhib-
ted decerebrate rigidity, indicating that this condition
arises from a lesion at about the same level in man as
in animals. Yet one senses that he is still looking for
some further meaning to attach to his various observa-
tions, and by 1942 he has found it. "It is a well-accepted
belief that consciousness resides in the cerebral cortex,
that it lies widespread there in [silent] areas. It was
because of this doctrine that for centuries men have
looked to the cortex to discover the anatomical substra-
tum of concussion, of traumatic stupor. Hemorrhages
into the grey or white matter or their junction would
have been good evidence and were, indeed, good evi-
dence when they were found. . . . But [such] haemor-
rhages are by no means widespread and are [often]
sufficient to account for fatigue or stupor. We can
only rid ourselves of these difficulties by removing the
seat of consciousness elsewhere. Consciousness is a
primitive and essential function. As the cerebral mantle . . .
has developed, so have the intellectual processes
which consciousness makes possible. But that is not to
say it is itself a function of the hemispheres. Uncon-
sciousness has many similarities with sleep; a patient
passes through the stages of drowsiness and hyperson-
mia until he can no longer be awakened, and sleep we
know to be related to hypothalamic and brain-stem
locations. It is significant that pari passu with increas-
ing drowsiness the patient becomes ill, and there
emerges the striking conclusion that there is a short-
chain link between the vital centres and unconscious-
ness in a way that seems improbable if the cortex is the
site."66 Jefferson goes on to quote two cases, a frontal
lobe tumor and a cerebellar tumor; in both patients
there was a sudden loss of consciousness and in both
ventricular drainage restored the intracranial pressure
to normal. Neither patient recovered consciousness
and, in each, autopsy revealed a brain-stem hemor-
rhage. "If the view that the cortex is the seat of con-
sciousness were true then consciousness should return
when pressure in the hemispheres is restored to normal.
But it is not so."66 "The level at which all these happen-
ings [associated with prolonged stupor] occur is in the
more primitive but still extremely complex neural mecha-
nisms . . . considerably below cortical level."22
One can almost hear his Archimedean shout of "Heu-
reka!"

Ultimately, with the demonstration of loss of con-
sciousness as a feature of the upward cerebellar pressure
cone in posterior fossa lesions, the necessity to rely on
the existence of an actual brain-stem hemorrhage to
explain this phenomenon disappears, and the picture is
complete: "There is an area, probably mesencephalic
but extending down over the pons to the upper medulla,
compression of which will produce paroxysmic states
[Jefferson's term for pathological loss of awareness] as
well as the other vegetative states which are well known.
It is very unlikely that there is a group of 'master cells'
functioning as a nuclear mass, for that is not what we
recognize or expect as a physiological 'centre,' nor do
we know its bounds, but in the basal regions of the
brain from the hypothalamus to somewhere in the
ponto-medullary region a lesion will affect conscious-
ness and the clinical state will vary at different levels,
and perhaps with the mode of interruption of physio-
logical integration."34 In his last, posthumously pub-
lished, paper Jefferson returned to the same theme,
this time supported by examples from the new and
rapidly expanding field of neuropharmacology, the im-
portance of which he had realized before most of his
colleagues.7

Wider Interests

As Jefferson's search for the seat of consciousness
approached a successful conclusion, so his interests
broadened even further. He had never involved himself
in laboratory studies — a limitation which was perhaps
more serious for his pupils than for himself — prefer-
ring, as Walshe39 would later say of him, "to rely
primarily upon the unresting contemplation of the facts
of direct clinical observation" in which area he had "a
genuine gift of discernment and interpretation." The
limitation was deliberately self-imposed, for he tended
to distrust the results of laboratory studies, claiming
that "the clinician is more ready to learn from all
sources than is the physiologist . . . Much animal ex-
periment is only roughly transferable to man . . . But
the laboratory worker plays the game according to the
conventions of his fellows and (considers that) 'ap-
plied physiology' is a debased activity."19 Again, and in
a more positive vein, he writes "Man is essentially the
perfect subject for experiment. For what purpose do
we, as yet, desire knowledge save to use it for his benefit?
Sometimes we must use animals, but a vast harvest
remains to be reaped from the innocuous, non-destruc-
tive exploration of man himself. . . . Penfield's [obser-
vations on the] results of his stimulations of the human
cortex on 126 individuals will surely supersede . . . the
existing charts of the cortex made from animals rarer
than man."99 This paper was written in 1939, before the
horrors of Nazi experimentation on humans or the later
excesses of a small minority of psychosurgical investi-
gators had become known. Jefferson did not include it
in his Selected Papers.29 At any rate, for all his apparent
reluctance to take advantage of the facilities of a labo-
ratory, he remained nonetheless a scientist in his ap-
proach to neurosurgery, but he was also a philosopher
in his insistence on reflecting on the meaning at all
levels of the physiological mechanisms which he was
observing in his patients.

One of Jefferson's most felicitously written works is
an essay on the nature of the scientific method, which
he entitled "Scepsisscientifica."28 In this he well de-
scribes the dilemma of the scientist who, if he goes into
the laboratory "with a head empty of any expectation,"
may find himself pursuing and accepting "crude and
brutal fact irrespective of its having any recognizable
meaning." Yet if he works from "an idea, a preconcep-
tion to be put to the experimental test" there is a danger
that "the experiment may be conducted in such a way
as to assume an emotionally desired result." This situ-
cation can never be wholly avoided, but at least if we
refrain from unnecessary and untested assumptions we
shall not "raise an imposing superstructure of conclu-
sion on fallacious premises. Our greatest source of error
lies in our having explanations that satisfy us . . . be-
cause we see no other." It is fascinating to realize that
the man who so clearly delineated the dilemma of the
worker in a laboratory had himself spent so little time
there. We have, he adds, a natural resistance to new
truths "because they irritate, like an acid or a sting.
When our minds are vacant of rational explanation we
are . . . ready to accept any theory, however nonsensi-
cal." Scientists must therefore remain skeptical — al-
ways ready to test and retest their ideas — but the skepti-
cism must remain orderly not intuitive. "The proper name for the intuitive variety is prejudice."

Perhaps encouraged by the success of "Scepsis scient-
tifica," Jefferson turned next to consider the implica-
tions of the dawn of the computer age. This was a
huge challenge, and if he was not wholly able to meet
it, we can learn something from what now seem to be
the limitations of his prevision. In 1949 the thermionic
valve still reigned supreme, and the possibility that
alternatives would soon be developed which would
allow microminiaturization never occurred to, or was
rejected by, many scientists. Thus Jefferson accepted
that "a computer which approached the complexity of
the human nervous system would require a building
the size of the Empire State Building to house it and
the complete electrical output of Niagara Falls to run
it." Also, because many of the early computers were
programmed to run mechanical models, there are places
where Jefferson seems in danger of confusing computer
science with robotics. Perhaps more serious was his
failure, which indeed was shared by most clinicians
then and for years afterwards, to appreciate the power
of the computer in heightening our ability to assess the
quality of evidence in the biological as well as in the
physical sciences. Yet Sir Ronald Fisher's textbook of
statistical methods had been available since 1925, and,
although Fisher's writing was at times somewhat
opaque, his procedures were clearly enough set out.
Jefferson himself had never been in favor of publishing
large series of cases, and when he did he used them
mostly as the field from which he picked interesting
examples. In his obituary of Harvey Cushing, he
conceded that Cushing's "last great book on the men-
ingiomas shows very well what could come out of a
systematised clinic." But he could not resist adding
Cushing's comment (from which we may beg to differ)
that the book would have been much better and more
readable had it been based on 12 cases, as originally
planned.

A Man For All Seasons

If Jefferson's contribution to medical science had
been restricted to the papers from which I have quoted
above, it would still have been outstanding, but in fact
his bibliography extends to about 150 publications, and
the year in which he published most was 1955, when
he was 69 years of age. It has not been possible to do
homage here to the meticulous observation, or the
brilliant clinicopathological correlations, which resulted
in his clarification of the syndromes of carotid aneu-
rysms, or to his studies of invasive pituitary adenomas
and of trigeminal neuromas, all of them important in their time. His sense of justice led him to
rehabilitate the work of the neglected, and personally
rather unattractive, 19th century neurologist Marshall
Hall. He wrote sympathetically of René Descartes'
slightly ridiculous views on the localization of the soul
within the pineal gland. With all that, he acted as
adviser to the British government on the handling of
civilian head injuries during World War II and was
for many years adviser in neurosurgery to the Ministry
of Health. If at times Jefferson's unpunctuality could
drive a famished and exhausted resident, still waiting at
10 p.m. to commence the morning ward round, to
thoughts of mayhem, the occasional unexpected relax-
ation and sharing of his thoughts over a cup of tea,
which Jefferson had admired in Elliot Smith, was re-
ward enough. He delighted in his work — who but
Jefferson could have entitled a paper "On being happy
and liking it"? Even the sting of his rebukes was often
 mollified by the wit with which they were delivered, for
hctoring and bullying were wholly foreign to Jeffer-
son's nature. One example will suffice. As a junior
resident it fell to my lot to administer anesthetics when
the attending anesthesiologist was unavailable. On one
occasion, Jefferson suggested that I administer a pre-
operative morphine derivative to a patient with a cere-
bellar tumor but, concerned about the likely effect of
this on respiration, I decided to use atropine. To my
horror, the patient developed so severe a tachycardia
that the operation had to be abandoned. The inevitable
inquisition followed, and I confessed my disobedience.
"I hope" said Jefferson, the acid dripping from his voice
"that in other respects I run the Department to your
satisfaction."

Less hard-driving and organized than Cushing, less
innovative than Dandy, incapable of developing the
sort of training program for which Sachs is rightly
remembered, Jefferson was a deeper thinker than any
of them. While the practical information which those
others (and he himself) so painstakingly compiled fades
into the general body of accepted fact, Jefferson's ideas
remain seminal, even as the excellence of his writing
continues to attract us and challenges our emulation.
He himself shall have the last word: "Looking back on
it all, I can say what one ought to be able to say of one's life's work 'It's been the greatest fun!' "23

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