Search for the Soul, Mind and Consciousness

Near the end of the 19th century, when the discovery of the quantum was about to put an end to determinism in physical theory, the predominant view of biologists was that life was a machine. The biologist Thomas Huxley wrote in his "On the Hypothesis that Animals are Automata, and its History" [526],

> *…the feeling we call volition is not the cause of a voluntary act, but the symbol of that state of the brain which is the immediate cause of that act. We are conscious automata…*

Philosopher William James responded to Huxley in "Are We Automata" [527] in favor of consciousness not being automata,

> *I think we can, and propose in the remainder of this article to show that this presumptive evidence wholly favours the efficacity of consciousness… Since the mere supernumerary depicted by the Conscious-Automaton-theory would be useless, it follows … that if we can discover the utility of consciousness we shall overthrow that theory.*

However, despite the arguments and evidence he could present for consciousness, James was unable to link it to any known physical process,

> *You may, it is true, ascribe mind to a physical process. You may allow that the atom engaged in some present energy has a dreamlike consciousness of residual powers and a judgment which says, "Those are better than this". You may make the rain-drop flowing downhill posit an impossible ascent as its highest good. Or you may make the C, H, N and O atoms of my body knowingly to conspire in its construction as the best act of which they are capable. But if you do this, you have abandoned the sphere of purely physical relations.*

The early 20th century views of the mind were dominated by the psychologists with the constructs of Sigmund Freud (1900) and later the behaviorism of B. F. Skinner (1938), which eliminated any internal representations for mental process or consciousness. Gilbert Ryle (1948) eliminated the *ghost in the machine* and described mental processes merely in terms of transitions between states. Cognitive psychologists and linguists such as Noam Chomsky (1957) demonstrated that language acquisition cannot be explained by behavioral models alone and postulated internal mechanisms for processes that could not be directly observed. And all the while, philosophers of the mind continued to argue about the nature of the private and unique internal experiences of each of us [528] [529] leading to wide-ranging arguments and speculations across many disciplines; e.g., Nagel's influential "What is it Like to Be a Bat?" [530]. Philosophers also developed arguments at great length for

whether our internal experiences are compatible with determinism; e.g., the counterfactual possibility of *acting otherwise* with free will cannot include violating natural laws; however, can free will still possibly be consistent with determinism by means of a "local miracle" as argued by David Lewis' "Are We Free to Break the Laws?" [531].

It has been tempting throughout history to match qualia or *tinge* with particular objects associated with some part of ourselves, be it of the site of the soul, mind, or consciousness, and these have become intertwined throughout the history of reason, understanding, and spiritual essence [509]. The Greek *psyche* and the Latin *anime* became the Old English term soul, first appearing in the 8th century Greek description of man's appearance in Hades. Originally designating agility and self-movement, it has been translated variously as appetite, desire, and passion, representing the power that animates physical movement as well as reflection and deliberation [532]. Like Democritus before him, Epicurus (341-270 BCE) argued that the soul comprised particles diffused throughout the body and these became separated at death. Centuries later, Dante went out of his way to make sure Epicurus was reserved a prime spot in the *Inferno* of *The Divine Comedy* (1320) for his demotion of the soul,

> *In this dark part are entombed*
> *Epicurus and all his followers*
> *Who made the soul die with the body.*

Aristotle (384-322 BCE) identified a segment responsible for movement and an immortal piece at the root of intellect. He was the first to identify the series of cavities in the brain now called cerebral ventricles as the anatomical location of the soul. Aristotle described the need for these distinctions for the soul in living beings [353],

> *Since some such originative sources are present in soulless things, and others in things possessed of soul, and in soul and in the rational part of the soul, clearly some potentialities will be non-rational and some will be accompanied by reason. This is why all arts, i.e. all productive forms of knowledge, are potentialities; they are principles of change in another thing or in the artist himself considered as other.* [Metaphysics IX.2]

> *Some things can exist apart and some cannot, and it is the former that are substances. And therefore, all things have the same causes, because, without substances, affections and movements do not exist. Further, these causes will probably be soul and body, or reason and desire and body.* [Metaphyics XII.5]

Aristotle appears to be contemplating something beyond substance called soul. The soul gives rise to non-rational potentialities and yet it is also possible for the potentialities to change via a rational formula. Aristotle might therefore have

associated Schrödinger's equation with the rational change of the wave equation and the non-rational change due to a soul, would cause wave-function collapse which is probabilistic. Aristotle also developed particular detailed ideas regarding consciousness,

> *For our assumption is that things that are undergoing alteration are altered in virtue of their being affected in respect of their so-called affective qualities; for every body differs from another in possessing a greater or lesser number of sensible characteristics… But the alteration of that which undergoes alteration is also caused by the above-mentioned characteristics, which are affections of some particular underlying quality.* [Physics VII.2]

> *Thus the animate is capable of every kind of alteration of which the inanimate is capable; but the inanimate is not capable of every kind of alteration of which the animate is capable, since it is not capable of alteration in respect of the senses: moreover the inanimate is unconscious of being affected, whereas the animate is conscious of it, though there is nothing to prevent the animate also being unconscious of it when the process of the alteration does not concern the senses.* [Physics VII.2]

Had Aristotle been alive to see the developments in quantum mechanics, he may have argued that living systems are distinguished from inanimate systems by the existence of senses. That only animate systems measure, that is, consciousness is a necessary condition for measurement.

With the rise of anatomic research came specific proposals for the location of the soul or consciousness or other aspects of our being. For example, Galen (ca. 200 AD) used his anatomic research and his experience with spinal cord injuries as physician to the gladiators to conclude that the soul must reside in the brain (contrary to previous views that it should be in the heart), and this must also be the organ responsible for generating thoughts. Descartes divided the composition of human beings into a thinking substance or soul, the *res cogitans*, and a corporeal substance of physical matter, the *res extensa*. Descartes' view was so influential that from the late 17th century until the early 20th century, the predominant view in the West was some form of dualism, involving an immaterial soul interacting with a material brain. This dualistic view then required an explanation of the relation between mind and body. During his animal dissection work, Descartes identified a small cherry-sized structure called the pineal gland and insisted that it was the material site of his *cogito* and location of the rational soul. In his *De Anima Brutorum* (1672), physician Thomas Willis (1621-1675) made the identification that the corpus striatum was associated with imagination and the cerebral cortex with memory. The 17th and 18th centuries led to English empiricism with John Locke (1632-1704) arguing against Descartes and the other Rationalists, claiming that all knowledge results from experiences of the

senses and reflection on those experiences, the mind's "reflecting on its own Operations within itself" with "internal Sense," from which we derive our ideas of "Perception, Thinking, Doubting, Believing, Reasoning, Knowing, Willing, and all the different actings of our own Minds." [533]. The famous anatomist Samuel Soemmerring (1755-1830) identified the fluid of the cerebral ventricles as the location of the soul. Isaac Newton (1643-1727), ever astute, avoided these issues altogether, stating that,

> *I can calculate the motion of Heavenly Bodies, but not the madness of people.*

However, these examples of proposals for the site of qualia, mind or the soul were based on theories or hypotheses that had little direct verification and would not lead to further understanding. An exception in this early era was the deductive work of Leonardo da Vinci (1452-1519) who used his anatomic studies, as well as other sources in a systematic way to make a judgment on the best candidate for the function and location of the soul to be at a specific site in the anterior portion of the third ventricle of the brain [534]. Evidence from his exploration of this problem can still be traced in his surviving papers. Leonardo's investigations into the structure of the nervous system, including the brain, spinal cord, and cranial nerves, was spread over about thirty years. Due to the high level of his artistic abilities, he was also able to develop a three-dimensional drawing format. His ability to develop these types of reconstructive drawing methods put him in a unique position to then use a series of deductive steps to fix a cerebral location of the soul, which he termed the *senso commun*. His conceptual reasoning for solving the problem of the *senso commun* can be followed in a series of particular experiments and vivisections.

An important early set of experiments involved the "pithing of a frog," which resulted in the destruction of the upper spinal cord and medulla oblongata. The frog remarkably remains living for several hours without its head, heart, interior organs, intestines or skin. However, a puncture of the spinal medulla causes it to spasm and die immediately. This could be understood as all of the nerves derive from the spinal cord. Leonardo's thinking can be followed from the words *sense of touch, cause of movement, origin of nerves,* and *transit of animal powers* next to the appropriate structures in the drawings for this study. With the identification of the spinal medulla, Leonardo had deduced evidence for the foundation of movement and life. The frog experiments were extended to many others, including that of damaging of a dog's brachial plexus, the network of nerves extending from the spinal cord (similar experiments were not carried out for another 250 years). These were supplemented by his many studies of the layers of the head of various animals as well as humans. These initial studies were later used to abstract and construct a three-dimensional synthesis of the nervous system of the human head based on his experimental investigations. Crucial to this was his ability to make three-dimensional drawings of the human skull, without the need for three-dimensional models, using techniques he had learned from architectural concepts for geometrizing space. These also included the techniques of

cutaways and exploded views. In these drawings, he traced the optic nerves back to the optic chiasm and continued into the anterior cavity which he labeled *intelleto* (intellect) and *imprensiva* (sensory information). The olfactory and auditory nerves were bundled toward the middle ventricle labeled *volonta* (will) and *senso commun* as well as a posterior ventricle labeled *memoria*. Leonardo's deduction was that information from the sensory organs is integrated and acted upon by the middle ventricle, the *senso commun*, Figure 5.20.

Figure 5.20 Leonardo da Vinci's deductive determination of the senso commun or site of the soul where all of the five senses come together, located in the anterior portion of the third ventricle above the optic chiasm, indicated by a series of intersecting lines he superimposed on drawings of the human cranium.

However, models were also developed using his skill as a sculptor to outline the shape of the ventricular system by injecting wax with a syringe. He could dissect away brain tissue after the wax had set, resulting in an accurate representation of the ventricular system. Leonardo's use of deductive methods along with his highly developed artistic skills enabled him to resolve quite complex anatomical structures. Leonardo determined the location of the *senso commun* to be just above the optic chiasm proximate to the anterior portion of the third ventricle. Current knowledge about brain structures indicates that this is a region which is vital to the way that humans perceive both their inner and outer worlds and these functions are quite sensitive to any damage in this area. Although the process by which information from the senses results in cognitive functions is still only partly understood, it is remarkable that Leonardo was able to narrow in on a crucial nexus of brain function using both deductive methods and the most sophisticated means of retrieving and representing

information that were then at his disposal.

Leonardo's comments are revealing [535]:

> *The Common Sense, is that which judges of things offered to it by the other sense…And this name of Common Sense is given to it solely because it is the common judge of all the other five senses i.e. Seeing, Hearing, Touch, Taste and Smell. This Common Sense is acted upon by means of Sensation which is placed in a medium between it and the senses. Sensation is acted upon by means of the images of things presented to it by the external instruments…Surrounding things transmit their images to the senses and the senses transfer them to the Common Sense, and by it they are stamped upon by memory and are more or less retained according to the force of impression.* [Richter no. 836]

> *The soul appears to reside in the seat of judgment, and the judicial part appears to be in that place where all the senses come together, which is called the "senso commun", and it is not all of it everywhere in the whole body as many believed, but all in this part. For if it were all in the whole and all in each part it would not have been necessary to make the instruments of the senses converge to one and the same concourse in one place only…How the sense gives to the soul and not the soul to the sense, and where the sensory function is missing from the soul, the soul in this life lacks information from the function of that sense, as appears in a mute or one born blind.* [Richter no. 838]

It would take another 300 years so that by the 19th century, improvements in the design and function of microscopes led to understanding of the cellular organization in brain tissues [514] [534]. The first microscopic image of a nerve cell was obtained by Gabriel Valentin (1810-1883) in 1836, and Jan Evangelist Purkinje (1787-1869) identified the first nerve cell in 1837. Modern neuroscience as we know it began when Santiago Ramón y Cajal (1852-1934) gave critical evidence for the "neuron doctrine," the picture of neurons serving as the basis of signal functioning in the nervous system due to the precise interconnections of neurons [514]. This transformed the cellular view of the brain into our modern neuronal conception of it. Ramón y Cajal was attracted to the area by the hope of explaining the phenomenon of consciousness. He described his life-long exploration as an attempt to break into [536]:

See the print edition of The Quantum Measurement Problem for quotation.

Rather in the mold of Leonardo, Ramón y Cajal was also an exceptional artist. It was his more than twenty years of producing meticulous ink drawings of brain cells in compressed detail, based on countless hours of viewing brain samples in the microscope, that transformed neurology and led to the breakthroughs for our current

understanding of the brain based on the concept of the *neuron* as the basic building block of the nervous system. In addition, also similar to Leonardo, he developed the practice of making cumulative deductions from the large mass of details he had collected. His deductive skill and dedication gave him an uncanny ability to surmise the functional properties of neurons from his static drawings of brain cells. In addition to his neuron doctrine, Ramón y Cajal also proposed a principle of dynamic polarization by which electrical signaling is unidirectional within neurons, propagating from the receiving pole of the neuron to the dendrites and the cell body of the axon, and along the axon to the output pole of the neuron [514]. This allowed the picture of coherent neural circuits to develop with the brain's primary functions being

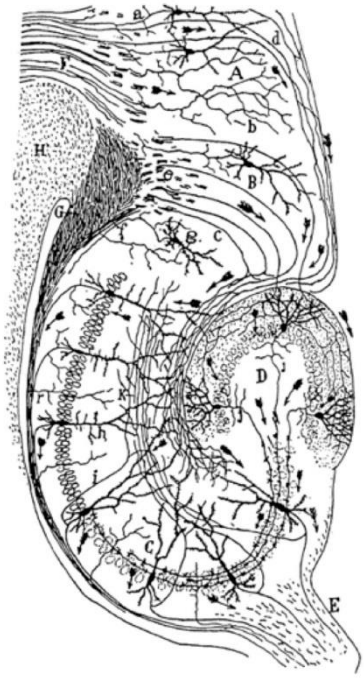

Figure 5.21: Ramón y Cajal's 1911 depiction of directionality of information flow in the nervous system, giving the first view of a coherent neural circuit. Image obtained by staining of a rodent hippocampus.

information processing. This led to the later work of Sherrington and Eccles in the early 20th century to conclude that each neuron involves a competition between excitation and inhibition with a winner-take-all resolution leading to an integrative action of the brain in terms of signals at the level of individual neurons. Ramón y Cajal distinctively indicated the information flow between neurons that he had deduced by the use of arrows in his drawings and remarkably the directional arrows were later verified to be correct, Figure 5.21.

The state of neuroscience today, 100 years after Ramón y Cajal's work, still has not resolved the issues of consciousness and free will, and if Bohr is correct that

consciousness and free will are non-mechanistic processes, it is logically possible that this must await a resolution of the measurement problem as a first step in this direction.