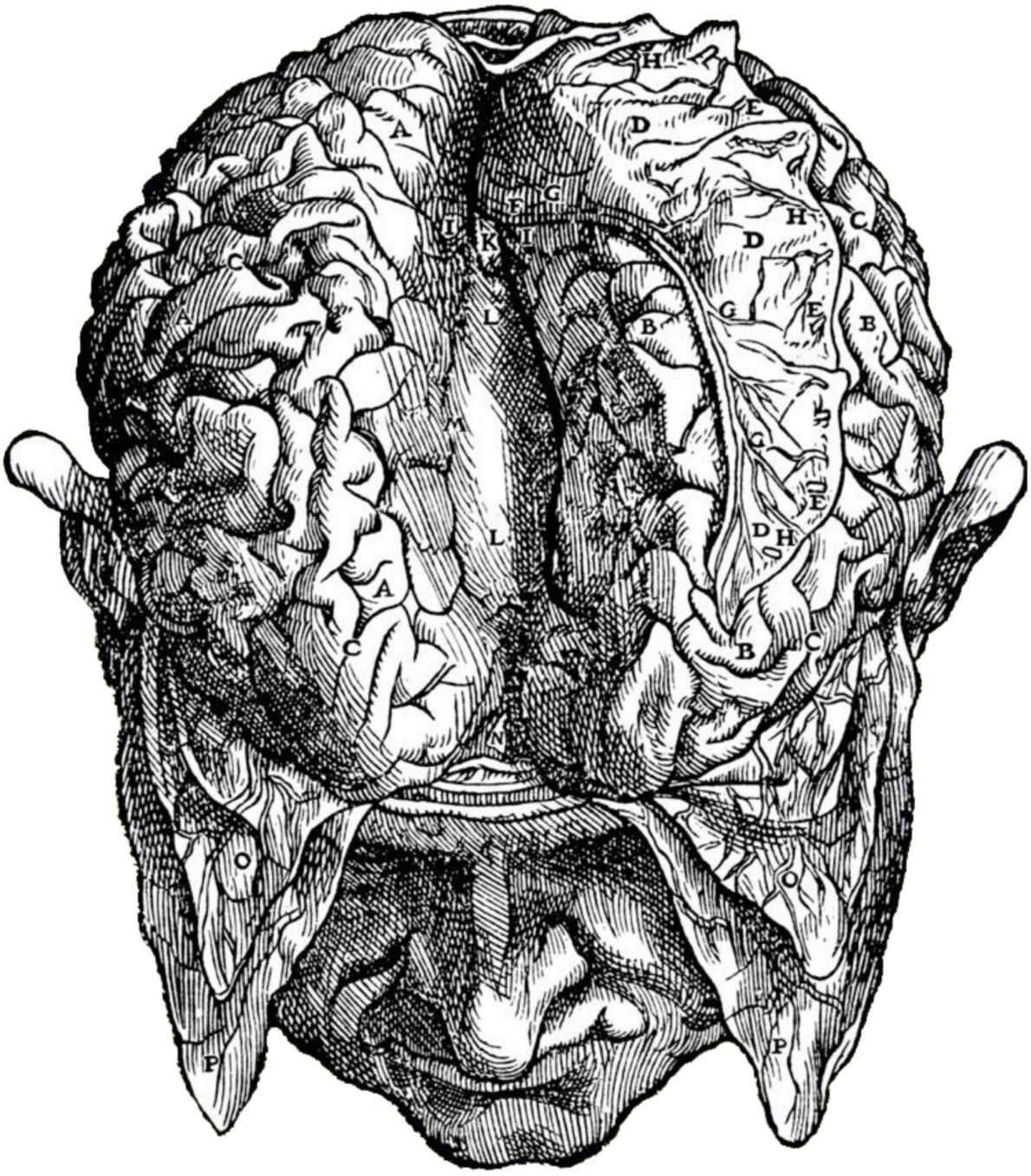
Looking at the Human Brain: from Vesalius to the Present

Andreas Vesalius (1514-1564) published his *De Humani Corporis Fabrica* (On the Fabric of the Human Body) in 1543 (O'Malley, 1964). This book, based on dissections of human cadavers, provided illustrations of the human brain that were both anatomically correct and esthetically pleasing. The scientists that followed Vesalius expanded on our knowledge, and produced their own representations of the human brain. This essay traces the evolution of these pictures.

The View from Above

One of Vesalius' most striking illustrations shows the head of a man with the top of his skull (calvarium) removed (Catani & Sandrone, 2015, p 220). The cerebral meninges (membranes) – composed of the dura mater (tough mother, P in the illustration) and the arachnoid mater (spidery mother, O) – were cut in the midline and then folded down over the edge of the skull. The cerebral hemispheres (A and B) were spread apart and the falx cerebri (cerebral sickle, D) was pulled up and folded over the left hemisphere. This revealed the corpus callosum (tough body, L) connecting the two hemispheres. At the base of the falx cerebri was a large vein later known as the inferior sagittal sinus (F, G).



In 1656, Vesalius' illustration served as a model for Rembrandt's representation of the brain in *The Anatomy Lesson of Dr Deyman.* The original painting portrayed the professor and his students in much the same way as the earlier painting *The Anatomy Lesson of Dr Nicolaes Tulp* (1632). After the painting was damaged by fire in 1723, all that remains are the hands of the professor as he dissects the meninges, his assistant holding the calvarium, and the cadaver of the

recently executed thief, Joris Fonteyn, also known as “Black Jan:”

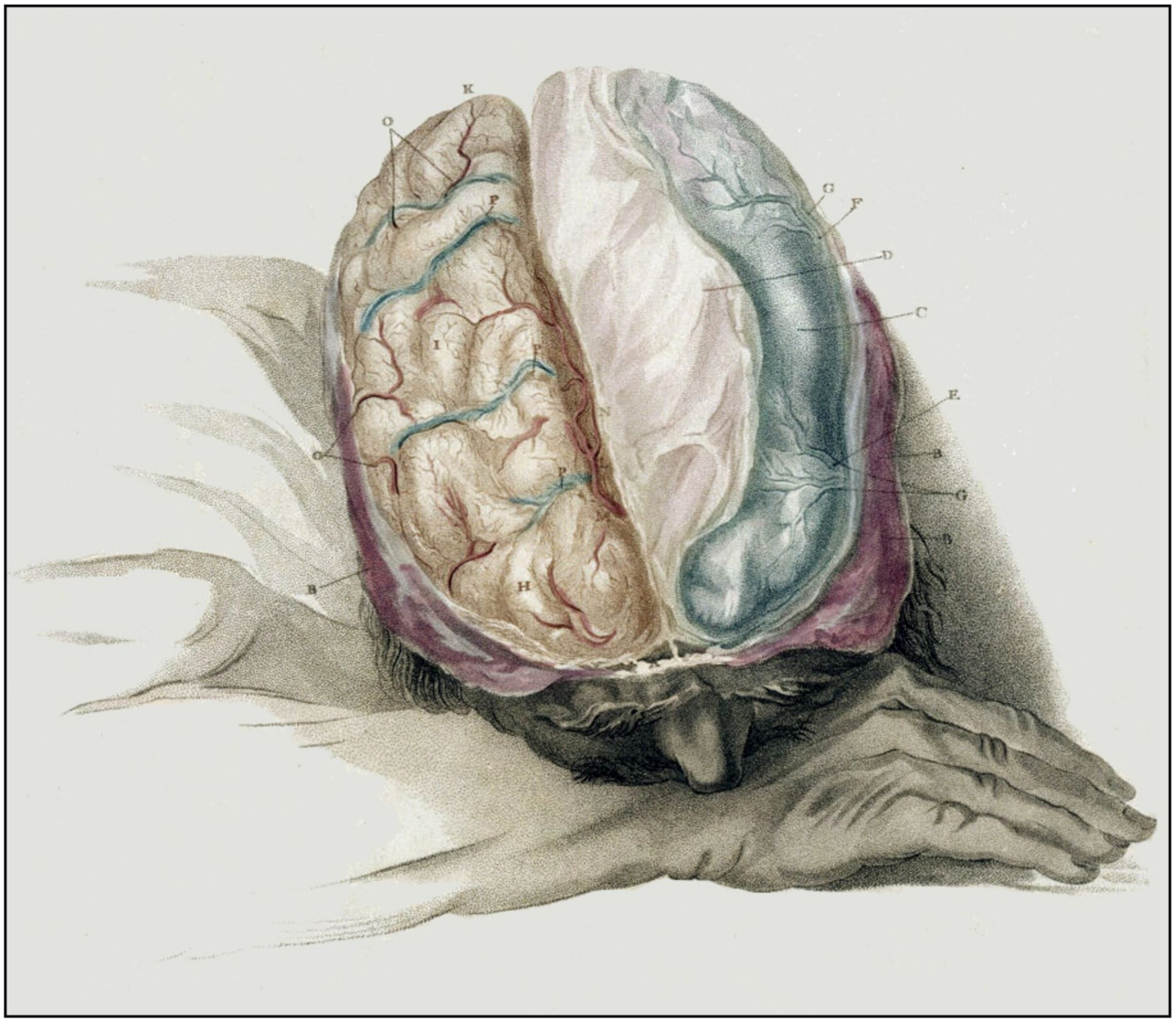
Anne Carson wrote a brief prose poem about the painting in her *Short Talks* (1992):*

> A winter so cold that, walking on the Breestraat and you passed from sun to shadow, you could feel the difference run down your skull like water. It was the hunger winter of 1656 when Black Jan took up with a whore named Elsje Ottje and for a time they prospered. But one icy January day Black Jan was observed robbing a cloth merchant’s house. He ran, fell, knifed a man and was hanged on the twenty-seventh of January. How he fared then is no doubt known to you: the cold weather permitted Dr. Deyman to turn the true eye of medicine on Black Jan for three days. One wonders if Elsje ever saw Rembrandt’s painting, which shows her love thief in

> violent frontal foreshortening, so that his pure soles seem almost to touch the chopped-open cerebrum. Cut and cut deep to find the source of the problem, Dr. Deyman is saying as he parts the brain to either side like hair. Sadness comes groping out of it.

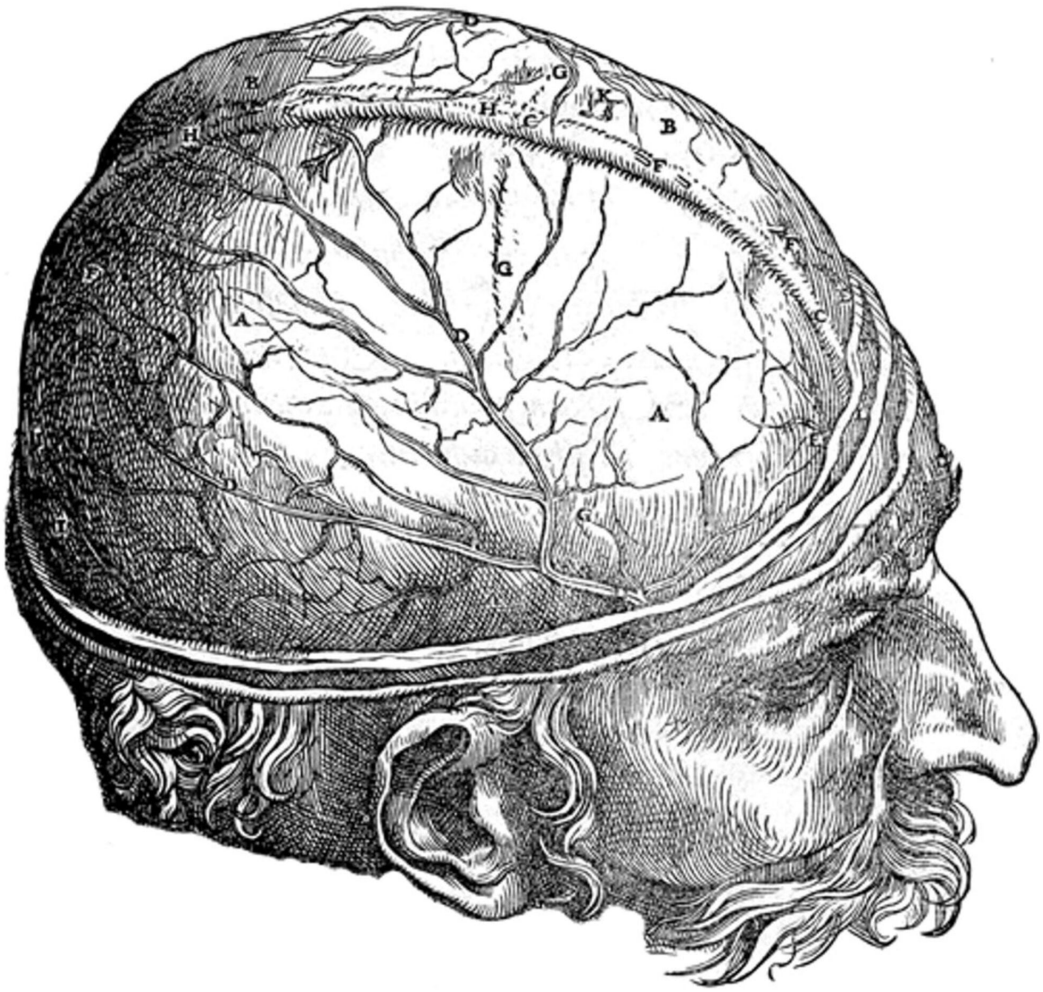
Carson uses two striking images: the transition from sun to shadow like water on the skull, and the parting of the brain like hair. She also remarks on the foreshortening – Rembrandt was using Mantegna's *Lamentation of the Dead Christ* (1480) as a model. And she sadly links the soles of the feet to the soul of Black Jan, recently released from his cerebrum.

In a series of engravings to illustrate the brain (1802), Charles Bell produced a delicately colored view of the brain and meninges (available from the Wellcome website) very similar to that of Vesalius. The dura mater (B) is folded away. The arachnoid mater is preserved over the left hemisphere. The arachnoid mater (D) from the right hemisphere is folded over the left hemisphere. Bell identified anterior middle and posterior lobes (H, I, K) in the right hemisphere but these were not clearly demarcated. Deep in the cerebral fissure can be seen the corpus callosum (L) and the anterior cerebral artery (M).

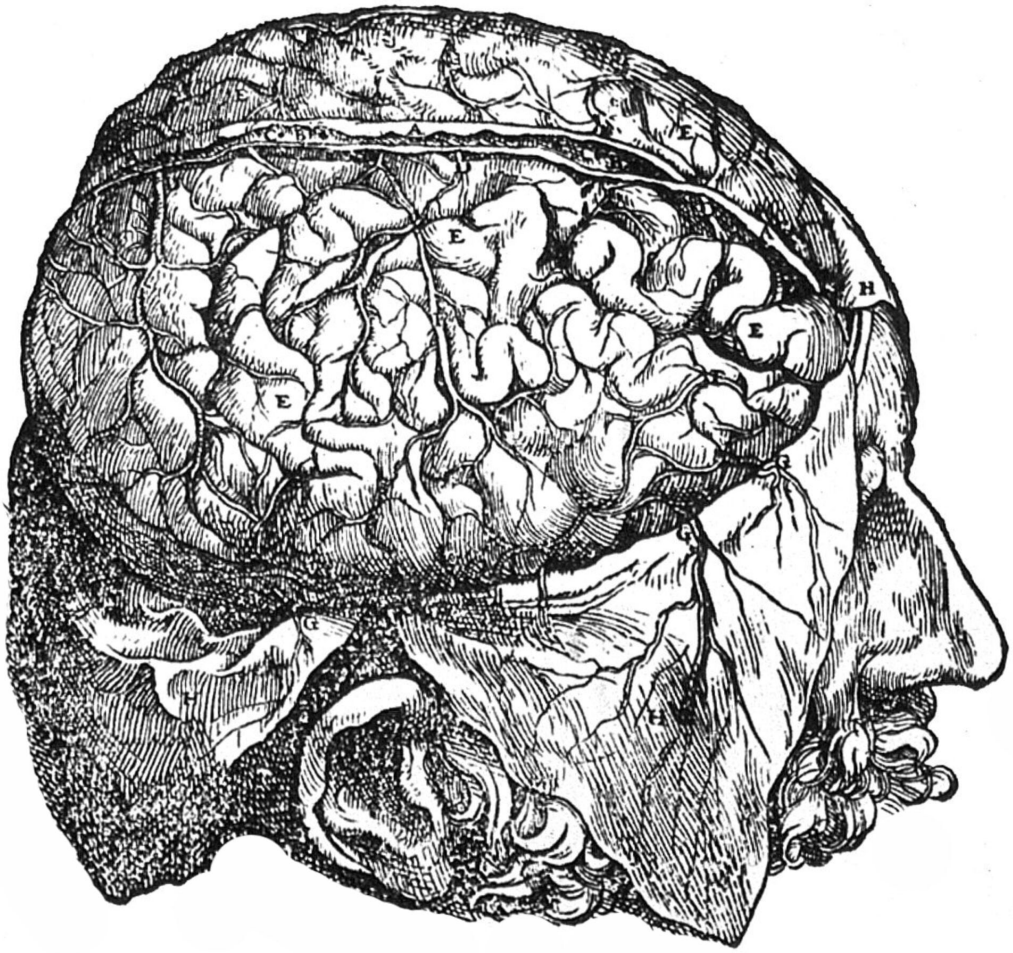


The View from the Side

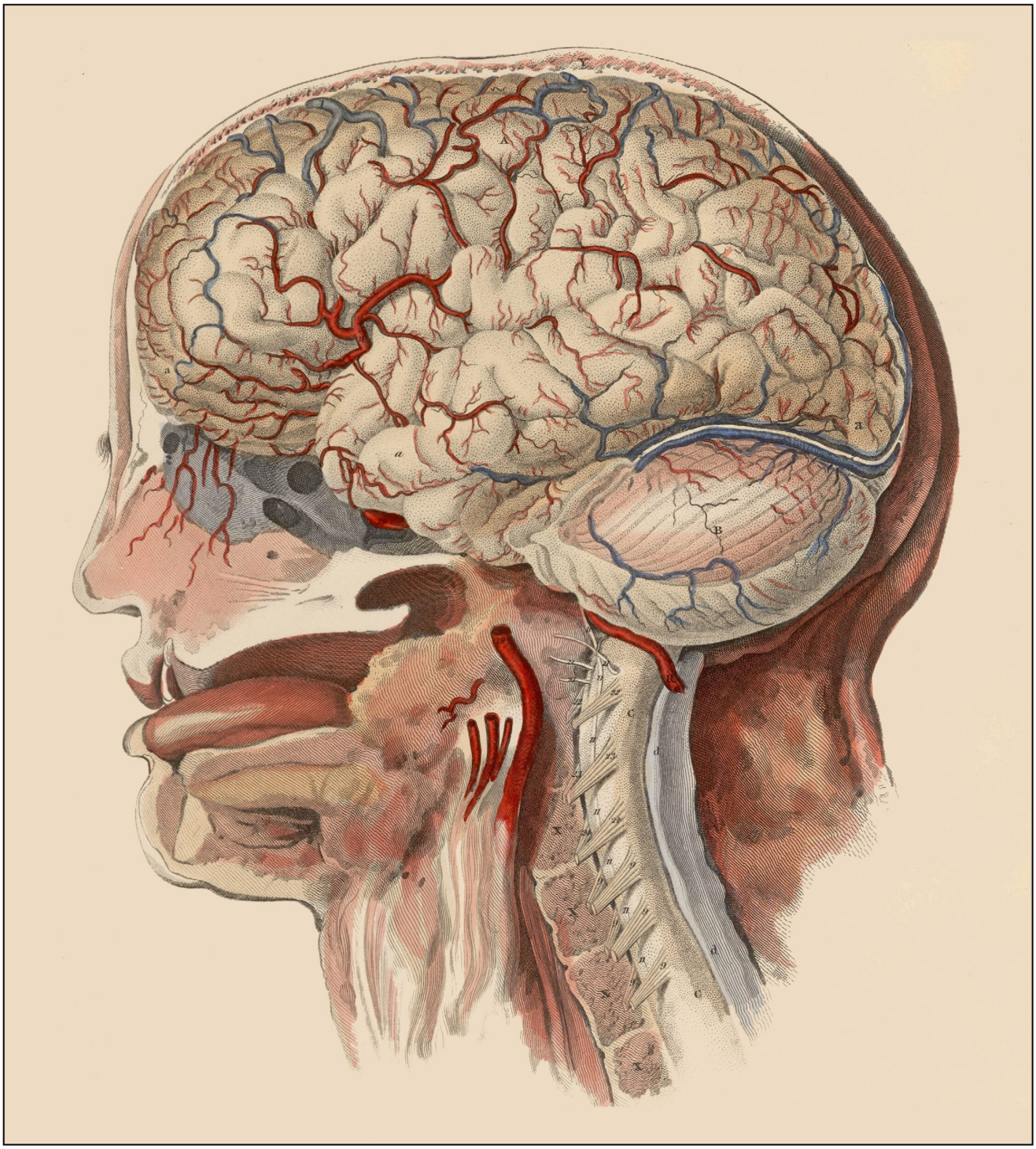
The first illustration of the brain in Vesalius’ book shows the dura mater looks viewed from the side once the skull has been removed. Of note are the superior sagittal sinus (C), and the paired blood vessels (D) that we now know as the middle meningeal artery and vein. This was before William Harvey’s 1628 differentiation of the arteries and veins



The dura was cut through and both dura and arachnoid mater werefolded down over the edge of the skull to reveal the underlying brain. Vesalius made no effort to delineate the cerebral surface accurately. The cerebral gyri are reminiscent of the random coils of the small intestine.

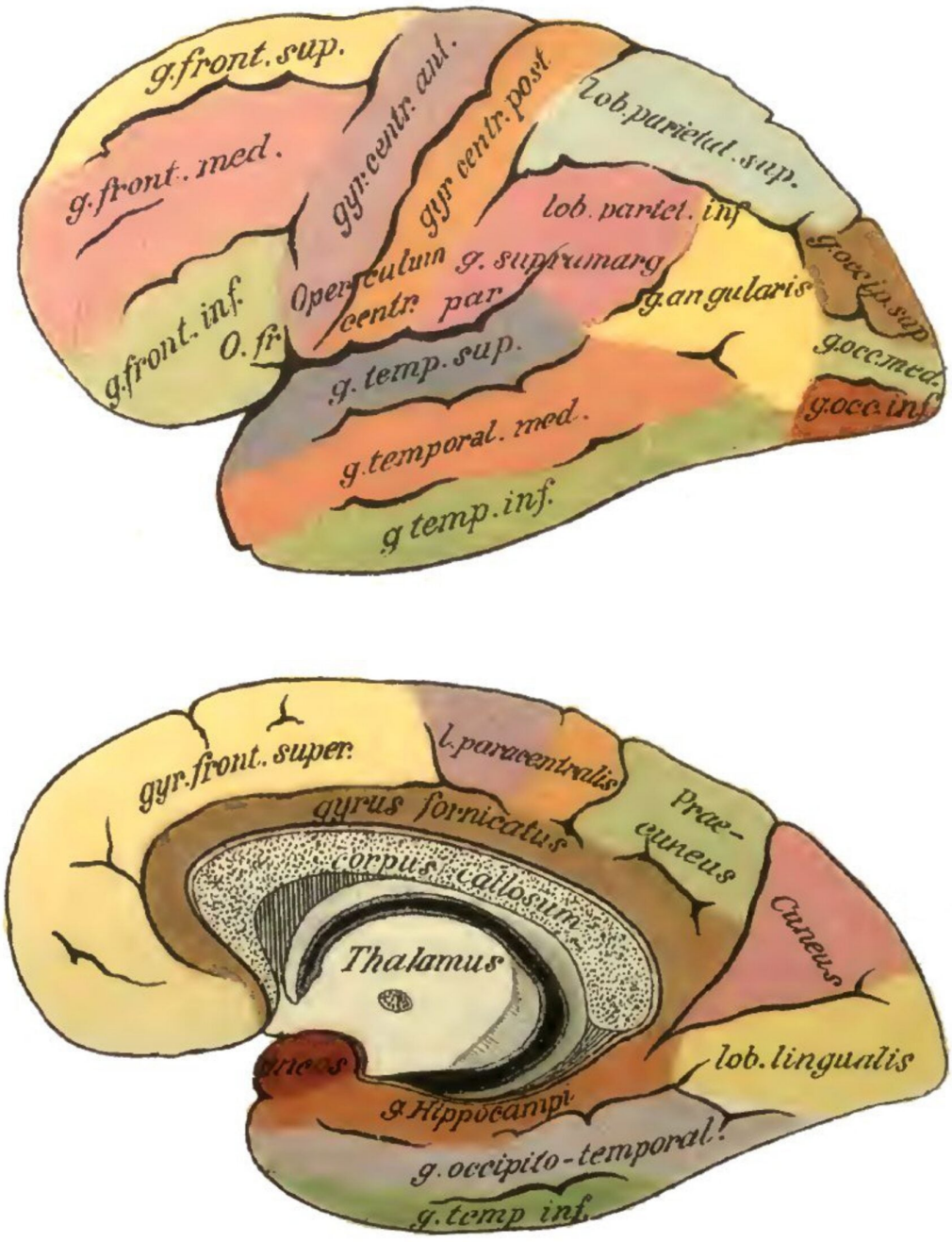


It was not really until the 19th Century that more realistic depictions of the cerebral gyri and sulci became available. The following illustration is from a series of beautiful hand-colored etchings produced by the surgeon John Lizars and his father Daniel Lizars in about 1825. The cerebrum and the cerebellum are well represented, together with their arteries and veins (with their red and blue colors accentuated). However, the orientation of the brainstem and its connections to the spinal cord are quite distorted.



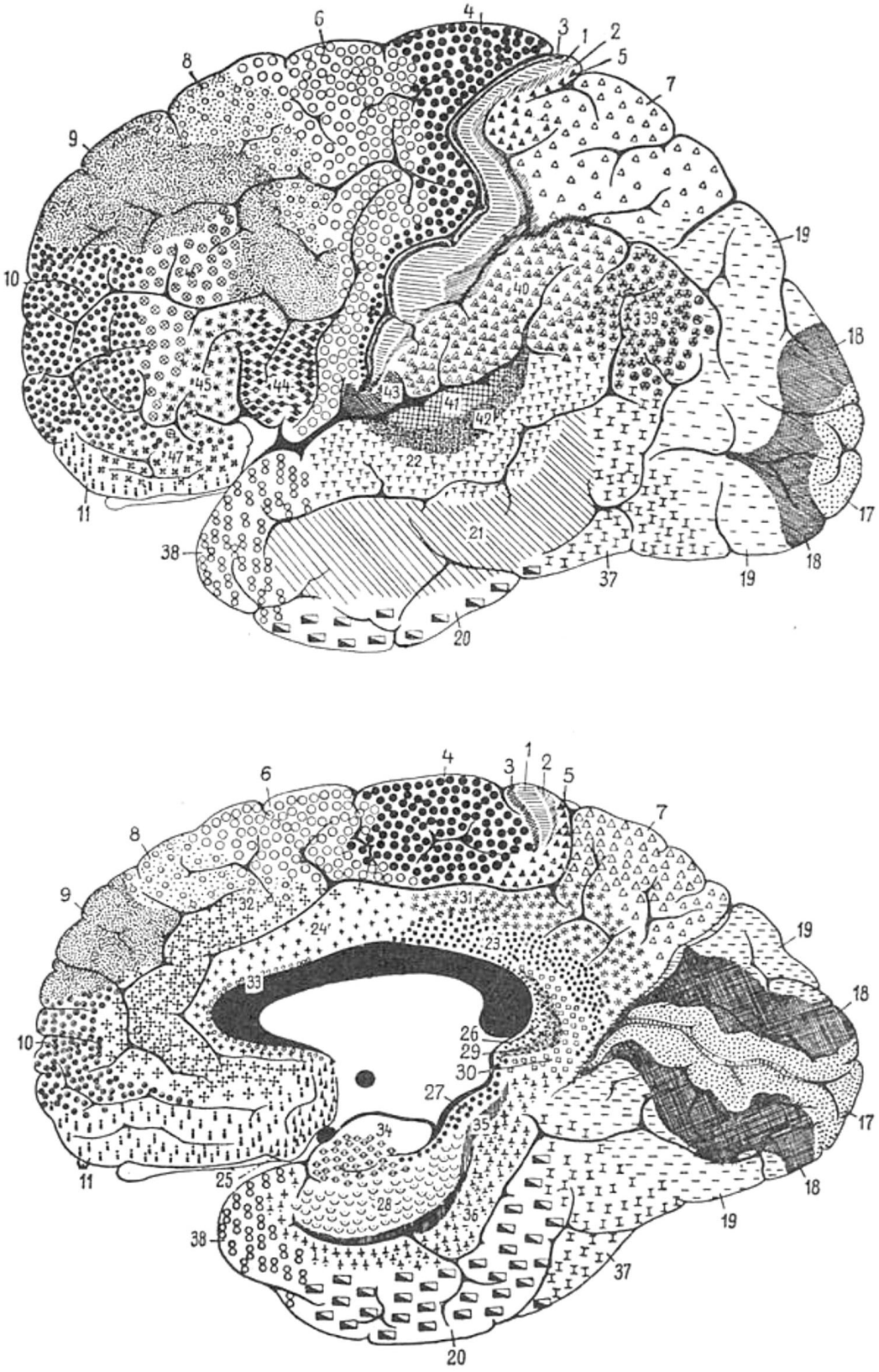
It was not until late in the 19th Century, as physiologists began to study the localization of function, that images distinguished the different gyri of the cerebrum. The following illustration is from the atlas of Christfried Jakob (1895). The gyrus fornicatus (arched), now known as the cingulate (girdle) gyrus, is an important part of the limbic system which mediates visceral sensation, emotion and memory.

The word fornication (extramarital sex) derives from ancient brothels, which often provided vaulted or arched chambers for their clients.



In 1909 the German anatomist Korbinian Brodmann further differentiated the cerebral cortex into 52 regions based on microscopic analysis of the cortical structure (Brodmann,

1909, p 131)

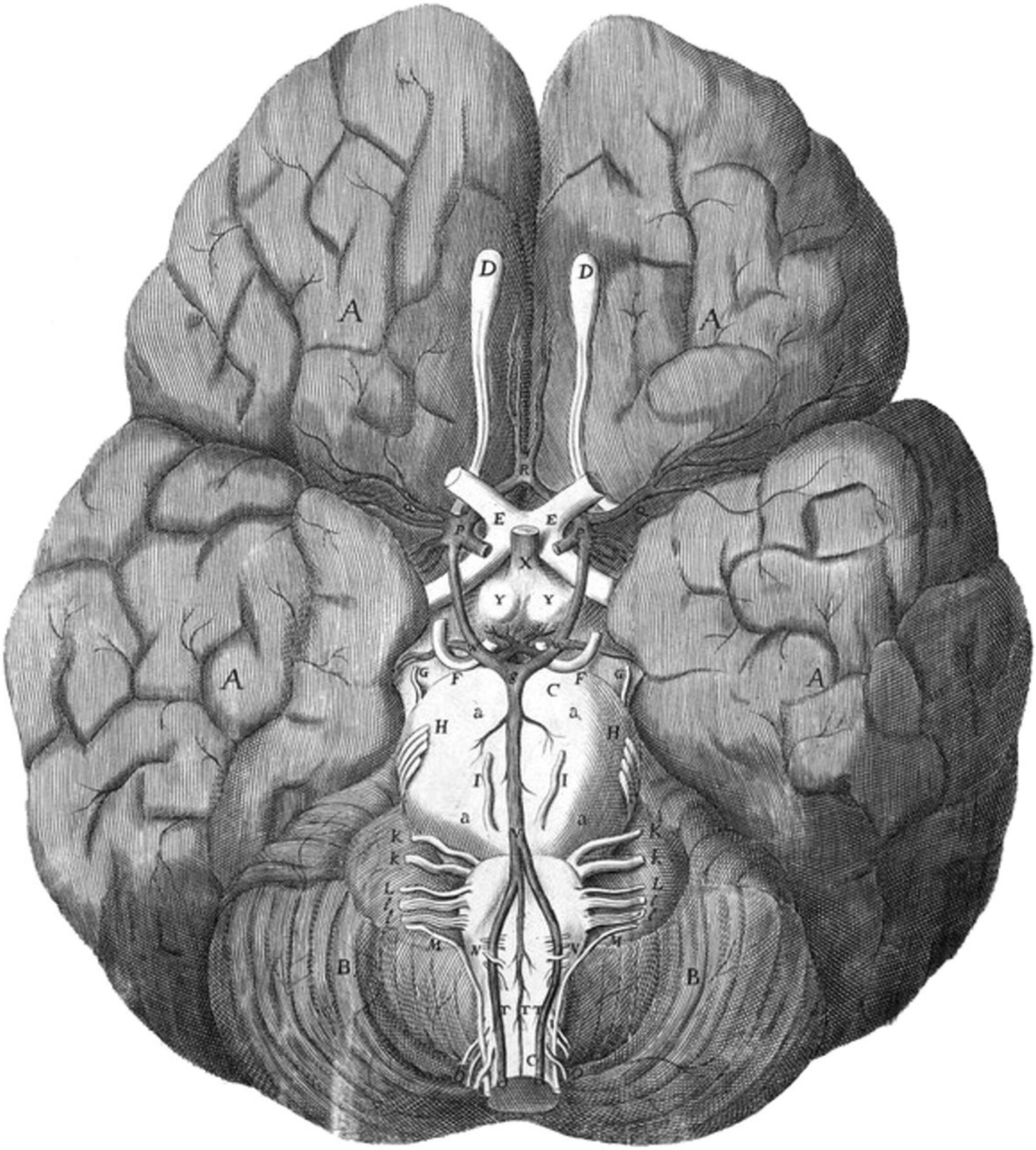


Areas 1, 2, and 3 represent the primary somatosensory cortex

on the postcentral gyrus. Area 4 is the primary motor cortex on the precentral gyrus. Area 17 is the primary visual cortex is the primary visual cortex located in and around the calcarine fissure. Areas 41 and 42 are auditory areas located on the superior surface of the temporal lobe. The areas are similar in the brains of other primates. However, area 10 in the frontal lobes and areas 39 and 40 at the temporoparietal junction are particularly important. In the human brain.

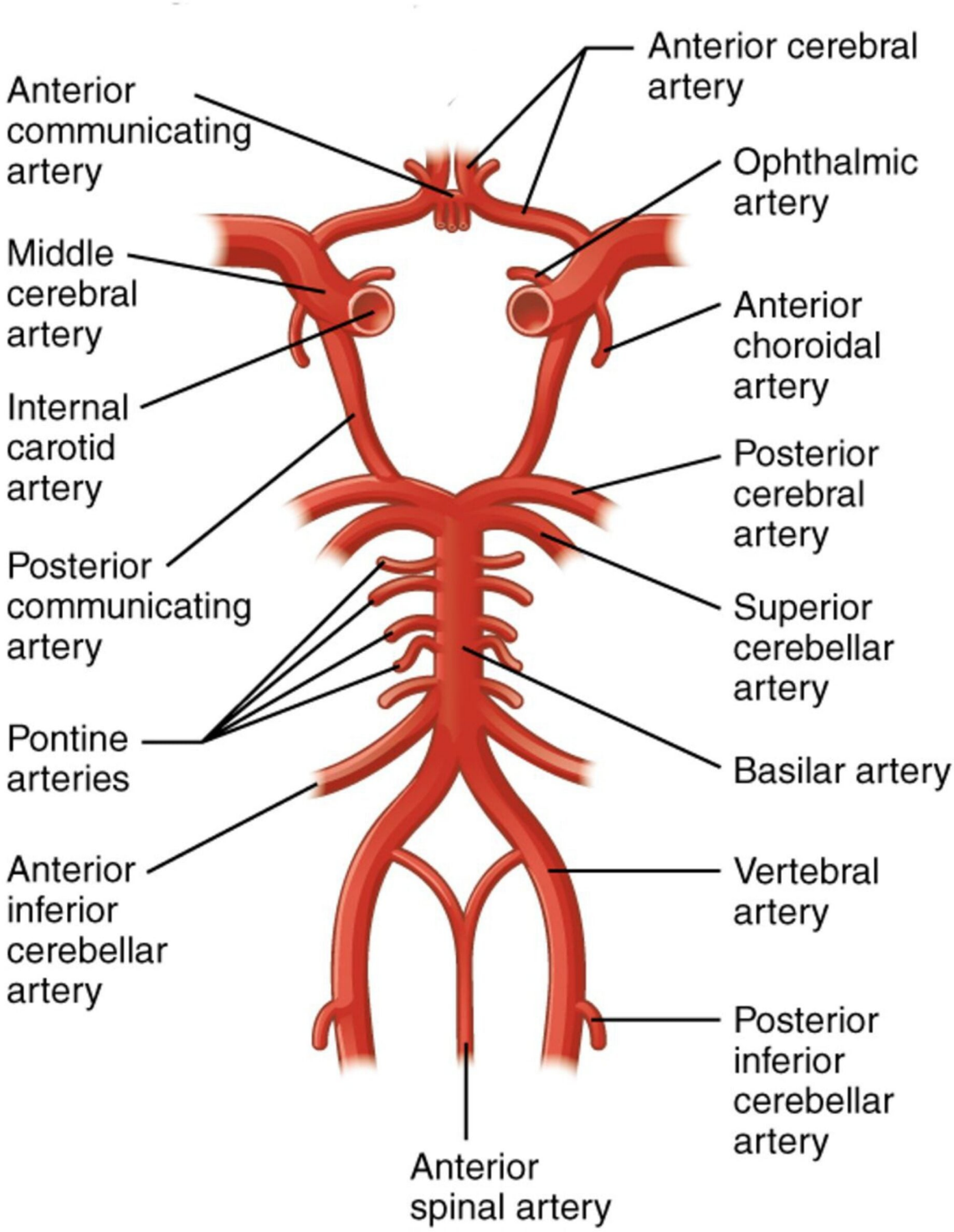
The View from Below

There is an illustration of the human brain viewed from below in Vesalius' book, but it is "still relatively crude and the brain stem in particular is unlife-like" (Clarke & Dewhurst, 1972, p 62). In his *Cerebri Anatome* (1664), Thomas Willis provideded what has become the classical view of the base of the human brain. The original drawing was by Christopher Wren, the architect of St Paul's cathedral (Scatliff & Johnston, 2014).



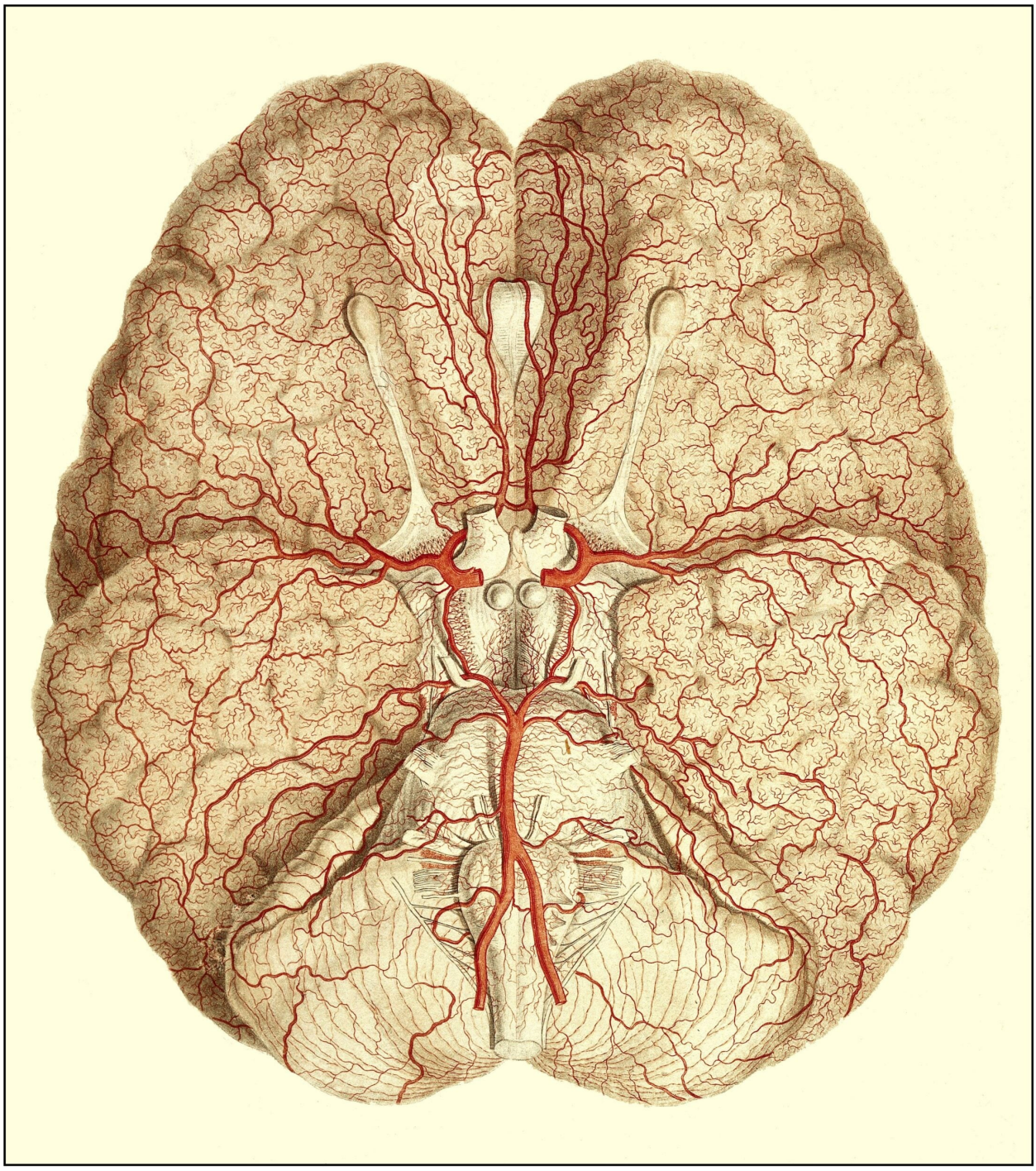
The drawing clearly demarcates the structures at the top of the brain stem: the olfactory bulb and tract (D), the optic nerve and chiasm (E), the stalk of the pituitary gland (X), and the mammillary bodies (Y). Willis shows cranial nerves of the midbrain: the oculomotor nerve (F), the trochlear nerve (G). The trigeminal nerve (H) is properly located. The lower

cranial nerves are not well demarcated. These were not clearly distinguished until the work of Samuel Soemmerring in 1778 (Storey, 2022). One of the most important aspects of Willis's illustration is that it shows the connections between the arteries supplying the brain: the circle of Willis (illustrated below). His drawing shows the complete circle but the arteries supplying the cerebellum are missing.



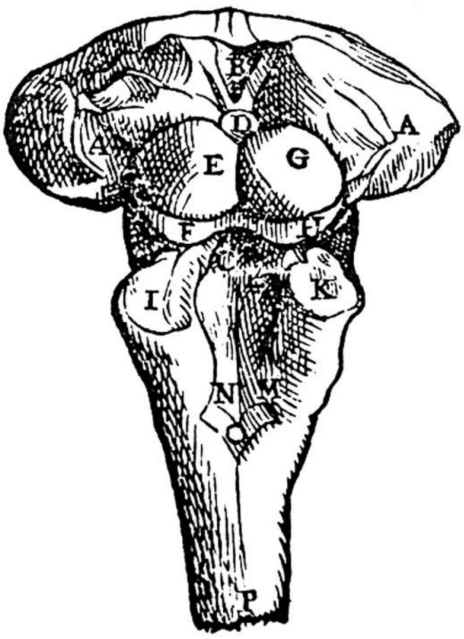
Félix Vicq-d'Azyr produced a more colorful version of the basal brain in 1786 (Plate XIX). The beautiful plates for his book were produced by the engraver Alexandre Briceau. The cerebellar arteries are shown, and the frontal lobes are

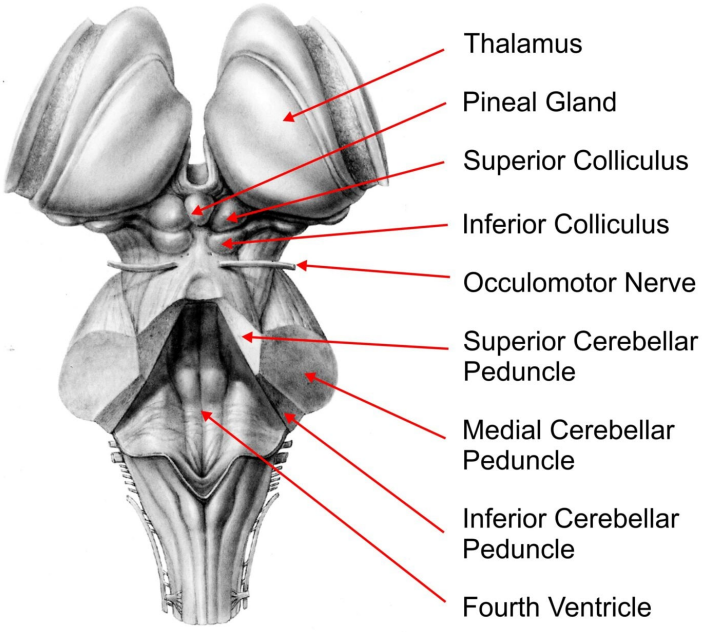
separated to reveal the corpus callosum:



Views of the Brain Stem

After removing the cerebral hemispheres and the cerebellum, the dorsal aspect of the brainstem becomes visible. Vesalius' drawing of the brain stem is shown below together with a more anatomically correct diagram (derived from Martin, 2012):

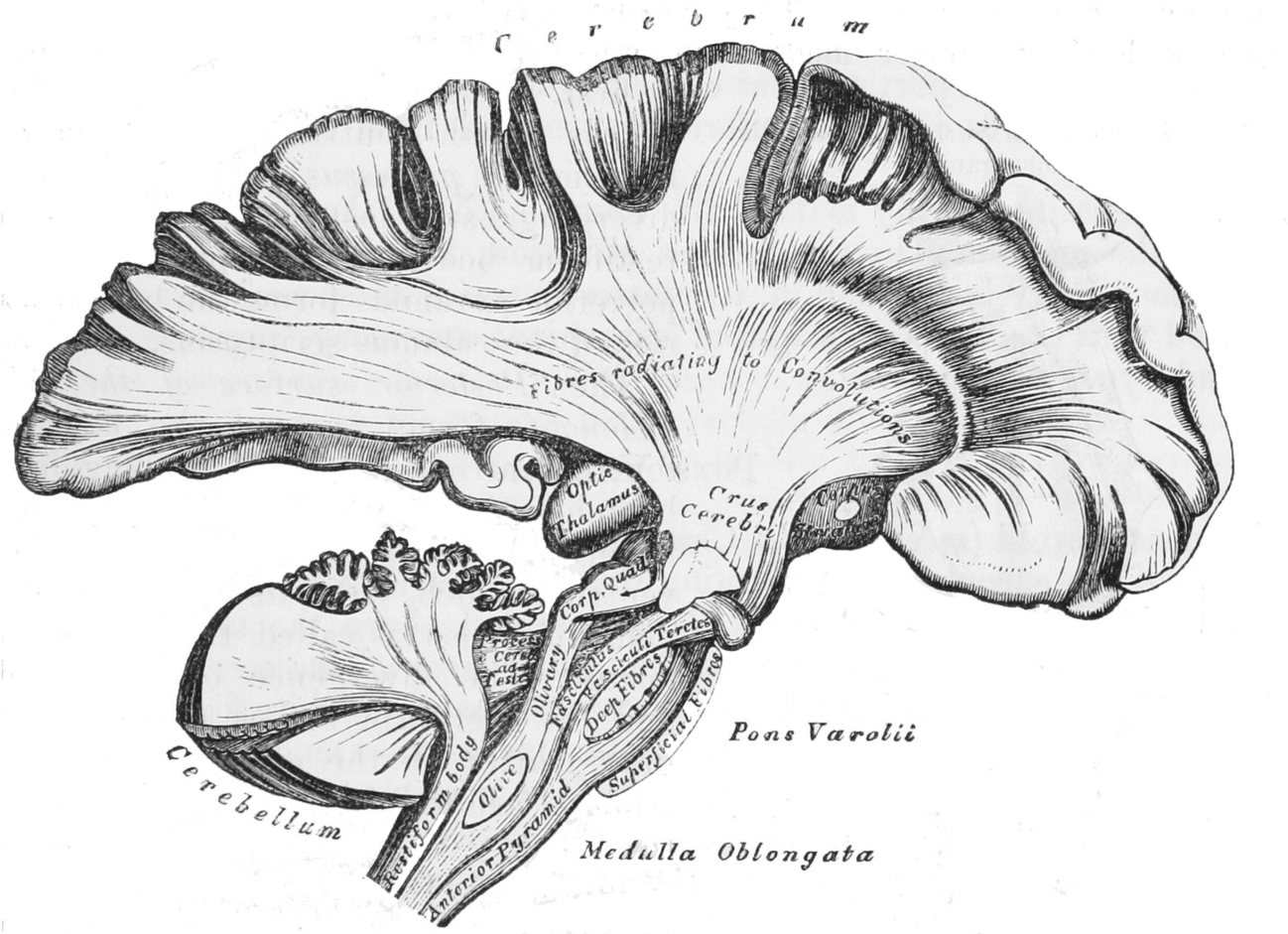


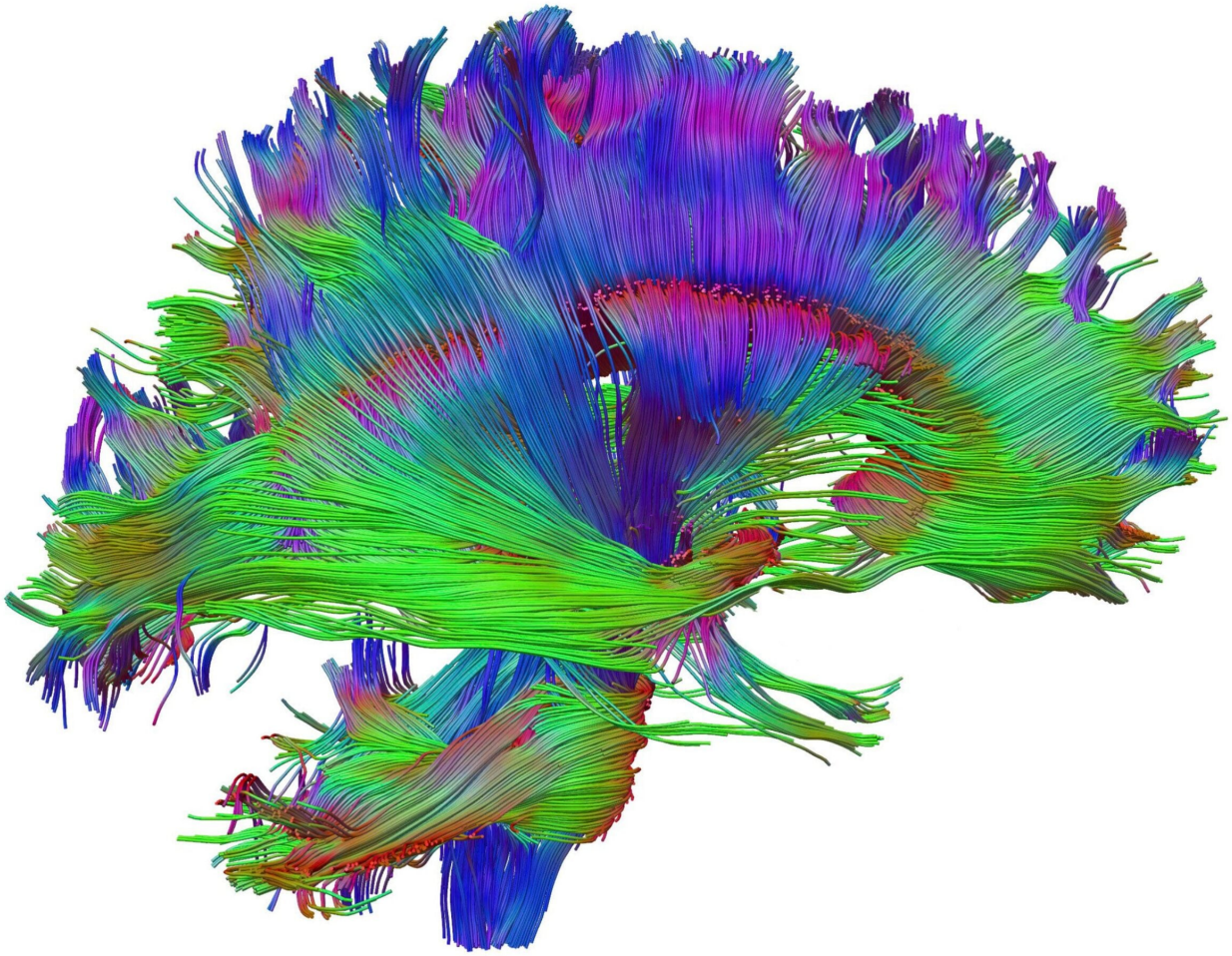


Vesalius got a little carried away in describing this view of the brainstem (Catani & Sandrone, 2015, pp 124-130). He envisioned the upper part of the brainstem as the male perineum, likening the pineal gland (D) to the penis, the superior colliculi (E, G) to the testes and the inferior colliculi (F, H) to the nates (buttocks). He was unclear as to how the cerebellum was attached to the brain stem, noting only the connections to the dorsal spinal cord through the inferior peduncles (I, K).

It is impossible to discern the functions of the brain stem by simply looking at its surface anatomy, and the names assigned to the surface features have little relevance to what goes on beneath. To understand the brainstem one first needs to determine the pathways between the different regions. The anatomy of pathways in the brain stem and cerebrum was determined in the 19th Century by dissection and later by histological studies. The following figure shows an illustration from the first edition of Gray's Anatomy (1858, p 453). This can be compared to a recent analysis of brain pathways obtained by Flavio dell'Acqua (Wellcome website) using Diffusion Tensor Imaging (DTI), a specialized form of

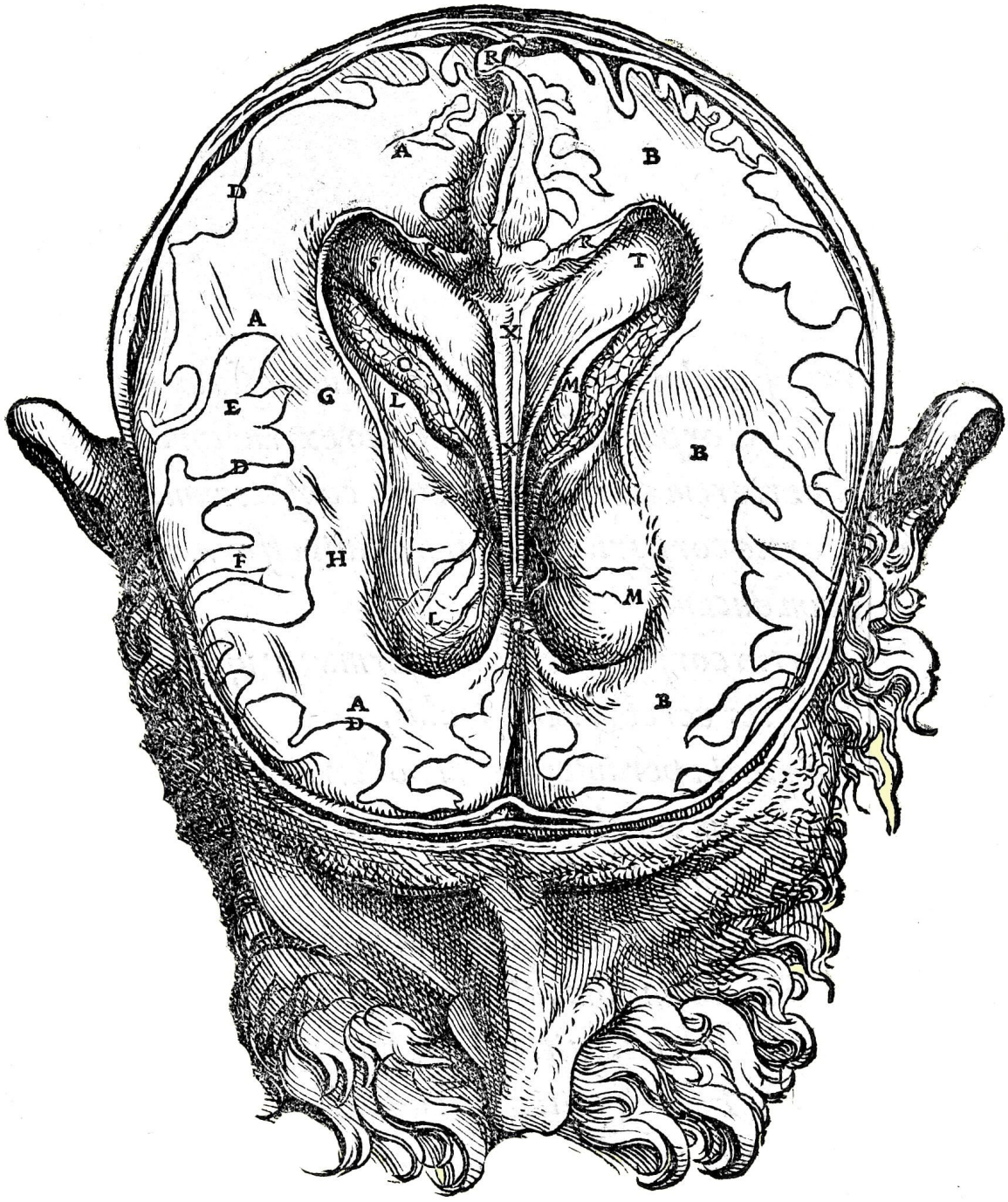
Magnetic Resonance Imaging (MRI). Pathways connecting different regions of the brain are colour-coded: fibers travelling up and down are blue, front to back are green, and left to right are red. The DTI image has been left-right reversed to facilitate comparison. The red fibers in the upper part of the figure represent the commissural fibers of the corpus callosum. The green fibers in the lower part of the figure show the ponto-cerebellar fibers connecting the nuclei on the pons to the cerebellum through the middle cerebellar peduncle. These fibers are not seen in the illustration of Gray and Carter.





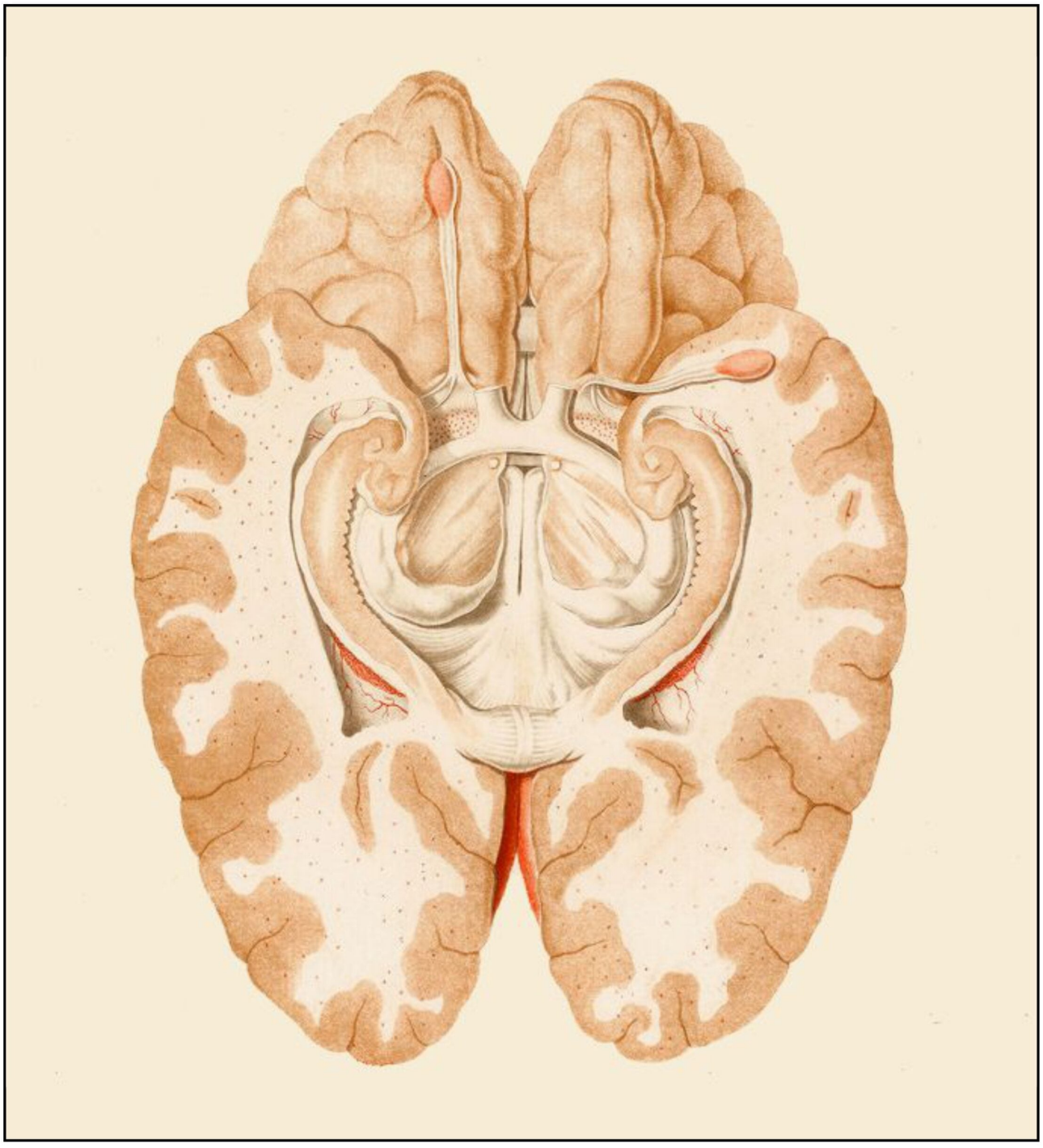
The Brain in Axial Section

Vesalius included in his book several sections though the brain, one of which is shown below. He was mainly concerned with the cerebral ventricles, which were then thought to contain the vital spirits. In the illustration, the anterior portion of the corpus callosum (R) and much of the septum pellucidum (Y) have been bent backward to reveal the lateral ventricles. The lower part of the septum (X) remains. Within the ventricles can be seen the choroid plexus (O). Vesalius distinguished between the gray and white matter but did not otherwise concern himself with the internal structure of the cerebral hemispheres.



The following illustration is from Vicq d'Ayr's 1786 treatise shows a section through the brain at a lower level than in Vesalius' section. The illustration also differs from Vesalius by viewing the section from below rather than from above and by placing the front of the brain at the top. The section shows the hippocampus in the medial wall of the temporal horn of the lateral ventricle. The viewer is charmed by the fact that the left olfactory tract and bulb have been insouciantly turned to lay laterally over the cut surface of the anterior

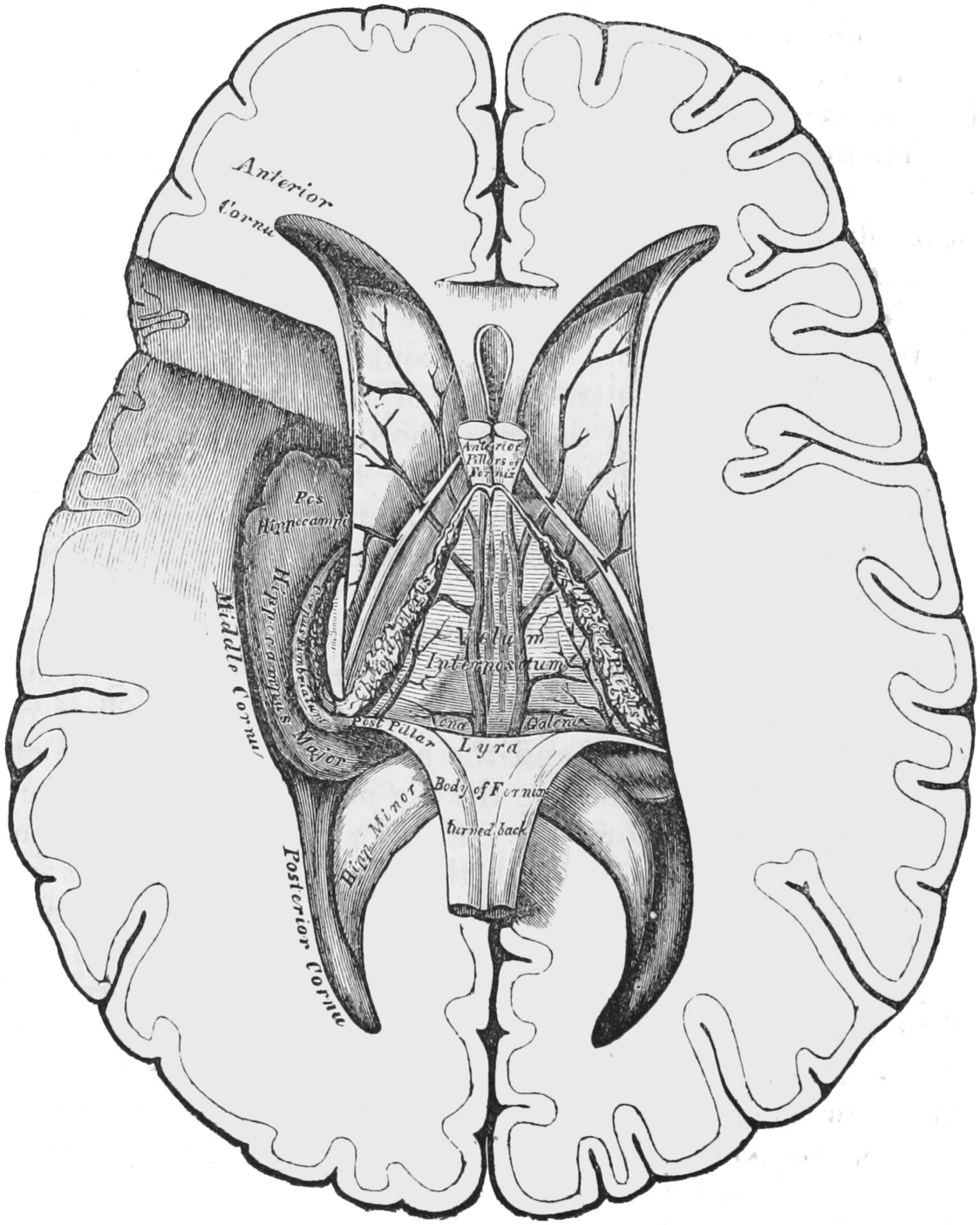
temporal lobe.



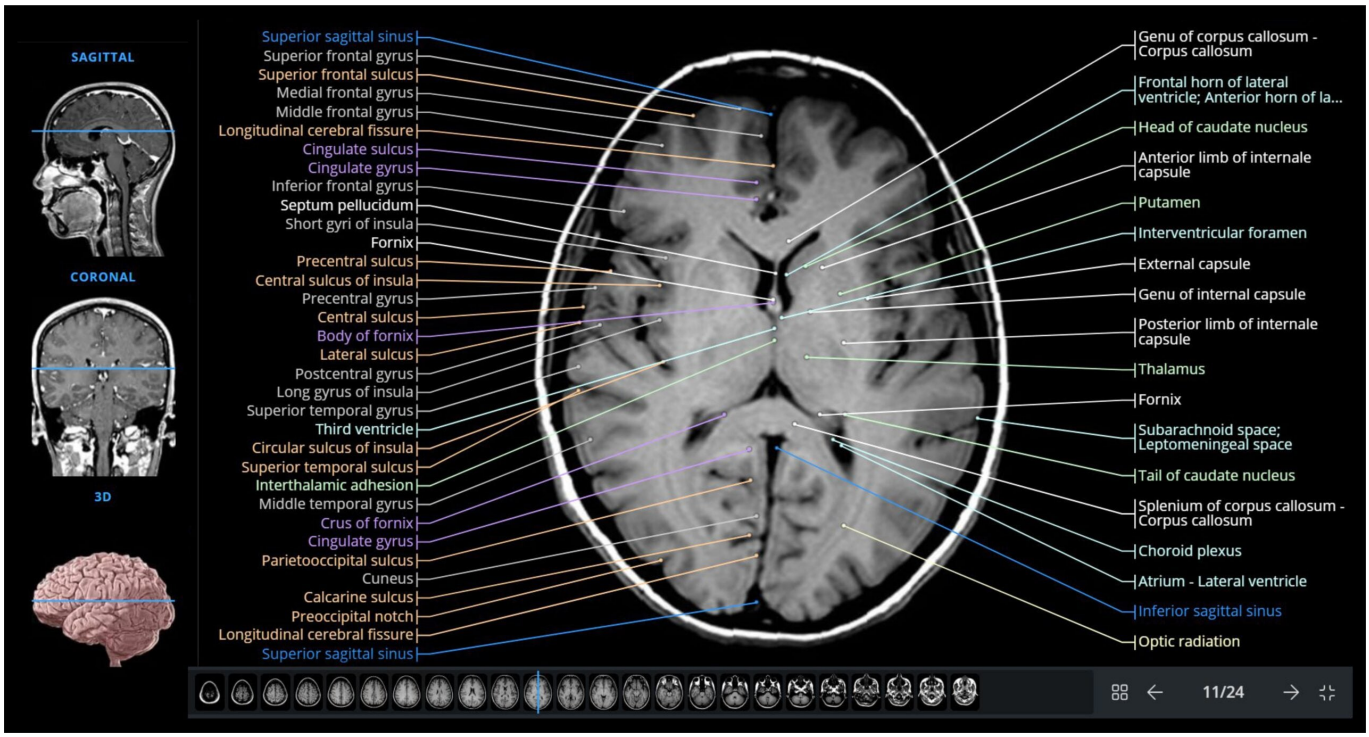
Vicq d’Azyr was fascinated by the structures lying deep within the brain that we now call the limbic system (Parent, 2007). He showed that the major output from the hippocampus was through a bundle of fibers called the fornix that arched around underneath the corpus callosum and then descended to the mammillary body in the hypothalamus. The mammillary bodies

than connected to the anterior nucleus of the thalamus through the mammillo-thalamic tract, often known as the tract of Vicq d’Azyr.

The relations between the Vesalius section and that of Vicq d’Azyr can be understood by studying an ingenious illustration from the first edition of Gray’s Anatomy (Gary & Carter, 1858, p 464) The right side of the illustration is similar to the view of Vesalius. On the left side, the section has been dissected more deeply to reveal the hippocampus as in the section by Vicq d’Azyr. The triangular membrane beneath the corpus callosum (*lyra*) has been cut through the descending parts of the fornix and bent backwards. This both reveals the superior aspect of the thalamus and also allows one to imagine the true course of the fornix as it curves upward, forward and then back down. This approach derives from a similar (though less effective) illustration from Vicq d’Azyr (Plate XIV). The drawing by Henry Vandyke Carter is a marvelously lucid (Richardson, 2008). One of Carter’s characteristics was to write the name directly on the illustrated structure.



The illustration below shows a modern Magnetic Resonance Image of an axial section of the normal human brain (IMAIOS.com). The section is located between the levels of the Vesalius section and that of Vicq d’Azyr:

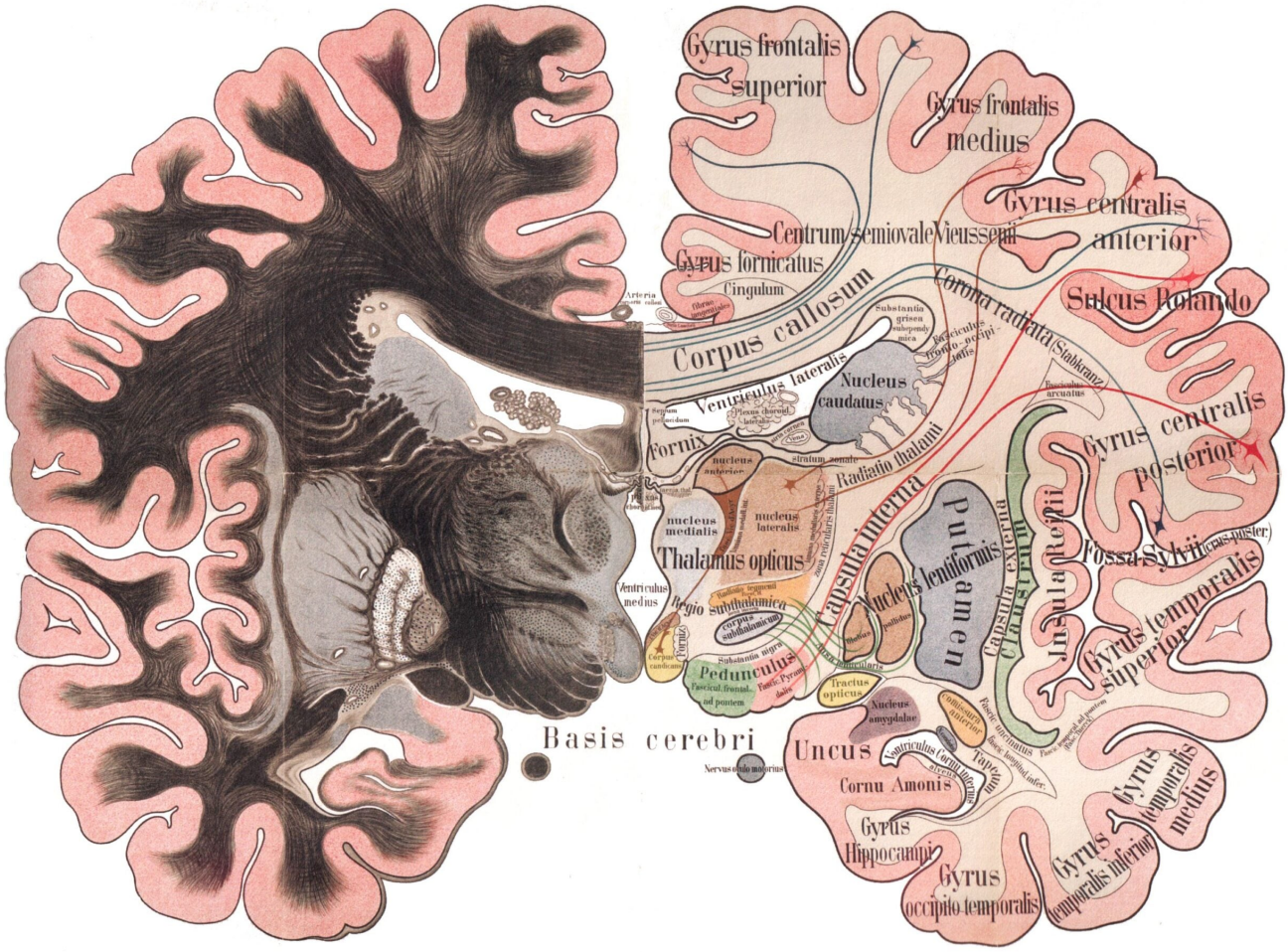


The Brain in Coronal Section

Vicq d'Azyr included several coronal sections of the brain in his 1786 treatise, one of which (Plate XXVI) is shown at the top of the next page. The structure of the nuclei and pathways are only faintly indicated, and the reproduction has been digitally darkened to enhance them. At the top can be seen the corpus callosum connecting the two hemispheres. In the center of the section are the basal ganglia (with their characteristically striped appearance: the corpus striatum) and the thalami. Below the basal ganglia can be seen the hippocampus in cross section.

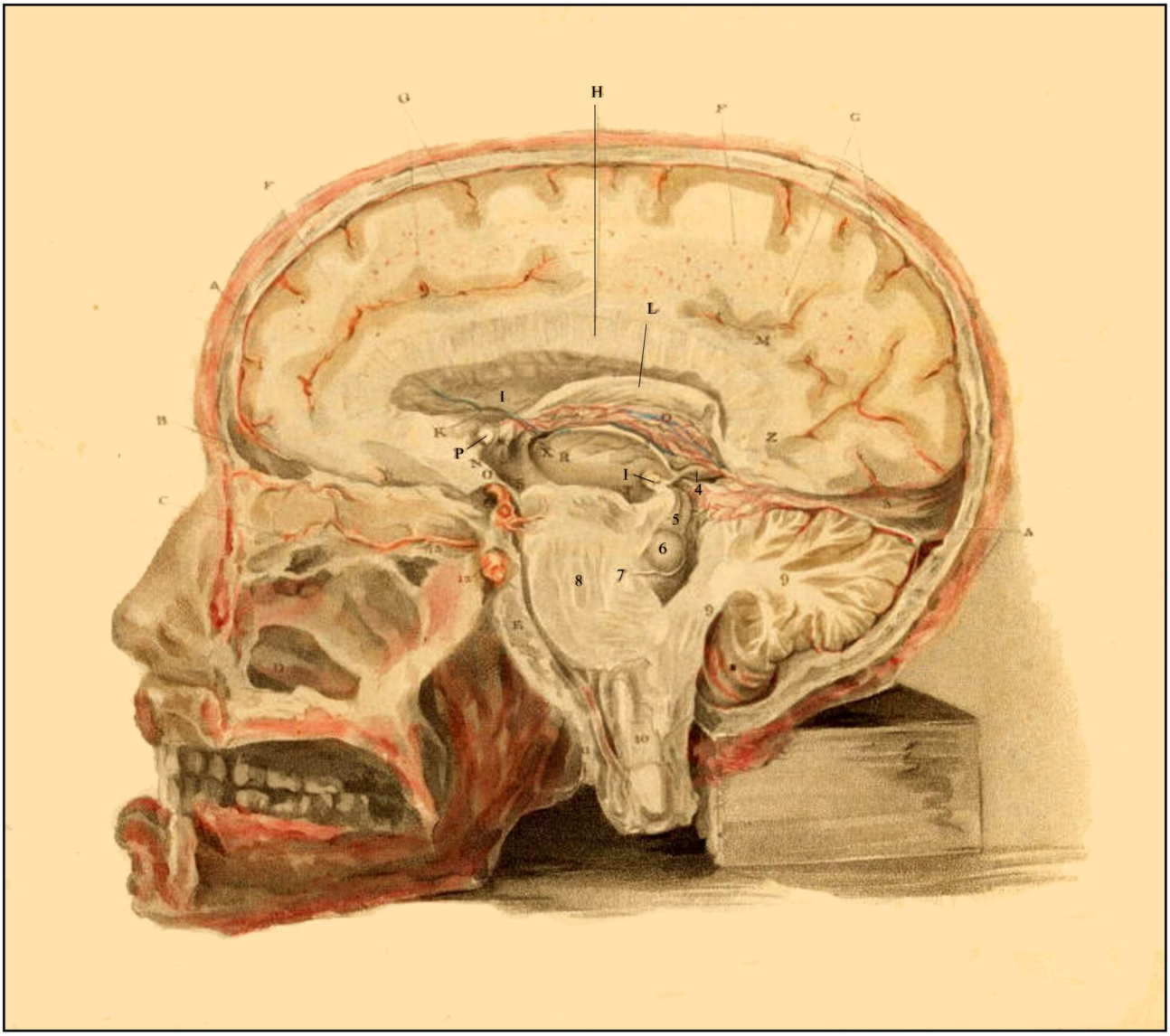
The structural details of the brain are better seen if the section is stained with chemicals that distinguish the grey and white matter. These only came into use in the late 19th Century. At that time physiologists began to study the connections between regions of the brain using electrical stimulation, and tracts were traced by studying the degenerative effects of focal lesions. At the bottom of the next page is a poster published in 1897 by Adolf von Strümpell, one of the founders of German neurology (Engmann et

al., 2012). The left side of the poster reproduces a stained section, and the right side shows a diagram delineating the nuclei and their connections. The descending fibers of the pyramidal tract are indicated in red: these fibers have their cell bodies in the pre-central cortex and travel through the internal capsule into the cerebral peduncle. Fibers connecting between the hemispheres through the corpus callosum are shown in grey. The green fibers represent the connections between the nuclei of the corpus striatum and the midbrain.



The Brain in Sagittal Section

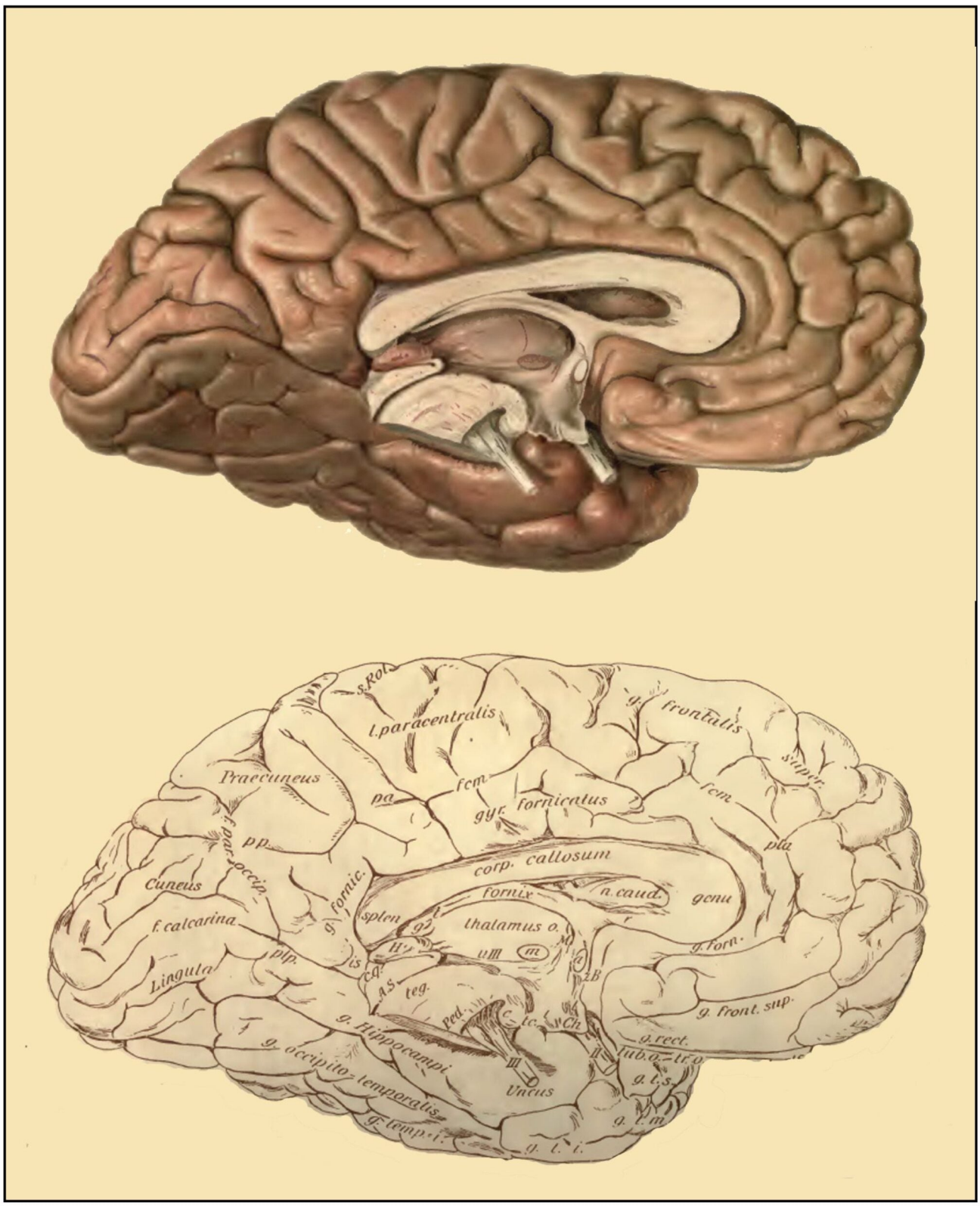
Charles Bell included in his 1802 series of engravings an illustration of the brain as viewed in a sagittal section taken just to the left of midline (Plate VII). Some of the lettering has been enhanced to facilitate the identification of the structures:



The section shows the corpus callosum (H), above the lateral ventricle (L) through which can be seen the septum pellucidum at the midline, the fornix (L), the anterior commissure (P), the third ventricle (R). Bell also identified the posterior commissure (1), the pineal gland (4), the superior and inferior colliculi (5, 6), (the testes and buttocks of Vesalius), the trochlear nerve (7) and the pontine nuclei (8).

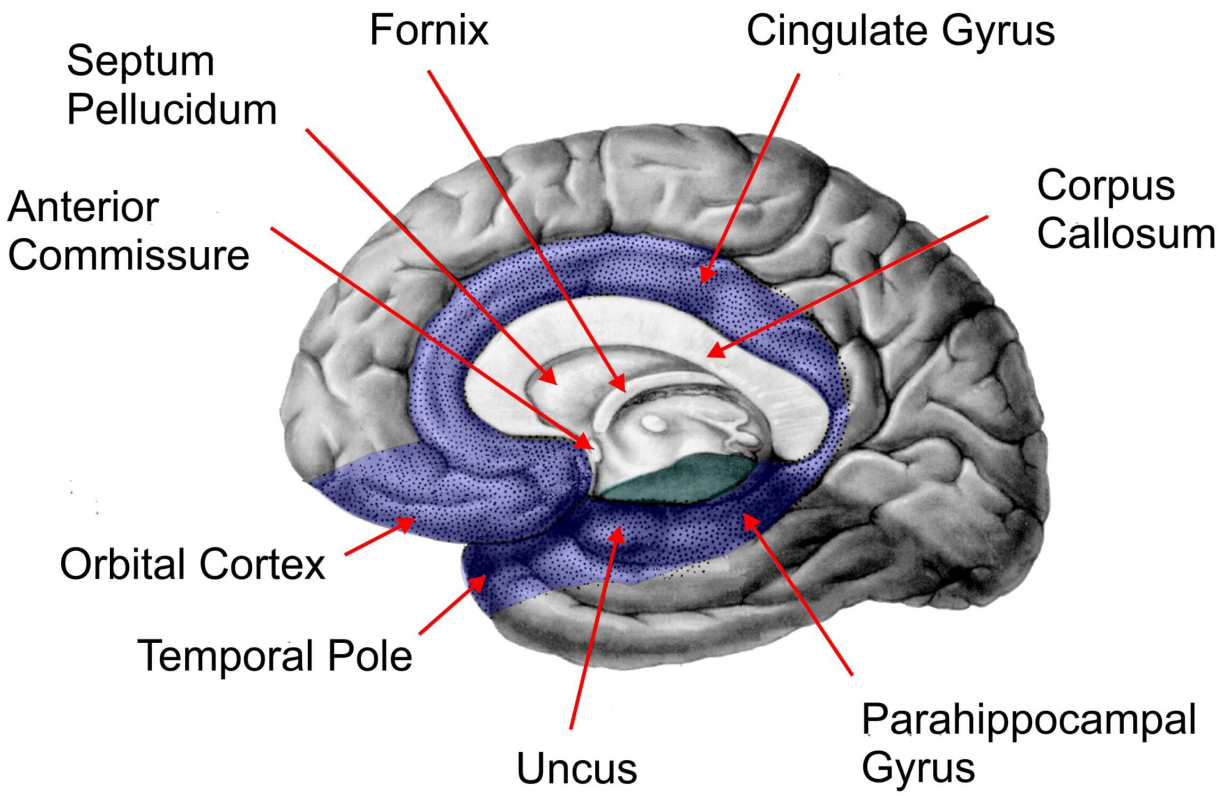
The mesial surface of the forebrain is shown in an illustration on the following page from Christfried Jakob's 1899 *Atlas of the Nervous System* (Plate 4). Jakob, who had served as an assistant to Adolph von Strümpell, produced the first edition of his magnificent atlas in 1895 when he was

only 29 years old. The second edition (1899) was soon translated into English.



Removing the brainstemfrom the hemisphere allows one to see the mesial surface of the temporal lobes, in particular, the

hippocampal gyrus and the uncus (hook, a term coined by Vicq d'Azyr) at its anterior end. Paul Broca (1878) proposed that the regions of the cerebral hemisphere surrounding the upper end of the brainstem formed an evolutionarily ancient limbic (*limbus*, edge) lobe of the brain (Pessoa & Hof, 2015). This region of the brain appeared to mediate visceral sensations and emotions. The following modern illustration is derived from Martin (2012):

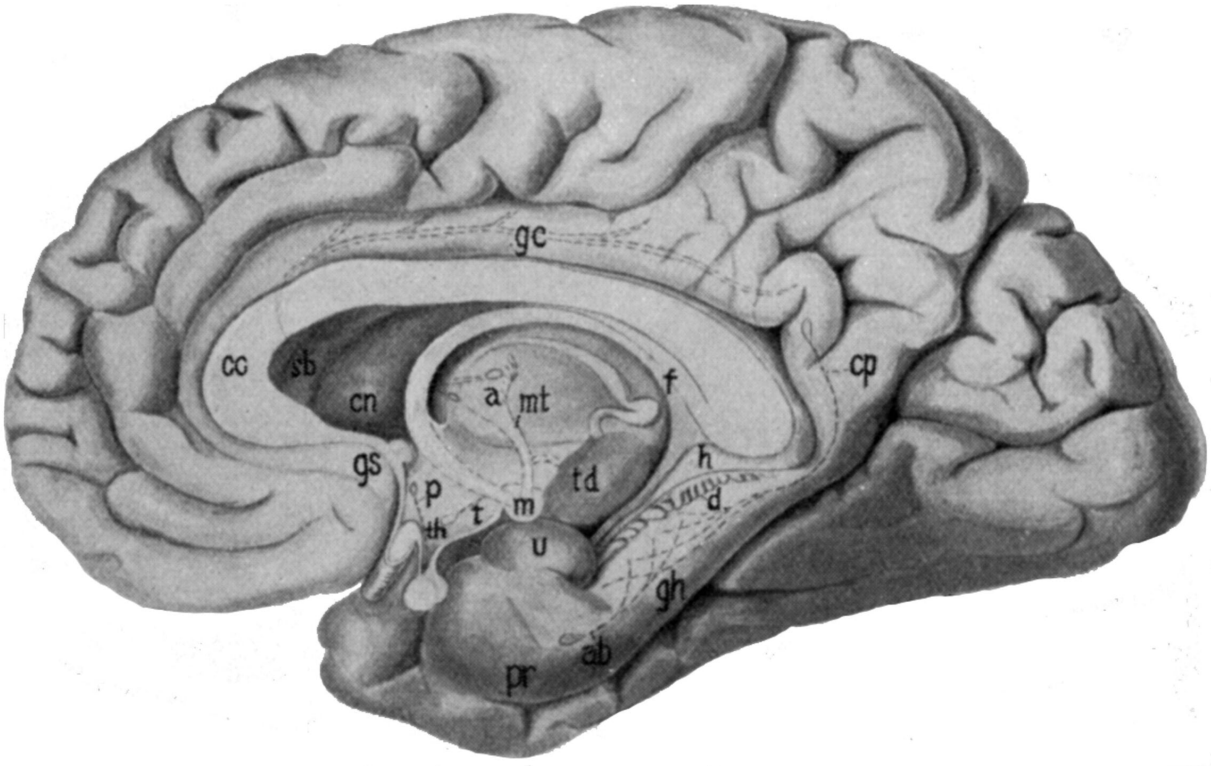


In 1937, the American neuroanatomist James Papez proposed that circuits connecting the regions of the limbic lobe to the hypothalamus mediated the experience of emotions:

> The central emotive process of cortical origin may then be conceived as being built up in the hippocampal formation and as being transferred to the mamillary body and thence through the anterior thalamic nuclei to the cortex of the gyrus cinguli. The cortex of the cingular gyrus may be looked on as the receptive region for the experiencing of

> emotion as the result of impulses coming from the hypothalamic region, in the same way as the area striata is considered the receptive cortex for photic excitations coming from the retina. Radiation of the emotive process from the gyrus cinguli to other regions in the cerebral cortex would add emotional coloring to psychic processes occurring elsewhere. This circuit would explain how emotion may arise in two ways: as a result of psychic activity and as a consequence of hypothalamic activity.

The following illustration is from his paper. The most important structures in the Papez circuit are the hippocampus (gh), the uncus (u), the fornix (f), the mammillary body (m), the mammillothalamic tract (mt), anterior nucleus of the thalamus (a), the cingulate gyrus (gc), the hypothalamus (p).



Papez’s studies were expanded by Paul MacLean (1949) who proposed that these structures composed a “visceral brain.” The ideas of Papez and MacLean were originally proposed by

Christfried Jakob in the early years of the 20th Century (Triarhou, 2008; Catani & Sandrone, 2015, pp 104-115). However, he had moved to Buenos Aires, and his papers, published in Spanish, were not as widely read as they should have been.

The connections between the limbic structures and the rest of the brain are far more complex than originally proposed (Kamali et al, 2023; Nieuwenhuys et al., 2008). The amygdala nucleus located in the temporal lobe anterior to the uncus, and the nucleus accumbens in the basal forebrain were not considered in the original formulation of the limbic system.

We still do not fully understand the workings of the limbic system, which we now know to be intrinsically related to memory as well as emotion.

Envoi

All that we experience – our thoughts, feelings, memories, and dreams – are somehow mediated by the brain. Over the years we have developed more and more accurate images of this organ of the mind. We now know the place but do not yet fully understand what happens there.

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Note on the illustrations:

The illustrations were derived from digital representations of

the original publications (listed above). I have digitally enhanced the illustrations as best I could in an attempt to reach what I imagine was their original state.

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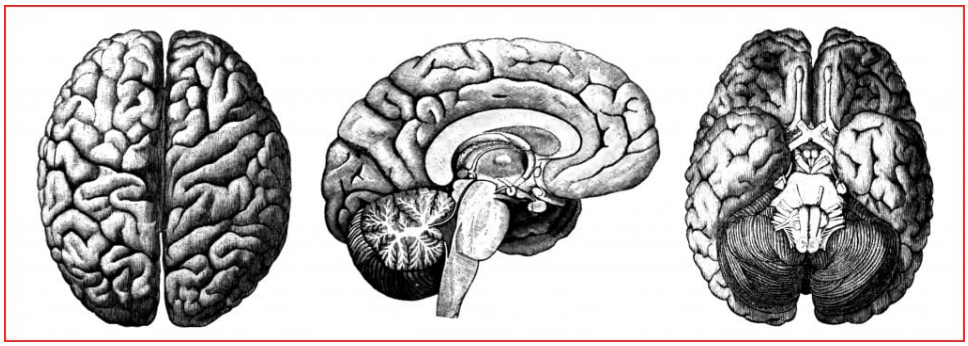
Human Brain

Over the past two months I presented a course on the Human Brain to students in the LIFE ('Learning is Forever') Institute at Ryerson University in Toronto. The course was designed for the senior layperson. It introduced the basic anatomy and physiology of the nervous system, and described the various disorders that can affect the elderly human brain.



The course was given at a second-year university level. Some of the material may have been more than the students needed to know, but most were able to follow the main points of the talks, and some were fascinated by the details.

The presentations were supplemented with extensive teaching materials – slides, notes, movies, etc. Many of the illustrations were adapted or created specifically for the course. I am now making these generally available through the page entitled Human Brain on my website.

Person and Memory

Although psychology has become an established science, it still has deep connections to philosophy. This is particularly true when we consider the concept of person that is at the foundation of all psychology. A person exists (and persists) through the processes of consciousness and memory. The following photograph (by Marie-Lan Nguyen) shows a Roman statue of Clio, the muse of history, from the Museo Pio Clementino of the Vatican. Clio records what is happening and recalls what has happened. History ensures that the past

persists. The past helps us to understand the present.

Clio, Museo Pio Clementino

The statue derives from the 2nd century CE. Its head and body were originally from different statues. Our knowledge of the person comes from both psychology and philosophy. This posting looks at memory and person from these two viewpoints. The photograph has been modified to provide more space on the statue's right. There is much we do not know.

From soul to person

The philosophers of the Enlightenment doubted the existence of the soul. Thoughts and sensations were all that could be directly experienced. These required a subject to experience them. In his *Essay Concerning Human Understanding*, Locke (1689) proposed the terms "self" and "person" for this subject. A person is

> a thinking intelligent being, that has reason and reflection, and can consider itself, as itself, the same

> thinking thing in different times and places; which it does only by that consciousness which is inseparable from thinking, and, as it seems to me, essential to it; it being impossible for anyone to perceive, without perceiving that he does perceive. (Book II, Chapter 27)

As well as consciousness, the idea of person required a memory of one's past thoughts and actions. Consciousness of both past and present could then support the identity of the person over time. Without memory, each moment of experience would require a different subject:

> For since consciousness always accompanies thinking, and it is that which makes everyone to be what he calls self, and thereby distinguishes himself from all other thinking things; in this, alone, consists personal identity, i. e. the sameness of a rational being; and as far as this consciousness can be extended backwards, to any past action or thought, so far reaches the identity of that person; it is the same self now, it was then; and it is by the same self with this present one, that now reflects on it, that that action was done. (Book II, Chapter 27)

Locke considered memory as a simple storehouse of perceptions that could be revived at a later time

> this laying up of our ideas in the repository of the memory signifies no more but this, that the mind has a power in many cases to revive perceptions which it has once had, with this additional perception annexed to them, that it has had them before. (Book II, Chapter 10).

In this way, Locke considered the human mind as essentially passive: a clean slate (*tabula rasa*) upon which the world writes through the process of sensation, and an untended warehouse of slowly fading messages from the past.

Personhood clearly requires both consciousness and memory but the relationships are not simple (Behan, 1979). Am I a person

when I am unconscious? Am I the same person as the two-year old child who grew up to be me, but whose experiences I can no longer remember? Personal identity must depend on physical as well as psychological continuity (Parfit, 1984; Olsen, 2010). In modern science we might also consider genetic continuity: over time our cells may change but our genes remain the same.

The self as described by the philosophers of the Enlightenment had a definitely moral aspect. Locke proposed that conscious memory must take responsibility for a person's past actions. The self

> extends itself beyond present existence to what is past, only by consciousness,—whereby it becomes concerned and accountable; owns and imputes to itself past actions, just upon the same ground and for the same reason as it does the present. (Book II, Chapter 27).

Whereas the soul had existed in relation to God, the person was much more closely related to society. The Enlightenment was far more concerned with the rights and duties than with sin and salvation. Our modern concept of the person continues this idea of individual responsibility:

> A person is a being with a certain moral status, or a bearer of rights … a being who has a sense of self, has a notion of the future and the past, can hold values, make choices; in short can adopt life-plans … a being with his own point of view on things … a being who can be addressed, and who can reply … a 'respondent.'. (Taylor, 1985, p. 97)

Active Attention

In his *Essay on Human Understanding*, written in reply to Locke's essay, Condillac (1746, reviewed by Kaitaro, 2007) pointed out that perception and memory are not simply passive responses to incoming sensation. Attention selects which or our sensations are perceived and remembered, and finds relations among these sensations. Furthermore, attention is

purposeful, acting according to our needs.

> The association of several ideas can only be caused by the attention which we have given them when they occurred together: as well, things only attract our attention because of their relation to our temperament, passions and state of mind, or, in a word, our need. (Condillac, 1746, Part I, Section II, Chapter 3)

One of the ideas that the human mind creates is that of the self. Condillac proposed that this comes about through a process that compares present perceptions with memories of past perceptions:

> When objects attract our attention, the perceptions that they cause are associated with a feeling of self … Consciousness not only is aware of our perceptions but also, if these repeat, informs us that we have already experienced them, and tells us how, despite their variety and succession, they relate to … a being that is always the same. … Without what I call *reminiscence*, each moment of our life would appear as the first in our existence, and our consciousness would never extend beyond our first perception. (Condillac, 1746, Part I, Section II, Chapter 1)

However, although Condillac considered consciousness as an active process, he came to think that this activity itself could be derived from sensation. In his later book, *Treatise on Sensations* (Condillac, 1754, discussed in Falkenstein, 2010), he attempted to see how all of our thinking could come from sensation, using the concept of a statue that is sequentially stimulated in each modality. Though he disagreed with Locke about the passivity of the mind, he still decided that active mental processes could be derived from experience. Sensation teaches us to think. Nothing is innate.

However, as pointed out by Donald (2001), Condillac’s statue cannot develop in this way unless it has from the beginning

the ability to be conscious of the various sensations that it experiences. Furthermore, the statue would have to be endowed with some curiosity or there would be no motive for it to make any associations between the different sensations that it experiences.

Nevertheless, by the end of the book Condillac's statue has developed attention, perceptions, associations, memory and desire. Condillac appears to be stating that this statue is equivalent to a human being. Yet, although it has some idea of its own body, the statue does not have any clear understanding of itself. The statue's final soliloquy includes the haunting comment:

> I see myself, I touch myself, in a word, I sense myself, but I do not know what I am. (Condillac, 1754, Part IV, Chapter 8)

This absence of any self-understanding may be related to the statue's lack of any social experience. Condillac provided it with sensations of itself and of objects, but not of other perssons. The human concept of the self develops at the same time as the concept that there are other persons in the world each with its own consciousness and will (Wellman, 2011).

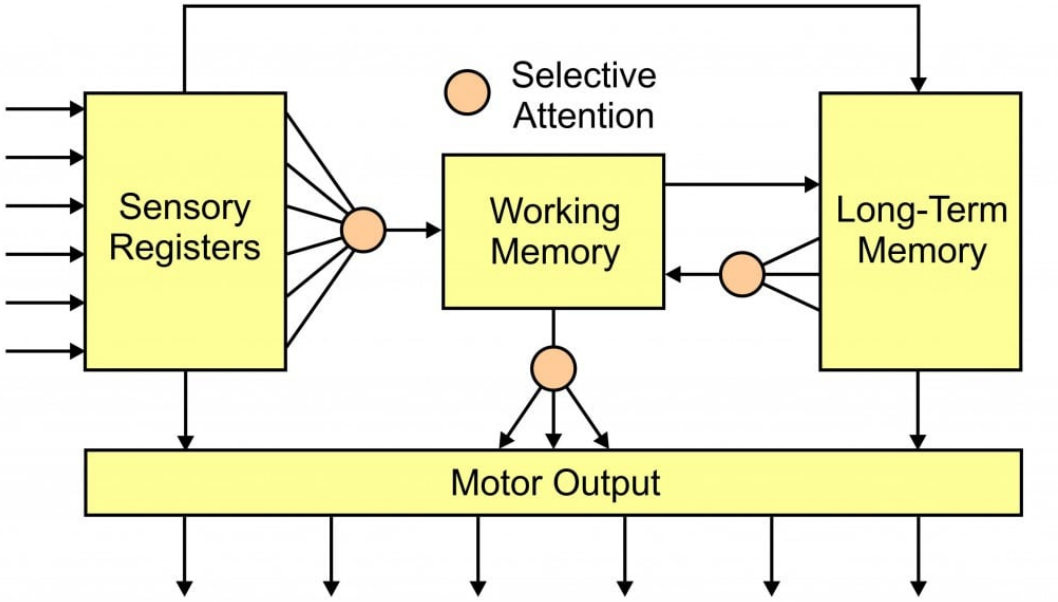
Cognitive Psychology

Competing claims that human mental processes were passive or active played themselves out again in the 20th Century. Behaviorists proposed that all our actions derive from the stimuli that we receive. At mid-century, however, a cognitive revolution occurred: psychologists decided that human perception is an intensely active process, and that memory is far more complicated than a simple repository of experience.

Human memory is presently conceived as having short and long durations. Short-term memories include sensory stores which serve to register modality-specific incoming information, and

working memory which selects information from these stores, and transforms it into action according to current needs and goals. Working memory has access to learned procedures and concepts that are maintained in long term memory, and uses various subsidiary stores, such as the phonological loop and the visuo-spatial scratchpad, to hold information while it operates.

The diagram below shows the general structure of human information processing, with the different human memories shown in separate boxes. Current cognitive psychology considers these memories as residing in neuronal networks that are far more widespread and overlapping than the diagram suggests. Attention is the process that selects what information is transferred into and out of working memory.



Long-term memory is what is usually considered as “memory” in everyday speech. Cognitive psychology divides this into explicit and implicit, depending upon whether the recalled information is accessible to consciousness. This distinction is also described as declarative vs. procedural. The memory of how to ride a bike is implicit/procedural; the memory of the capital city of France is explicit/declarative.

Endel Tulving (1972, 1983, 2002) proposed that explicit memory is further divided into two types: semantic and episodic. Semantic memory is the memory for facts. Such facts are recalled without any relation to our experience when we initially learned them. Episodic memories are recalled together with aspects of what we experienced when they were initially stored into memory, i. e., they are recalled as part of an episode in our life. The archtypical episodic memory is that of one's first kiss, a memory that usually cannot be recalled without re-experiencing many attendant sensations and emotions. The following table (modified and abridged from Tulving, 1983, p. 35) gives some of the distinctions between the two types of memory:

Feature	**Episodic**	**Semantic**
Source	sensation	comprehension
Units	events, episodes	facts, ideas
Organization	temporal	conceptual
Reference	self	universe
Veridicality	personal belief	social acceptance
Registration	experiential	symbolic
Access	deliberate	automatic
Retrieval queries	when? where?	what?
Recalled information	personal past	facts
Reported experience	remember	know

Episodic memories are associated with a special type of consciousness that Tulving and his colleagues have called “autonoetic” (Wheeler et al., 1997). This allows us to re-experience events from the past without our becoming confused with our present experience. Remembering something is similar to the original experience but is clearly not the same. Autonoetic consciousness provides us with the ability for “mental time travel.” Moreover, as well as letting us remember our past, it allows us to experience what might happen to us in the future.

One experimental technique for evaluating episodic memory involves having subjects recall previously learned associations. They are then asked whether they “remember” these items (on the basis that they also recall what happened when the association was studied), or simply “know” the association (reviewed by Tulving, 2002). Remembered information has the “flavor” of the original experience, whereas known information is simply factual. However, although most subjects can make the remember/know distinction, its meaning is not clear. The “remember” judgment may possibly indicate a larger amount of information or its greater vividness rather than (or in addition to) a different type of recollection.

Imaging studies have shown that recalling episodic memories activates different brain regions than recalling semantic memories. Recalling episodic memories involves the right frontal region of the brain, whereas recalling semantic memories is more left frontal (Tulving et al., 1994; Cabeza et al., 1997). Furthermore, a patient with difficulty in recalling episodic memories showed a focal lesion in the right frontal region (Levine et al., 1998).

Recent imaging studies have implicated that the recall of episodic information involves complex interactions between several different regions of the brain, most particularly the hippocampi, the anterior prefrontal cortex and the left

parietal cortex (Vilberg & Rugg, 2009; Rugg and Vilberg, 2013).

Tulving considered episodic memory to be a special development in human beings. Animals

> have minds, they are conscious of their world, and they rely as much on learning and memory in acquiring the skills needed for survival as we do … but they do not seem to have the same kind of ability humans do to travel back in time in their own minds (Tulving 2002).

However, human semantic memory, organized in large part through language, is also quite distinct from the memory that animals have for facts. Since it carries with it human culture, art, science, and history, our semantic memories are every bit as special as our memories of personal experience.

Everything that we learn occurs initially part of a subjective experience. How experience becomes memory is not clear. Semantic memories may derive from episodic memories after they have been separated from their personal associations through processes such as inference, abstraction, generalization or consolidation. However, it is also possible that the initial experience is stored simultaneously in the two types of memory.

Autobiographical Memory

Autobiographical memory is composed of both semantic and episodic elements (Conway & Pleydell-Pearce, 2000; Renoult et al., 2012). I can recall the names of my family members, the important dates of my life (birth, graduation, marriage), and the sequence of places where I have lived or worked in much the same way that I recall the capitals of countries. Yet I can also recall my actual experiences during my wedding or my first day at work. The story of my life can thus be viewed at different levels: in semantic outline or episodic detail.

Episodic memories are generally organized around the idea of a person that persists from one episode to the next (Picton, 2012). As well as linking together what has happened to us into a personal history, our autobiographical memory also contains explanations for why we did what we did. Thus we come to know how we tend to respond in certain situations, what needs and desires govern our actions, and what goals we might be aiming for. Thus we develop a sense of self:

> When it comes to our identities, narrative is not only *about* self, but is rather in some profound way a constituent part *of* self (Eakin, 2008, p. 2).

This psychological concept of the person shows some similarities to the existentialist view of the man as not being endowed with a soul but as having to create one out of nothing:

> Freedom is precisely the nothingness which is made to be at the heart of man and which forces human reality to make itself instead of to be. As we have seen, for human reality, to be is to choose oneself; nothing comes to it from the outside or from within which it can receive or accept. Without any help whatsoever, it is entirely abandoned to the intolerable necessity of making itself be. (Sartre, 1943/1995, p. 485, translation Barnes)

We can be quite creative in how we put together our personal story:

> we are all virtuoso novelists, who find ourselves engaged in all sorts of behavior, more or less unified, but sometimes disunified, and we always put the best ‘faces’ on it we can. We try to make all of our material cohere into a single good story. And that story is our autobiography. The chief fictional character at the center of that autobiography is one’s *self*. (Dennett, 1992).

Unfortunately, we are sometimes unreliable narrators. When we

are happy we can see our lives as the successful outcome of our intelligence, charm and drive. When we are depressed we may misperceive what has happened and exaggerate our personal failures. A good friend or a psychotherapist can help us by listening to our story, pointing out its inconsistencies, and suggesting different interpretations. They help us to be honest with ourselves (Coetzee & Kurtz, 2015). If our version of our life history is more fiction than fact, we can have great difficulty handling the present or coping with the future.

The concept of a personal narrative is often associated with morality. Should we not be responsible for the story of our life in some manner? “Accountable” was the word used by Locke in his discussion of the person. Charles Taylor remarks

> [I]n order to make minimal sense of our lives, in order to have an identity, we need an orientation to the good, which means some sense of qualitative discrimination, of the incomparably higher. Now we see that this sense of the good has to be woven into my understanding of my life as an unfolding story. (Taylor, 1989, p. 47)

Alasdair MacIntyre (1984) has also considered personal identity and its relation to ethics:

> In what does the unity of an individual life consist? The answer is that its unity is the unity of a narrative embodied in a single life. To ask ‘What is the good for me?’ is to ask how best I might live out that unity and bring it to completion. (MacIntyre, 1984, p. 218)

He goes on to describe the personal narrative in terms of a “quest” for the good. We seek to go from the as yet unfulfilled present person to a future person as he could be if he were to realize his essential nature (MacIntyre, 1984, p. 52).

Memory Style

Recent studies have indicated that some subjects have autobiographical memories that are more highly developed than normal subjects (Leport et al., 2012). These patients can recall much more about what occurred during their lives than normal subjects. When prompted by specific dates they can often recall exactly what they were doing and what was happening in the world. These subjects organized their autobiography using a strict chronological ordering.

Other subjects have a much less developed autobiographical memory than normal (Palombo et al., 2015). These subjects experience much less episodic detail when they recall their past particularly from childhood and adolescence. For the more recent past, the subjects appear to compensate, perhaps by using semantic memory to encode what others would maintain as episodic details. During remember/know recognition-testing, the subjects reported remember judgments much less frequently than control subjects. It is as though they have some deficit in either making or recalling episodic memories. However, it is difficult to evaluate this by asking them about their experience. This would be like asking a color-blind patient to describe his experience of red. On physiological testing, the subjects showed reduced activation in the brain regions normally associated with episodic recall.

These two groups of subjects may represent the limits of normal variability in memory styles. In this regard it is interesting to note some recent contributions from philosophy. Galen Strawson (2004, 2012) has proposed that there are two kinds of self-experience: diachronic and episodic. A diachronic (from the Greek *dia* through and *chronos* time) person considers himself or herself as an entity that has persisted from past to present and that will continue into the future. Most diachronic persons consider their past in terms of a personal narrative. An episodic (from the Greek *epi* in addition and *eisodos* entrance) person is one who has little or no sense of a past or future identity, and little concern with

his or her life story. The memory of the personal past is discontinuous and divorced from the present self. Strawson considers himself as episodic:

> I have a past, like any human being, and I know perfectly well that I have a past. I have a respectable amount of factual knowledge about it, and I also remember some of my past experiences 'from the inside', as philosophers say. And yet I have absolutely no sense of my life as a narrative with form, or indeed as a narrative without form. Absolutely none. Nor do I have any great or special interest in my past. Nor do I have a great deal of concern for my future. (Strawson, 2004, p. 433)

Strawson's use of "episodic" is different (indeed almost the opposite) from Tulving's. Strawson uses it to describe a person who considers the past (and future) as having little relation to the present, whereas Tulving uses it to describe the experiential quality of remembering. The term "episodic" has been used with even other meanings: Donald (2001, pp. 200-202) uses it to describe the temporal organization of experience into meaningful events.

Strawson proposes that episodic persons are not that uncommon. Since such persons would generally not write autobiographies, the historical record may be biased towards the diachronic. Strawson nevertheless quotes others who share his episodic nature. Goronwy Rees (1961) entitled his autobiography *A Bundle of Sensations*. The title makes allusion to David Hume, who was himself sceptical about the possibility of any person or perceiving subject. He considered each of us to be

> nothing but a bundle or collection of different perceptions, which succeed each other with an inconceivable rapidity, and are in a perpetual flux and movement. Our eyes cannot turn in their sockets without varying our perceptions. Our thought is still more variable than our sight; and all our other senses and faculties contribute to this change; nor is

> there any single power of the soul, which remains unalterably the same, perhaps for one moment. (Hume, 1738, Book I Part IV Section VI)

Strawson's main point, however, is to criticize the idea that a personal narrative is essential to moral development. Indeed because of the way that it is continually revised, a deeply experienced personal narrative may hinder more than help:

> the Narrative tendency to look for story or narrative coherence in one's life is, in general, a gross hindrance to self-understanding: to a just, general, practically real sense, implicit or explicit, of one's nature. It's well known that telling and retelling one's past leads to changes, smoothings, enhancements, shifts away from the facts … The implication is plain: the more you recall, retell, narrate yourself, the further you risk moving away from accurate self-understanding, from the truth of your being. (Strawson, 2004, p. 447).

Eakin (2008) has argued against Strawson's dissociation of personal identity from any narrative evaluation of one's past and future. It may all depend on the way in which the memory of the past is organized. Not all stories are told from beginning to end. As Christman (2004) has pointed out the events in a narrative may be linked according to causal connections (from the beginning), teleological directions (toward the end) or thematic relations (interacting foci).

> What the condition of narrativity amounts to, then, is the more basic requirement that the person must be able to look upon the factors and events of her life with a certain interpretive reflection, whether or not those factors and events have any particular narrative unity in a traditional sense. Christman (2004).

Person and Memory

A person is an entity with a unique point of view that can be

exercised in both space and time. From this particular perspective a person can perceive the present world, remember the past and speculate about the future.

Persons differ on how they view the relation between themselves and the world. Some live mainly for the present and have little relationship to their past. Indeed they may even feel that their past self was a different person from their present self. They may have difficulty recalling the experience of a past episodes in their lives even though they know that they occurred. Others pay particular attention to what has happened to them and how they might approach the future. They are intensely interested in how their life develops over time.

Whether such differences are the result of the normal variability of human memory systems or the result of a deficiency in some neural process or processes remains an open question. We need to find out how episodic memories are generated in the brain and how they differ from semantic memories. How differences in memory style relate to differences in personality also needs investigation. For example, are diachronics more likely to be introverted than extraverted?

Omphale

The posting concludes with a photograph of the statue of Omphale in the Schönbrunn Garden in Vienna. The photograph was taken by Manfred Werner using a flash, during a summer night-time concert of the Vienna Philharmonic.

For three years Hercules was Omphale’s slave and lover. At times they exchanged their clothing. In the statue Omphale wears Hercules lion-skin and carries his club. The photograph is formally very similar to the photograph of Clio at the beginning of this post. Yet for me they differ in much the same way as semantic and episodic memory. Clio is abstract and

put together after the fact. Omphale is an experience.

Omphale, Sommernachtskonzert Schönbrunn 2012

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> La liaison de plusieurs idées ne peut avoir d'autre cause que l'attention que nous leur avons donnée, quand elles se sont présentées ensemble: ainsi les choses n'attirant notre attention que par le rapport qu'elles ont à notre tempérament, à nos passions, à notre état, ou, pour tout dire en un mot, à nos besoins.

> Lorsque les objets attirent notre attention, les perceptions qu'ils occasionnent en nous, se lient avec le sentiment de notre être et avec tout ce qui peut y avoir quelque rapport. De là il arrive que non seulement la conscience nous donne connaissance de nos perceptions, mais encore, si elles se répètent, elle nous avertit souvent que nous les avons déjà eues, et nous les fait connaître comme étant à nous, ou comme affectant, malgré leur variété et leur succession, un être qui est constamment le même *nous*. La conscience, considérée par rapport à ces nouveaux effets, est une nouvelle opération qui nous sert à chaque instant et qui est le fondement de l'expérience. Sans elle chaque moment de la vie nous parait le premier de notre existence, et notre connaissance ne s'étendrait jamais au-delà d'une première perception: je la nommerai *réminiscence*.

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> [J]e me vois, je me touche, en un mot, je me sens, mais je ne sais ce que je suis.

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> La liberté, c'est précisément le néant qui est été au Coeur de l'homme et qui contraint la réalité humaine à se faire, au lieu d'être. Nous l'avons vu, pour la la réalité humaine, être c'est se choisir: rien ne lui vient du dehors, ni du dedans non plus, qu'elle puisse recevoir ou accepter. Elle est entièrement abandonee, sans aucune aide d'aucune sorte, à l'insoutenable nécessité de se faire être jusque dans le moindre detail.

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Determined to Be Free

Scenario

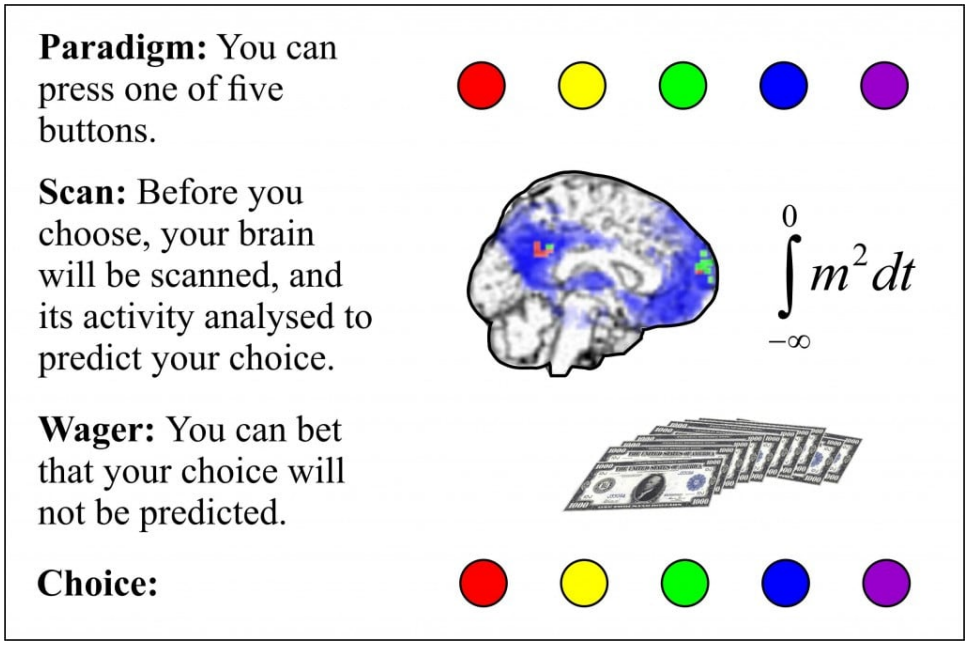
Imagine yourself 20 years from now. A brilliant cognitive neuroscientist claims to be able to read your brain and predict your future behavior. She studied with Sam Harris in Los Angeles and then completed her postdoctoral work with Chun Siong Soon and John-Dylan Haynes in Berlin. She knows her stuff and she uses the most advanced technology.

You will be able to press one of five buttons. Before you do so, the neuroscientist will take a scan of your brain, analyse

it and predict which button you will choose. She will pay particular attention to the posterior cingulate gyrus and the rostral prefrontal cortex. She is willing to bet you that her prediction will be correct.

If you take the bet, you believe in free will. If you do not, you are a determinist – or in this context a "neuro-determinist."

Faites vos jeux!



Concept of Determinism

Modern determinism was most clearly stated by Pierre-Simon Laplace in 1812. He proposed that an intelligence – whether God or Demon, whether real or hypothetical – could completely predict the future from the present if the intelligence knew all the "forces by which nature is animated" and could measure the exact "situation" of everything in the present universe:

> We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who

> compose it – an intelligence sufficiently vast to submit these data to analysis – it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes (Laplace, 1812/1902, p 4).

Determinism is the basic premise of science, which attempts to discern the causal laws by which the universe operates (Earman, 1986; Hoefer, 2010). Everything is caused by something else. Nothing is a *causa sui* (cause of itself). The universe contains no freely acting anything or anybody.

Determinism is usually interpreted in terms of what will happen. However, in Laplace's definition it also casts its net backward: if we know everything about the present then we can tell exactly what happened in the past.

What is not always recognized is that Laplace wrote his definition of determinism in the introduction to his book *A Philosophical Essay on Probabilities*. Now, probability is what we use when we cannot predict exactly what will happen. A hypothetical vast intelligence might, but we cannot. We estimate the odds rather than predict the outcomes.

If the concept of determinism is taken seriously, then the present is determined by the immediate past, that past is itself determined by what preceded it, and so on. Ultimately, everything must have been decided when the world began, and all our actions determined 13.8 billion years ago at the moment of the Big Bang. In the words of Omar Khayyam:

> With earth's first clay they did the last man knead,
> And there of the last harvest sowed the seed.
> And the first morning of creation wrote
> What the last dawn of reckoning shall read.
>
> (Fitzgerald translation, 5th Version LXVIII)

Determinism is a powerful working hypothesis but it may not be universally applicable. In the early 20th century, we became aware that atomic and sub-atomic processes are not deterministic (Ismael, 2015). They follow exact rules, but these are expressed in terms of probabilities rather than certainties.

Most biologists consider that at the levels of chemistry and physiology, quantum uncertainty averages out and we are "for all intents and purposes" fully determined. At macroscopic levels, quantum uncertainty therefore plays no significant role in the prediction of the future.

My suggestion, however, is that the universe veers away from strict determinism both at levels of extreme simplicity – quantum uncertainty – and at levels of extreme complexity – conscious choice.

Problem of Chaos

Sometimes, as Edward Lorenz (1996) has shown, fully determined systems are liable to chaos. Chaos occurs "when the present completely determines the future, but the approximate present does not approximately determine the future" (Lorenz, 2005).

The movie below provides an example of a typical deterministic system – billiard balls on a billiard table. If the rules by which the system operates and the positions and velocities of the balls are exactly known, the future of the system can be precisely predicted. The life of a billiard ball goes from collision to collision. Although there are occasional near misses there is no choice.

On the left is the actual system. It is not perfect – the table is frictionless and the balls are inelastic (there is only so much an old man can program) – but it does follow deterministic laws. On the right is the modeled system. If we initiate movement in the white ball, our prediction fits

exactly with what happens.

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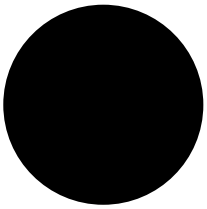

Some determined systems, however, are chaotic. In a chaotic system our predictions can be wildly off the mark if our measurement of the initial state of the system is not exact. Chaos is usually considered in terms of complex systems such as the weather: butterflies in Brazil causing tornados in Texas. However, chaos also occurs in very simple systems, even in billiards.

The next example shows the same deterministic system on the left as in the previous movie. On the right is the prediction. This time the measurement of the initial position of the white ball was out by one pixel. The measurement of the velocity vector was exact.

At the very beginning the prediction is approximately correct. After the first few seconds, however, the model shows no relationship whatsoever to the actual.

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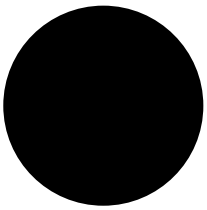


Chaos is an inherent part of physical determinism. It is therefore often impossible to measure the state of the world with sufficient accuracy to give any meaningful predictions of what will actually occur. Our model of the future may look nothing like what it will be.

Chaos does not disprove determinism: chaos is completely determined. However it makes it very difficult to prove that determinism underlies everything. That hypothesis would require that we be able to measure the universe with absolute accuracy. That we cannot do.

Limits of Prediction

Even without chaos, complete predictability is impossible. The universe contains neither time nor space enough to map its own future.

> Laplace was wrong to claim that even in a classical, non-chaotic universe the future can be unerringly predicted,

given sufficient knowledge of the present. (Wolpert, 2008).

The proof is related to Gödel's Incompleteness Theorem and Turing's Halting Problem. A Turing machine reads an infinite tape one symbol at a time. According to its internal state at the time of reading, the machine then changes the symbol written on the tape, moves the tape, and changes its state. The Turing machine is a model of a computer. We cannot predict when the machine will stop. We are unable to know if a problem is soluble before it is solved. We cannot predict the entire future before it has already occurred.

David Wolpert's work means that "No matter what laws of physics govern a universe, there are inevitably facts about the universe that its inhabitants cannot learn by experiment or predict with a computation." (Collins, 2009). The most we can hope for is a "theory of almost everything" (Binder, 2008).

However, even though we cannot prove determinism, we cannot disprove it. It continues to be a reasonable working hypothesis for most situations.

Lack of predictability is a characteristic of free will. A test for free will (Lloyd, 2012) might involve the following criteria: the ability to make decisions, the use of recursive reasoning in making those decisions, the ability to predict the future, and the inability to predict what one will decide. If you are in the process of deciding how to act and if you cannot predict how you will decide, you are in a state of free will.

Quantum Uncertainties

One way out of the problem that quantum uncertainty poses for determinism is to claim that yet-unknown deterministic laws underlie quantum events. Once we discover these laws we will be able to re-cast quantum mechanics so that all events are exactly rather than stochastically determined. The problem

with such a “superdeterminism” is that in order to derive the underlying laws governing quantal processes we would have to observe events at subquantal levels. That would require using subquantal measuring devices, and that would run up against Heisenberg’s Uncertainty Principle (Hilgevoord & Uffink, 2006). I think indeterminism is here to stay. The only thing we can be certain about is ultimate uncertainty.

Quantum uncertainty may provide a way for our behavior not to be fully determined by antecedent causes. We would need to imagine some way for unpredictable quantum events to change brain activity. Penrose and Hameroff (2011) have suggested that quantum events in the neuronal microtubules — the Orchestrated Objective Reduction of Quantum States — could underlie our choices of one action over another.

However, making free will depend on quantum uncertainty is unsatisfying in that it reduces free will to chance rather than choice. Random is not the same as free. If we make our decisions on the basis of random quantum events, we are just subject to the tyranny of the atom rather than the will of God.

Even Sam Harris agrees:

> Chance occurrences are by definition ones for which I can claim no responsibility. And if certain of my behaviors are truly the result of chance, they should be surprising *even to me* (Harris, 2012).

However, randomness can still play a role in free choice. We might decide to base our decisions on a random event, such as flipping a coin, so as to be fair to both sides of a question. We might also use a random process to add noise to a decision (like raising the temperature in an annealing process), or to determine how many options to evaluate or for how long (e.g. Dennett, 1978). For Peter Tse (2013) free will is caused by the “criterial selection” of random synaptic activity in

cerebral cortex.

Logical Problems

Two contradictory statements can be made in relation to free will and determinism (van Inwagen, 1983, 2008):

(i) Freedom of the will is not possible if the world is completely determined. Free will means that we are sometimes in the position with respect to a contemplated future act that we are able either to perform the act or to do otherwise. If we can indeed do otherwise – if two different futures can equally follow from the same present – then the future is not determined. The claim that we can choose between these two futures is incompatible with the idea that the past and the laws of nature together determine, at every moment, a unique future.

(ii) However, free will cannot act without determinism. If we make a decision, we can only carry it out if our behavior is determined by that decision – if action potentials travel down the nerves to the muscles, if the muscles move the limbs, and if the limbs perform the intended physical acts. Unless the world is deterministic, we cannot exercise our free will.

So we cannot have free will if the universe is completely determined, and free will is meaningless if the universe is not determined. There are two ways out of this conundrum. We can accept that the universe is determined, and conclude that our idea of free will is an illusion. Or we can agree with van Inwagen that free will is true and conclude that the world is not completely determined.

Van Inwagen considers free will to be true because he cannot imagine human life without personal moral responsibility. If there is no free will, everything we do is determined before we have anything to do with it. We need not think; we are never responsible for our actions; any idea of justice is meaningless. All evil will be exculpated by fMRI evidence that

the brain was just unable to be good.

A world where people do not believe in free will is not pleasant. Simply suggesting to subjects that there is no free will encourages dishonesty and mischief. The less someone believes in free will, the more likely he or she will cheat if the opportunity presents (Vohs & Schooler, 2008), and the more likely she or he will indulge in anti-social acts if they will not be discovered (Baumeister et al., 2009).

So, even if we are not free, should we act as if we were? This is a strange way to live our lives.

However, we can take positions other that of full determinism in relation to the problem of free will:

	Free Will Impossible	**Free Will Possible**
Determinism True	Determinism	Compatibilism
Determinism False	Nihilism	Libertarianism

Van Inwagen's position is one of philosophical "libertarianism." (This is not the same as political libertarianism, which disputes the laws of society rather than the laws of science.)

Most of us believe that we have free will, but we are also convinced that the universe is determined. We are "compatibilists" – determinism is true but so is free will. We do not know how the two co-occur, but somehow they must. In surveys of what we believe, compatibilists are in a clear majority: 75% of normal folk (Nahmias et al, 2005), and 80% of biologists (Graffin & Provine, 2007). Even 60% of philosophers, those that should not support logical contradictions, consider themselves compatibilists (Bourget & Chalmers, 2014). The other 40% are evenly divided between undecided, libertarians and deterministts.

Dan Dennett is the most prominent of our present

compatibilists. But he is unclear about exactly how free will can exist in a world of causes. Something to do with human knowledge and communication:

> Our autonomy does not depend on anything like the miraculous suspension of causation but rather on the integrity of the processes of education and mutual sharing of knowledge. (Dennett, 2003).

Evolution and Free Will

Darwin thought that free will was a delusion. Since we are not conscious of the instincts that actually drive our actions, we only think that we freely choose. In fact we do not.

> The general delusion about free will obvious – because man has power of action, & he can seldom analyse his motives (originally mostly instinctive, & therefore now great effort of reason to discover them: this is important explanation) he thinks they have none. (from Darwin's *Notebooks,* about 1839, edited by Barrett et al., 1987, p 608; these notes are discussed in Wright, 1994, p. 350).

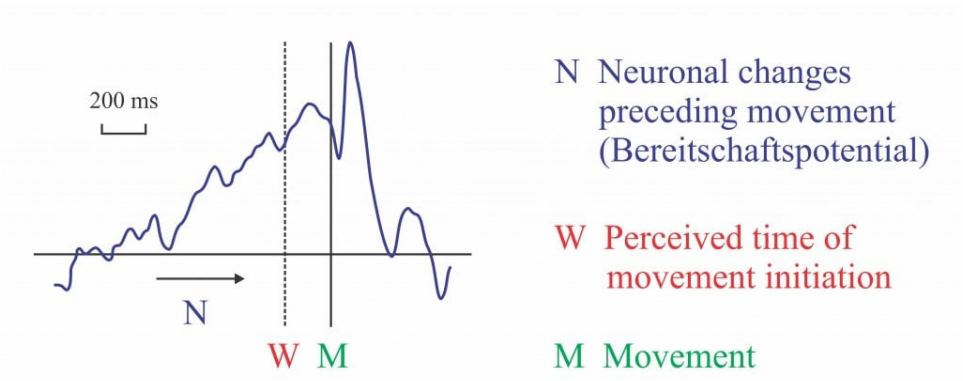
Evolution is often considered as part of a general determinism. Selection occurs according to hard and fast rules. Species that cannot survive to reproduce do not continue. Yet indeterminism rests at the very heart of Darwin's theory. Evolution depends on two processes: the production of offspring with variable characteristics and the selection of those offspring that survive in a world of limited resources. The variation is largely a result of genetic mutations and these are caused by indeterministic quantum events.

Some people have likened cognitive processing to Darwinian evolution (e.g., Edelman, 1987). In evolution, various species are created and only the most adaptive are selected. In cognition, various possible actions are considered and only the most appropriate are selected.

A major problem is why evolution determined that consciousness and free will occur. Human beings are certainly the most successful of all earth's species. This would suggest that consciousness and free will are highly adaptive traits that have been selected to facilitate our survival. Evolution is a deterministic process. Yet by selecting out the fittest, evolution has led to consciousness and free will. We have been determined to be free.

Neurodeterminism

Neuroscience entered the philosophical arena in the early 1980s when Benjamin Libet evaluated the relations between volition and the readiness potential (or *Bereitschaftspotentia*l) recorded from the scalp. The readiness potential began up to a second before the movement but the subject consciously perceived the time of movement initiation at about 200 ms before the movement. The brain decides unconsciously; awareness follows after.



Similar experiments have recorded unit activity in the human frontal cortex beginning about 2 seconds before the act (Fried et al., 2011) and fMRI activation patterns (Soon et al., 2008, 2013) between 4 and 10 seconds prior to the act.

These experiments have led to a theory of volition that has been called "neuro-determinism." Perhaps a better term might be "Libetarianism." Our actions are willy-nilly determined by cerebral processes about which we are unaware. We only become

conscious of what we are doing just before we do it. We do not control our actions, we just watch them taking place.

The 200 ms between the awareness of response-initiation and its occurrence could make it possible to inhibit or "veto" a response in process. Thus we can be consoled with the idea that even if we don't have free will, we have "free won't." Yet recent experiments have shown that even this might be unconsciously driven (Filevich et al., 2013).

One problem with the neural measurements is that we do not know what they represent. Many different cerebral processes contribute to the readiness potential – estimating time, preparing to respond (or not), monitoring performance, etc. Some of these can be unconscious and can correlate significantly with later acts. Yet such processes do not necessarily cause the act – the mind can always change at the last minute (or millisecond).

In addition, our concept of volition is multidimensional (Roskies 2010). It can refer to the general intentions that one has in regard to a particular situation, the planning of how and when to respond, and the specific initiation of an act. A subject's voluntary participation in a *Bereitschaftspotential* experiment involves his or her agreement to do what is asked by the experimenter, the setting up of the necessary timing and motor programs to control the responses, and the final initiation of the act. Any or all of these processes may contribute to the physiological recordings at different times.

Nevertheless, these physiological findings have led many scientists and philosophers to claim that our idea of free will is illusory:

> Our sense of being a conscious agent who does things comes at a cost of being technically wrong all the time. The feeling of doing is how it seems, not what it is (Wegener,

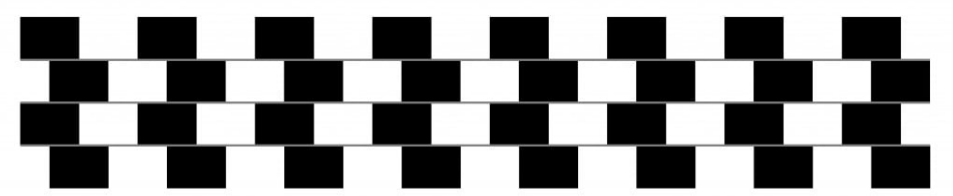
2002).

> Free will is an illusion. Our wills are simply not of our own making. Thoughts and intentions emerge from background causes of which we are unaware and over which we exert no conscious control. We do not have the freedom we think we have (Harris, 2012)

> Farewell to the purpose-driven life. Whatever is in our brain driving our lives from cradle to grave, it is not purposes. But it does produce the powerful illusion of purposes (Rosenberg, 2011).

Eddy Nahmias (2015) has suggested that we call their position "willusionism."

I submit that this idea is wrong – free will is not an illusion. Now, this is an illusion!



The argument that a particular experience is illusionary presupposes that other experiences are veridical. Indeed we only know that something is illusory if we can prove by some other experience that reality has been distorted. Despite the illusion of the tilting tiles in Richard Gregory's café-wall, we can prove with a spirit level that they are actually all horizontal.

So in order to show that a particular experience of volition is illusionary, there would have to be other experiences of

volition that are not illusionary and that are demonstrably different form the one considered illusionary.

Those who have proposed that free will is an illusion also point to clear evidence that we often do not know why we behave in a particular way. Psychoanalysis has long shown that we invent plausible but false reasons for how we act. This quotation is from Ernest Jones, one of Freud's early disciples:

> … the large majority of mental processes in a normal person arise from sources unsuspected by him. … No one will admit that he ever deliberately performed an irrational act, and any act that might appear so is immediately justified by distorting the mental processes concerned and providing a false explanation that has a plausible ring of rationality (Jones, 1908).

The psychoanalytic idea of rationalization has been supported by numerous recent psychological studies showing the effects of subliminal stimulation, the extent of our unconscious prejudices, and the vagaries of intuitions. We often are far more certain about things than we should be on the basis of the actual evidence (Burton, 2008).

Michael Gazzaniga's studies of split-brain patients showed how the left hemisphere can invent totally inaccurate explanations for our actions. He suggests that the left-hemisphere language-system tries to make sense of our experience but that sometimes the story it comes up with is false:

> It is the left hemisphere that engages in the human tendency to find order in chaos, that tries to fit everything into a story and put it into a context … even when it is sometimes detrimental to performance (Gazzaniga, 2011).

So perhaps we are always wrong? I think not. Just like the argument from illusion, the argument from rationalization only works if we are sometimes right. We have to know the real

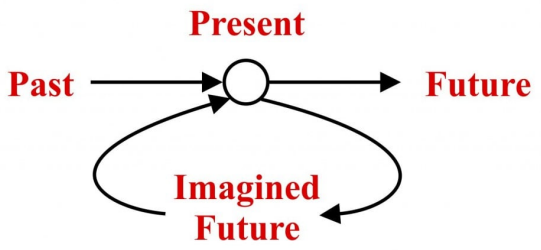
explanation in order to show that our rationalization is false.

Nature of Free Will

Only a small part of what we do is under conscious or controlled processing. Most of what we do occurs automatically. We are therefore often mistaken about why we acted in a particular way. We are not aware of causes outside of ourselves or hidden from conscious scrutiny, and we may invent reasons that are unrelated to what actually occurred, so that we can make sense of ourselves and our actions.

Nevertheless, we sometimes come to a decision about how to act by deliberately weighing the future consequences of several possible actions and choosing the most appropriate. We bring to bear on the problem all that we have so far learned about what things entail. For really important decisions, we often consult with others. We seek advice about what to do, ask our friends how they would decide in our position, and present scenarios for their comments. Freedom is inherently social. As mentioned above in relations to Dan Dennett’s compatibilism, free will has something to do with human knowledge and communication.

The future does not determine the present. That is not the way time flows. But the imagined future can determine the present. Once a feedback loop is created, time and causality become complicated. In causal circles, cause and effect can be simultaneous rather than sequential. Once we conceive of consequences, the future becomes part of the present and we can base our actions on how the future will (or should) be.



These ideas of the "imagined future" are similar to the concept of episodic simulation proposed by Dan Schachter and his colleagues (Schachter, 2012; Szpunar et al., 2014) and the thoughts behind Carl Hoefer's *Freedom from the inside out* (2002).

Such future-directed thought can have a top-down effect on the present. In particular, acts of free will can form a "self" – a set of predispositions to act in a characteristic way, sometimes automatically and sometimes deliberately (Kane, 2011, 2014).

Every undetermined self-forming choice is the initiation of a novel pathway into the future, whose justification lies in that future and is not fully explained by the past." (Kane, 2011)

In a way the exercise of free will is like setting a legal precedent. Past decisions can then contribute to present choices.

Return to the Scenario

And so we return to the hypothetical wager from the beginning of this post. Should we bet that our actions cannot be predicted? Will it be possible 20 years from now for a brilliant neuroscientist to predict our actions before they occur?

In the experiments of Eddy Nahmias and colleagues (2014), subjects were asked about just such a scenario: a future neuroscientist reads the brain activity of a person called

Jill and predicts what Jill will do. More than 80% of subjects accepted that this will be possible, but still claimed that Jill has free will if she is acting according to her own reasons. They believe that “the brain scanner is simply detecting how free will works in the brain” (Nahmias, 2015).

The astute among you may wonder whether during the scan you could fervently and honestly intend to press the red button. But then, once you have made your bet, on second thought you might wilfully decide to press one of the other buttons. After all, even at the last millisecond you can change your mind. You do not usually do this. That is why the brain scanner can often predict your behavior. But you always can change your mind.

I would take the bet.

Conclusion

I have considered physical determinism and pointed out its limitations in quantum uncertainty, chaos and incomputability. I have shown that complete determinism is in logical conflict with free will. I have reviewed some of the evidence that suggests that our unconscious brain determines what we might falsely believe to be our free choices. And I have refused to accept that evidence, arguing that we are still free whenever we base our actions on an evaluation of their consequences.

Determinism rules but only within limits. At the level of the atom there is quantum uncertainty. At the level of the brain there is conscious choice.

In our brains, most of what happens follows the laws of determinism, with the past causing the present and the present causing the future. Most of what we do is unconscious. Yet some acts are deliberately chosen after a conscious evaluation of what will happen. These are as much determined by the imagined future as by the actual past. As such they are both determined and free.

Note: This posting was derived from a talk given at the Rotman Research Institute Annual Conference. A pdf of the slides and the notes for the talk is available for download.

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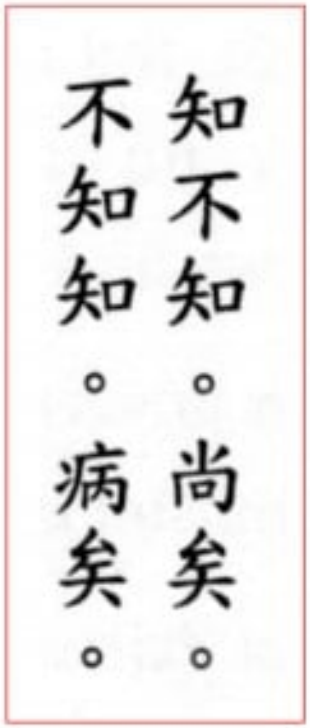
Numinous Experience

This post considers the nature of the human experience of the "numinous:" the sensation that one is the in the presence of something beyond comprehension or control. The term is difficult to define. Other words that overlap in meaning are "sublime," "sacred" and "transcendent" when referring to the source of the experience, and "awe," "reverence" and "ecstasy" when describing the state of mind induced.

The numinous is an essential component of religion. However, the scriptures warn that understanding the numinous may not come easily. Verse 71 from the *Tao Te Ching* (*dào dé jīng,*The Book of the Way of Virtue) by Lao Tzu claims that



zhī bù zhī shàng yǐ
bù zhī zhī bìng yǐ

The Chinese characters go from top to bottom and from right to left. Red Pine (2009) provides a direct translation:

To understand yet not understand
is transcendence
Not to understand yet understand
is affliction

Perhaps the words mean that we should try to understand what we do not know because not to do so leads to suffering. However, I may miss the sense as much as I mar the pronunciation when I try to speak the words.

Meaning of the "Numinous"

The word "numinous" derives from Latin word *numen*, meaning divinity, often the god or local presiding spirit of a particular place. The word ultimately comes from the Greek *neuein* for nodding, and may represent the barely perceptible nodding of a divine idol when it approves of being worshipped

or grants a wish.

The numinous is essential to religion. William James (1902) suggested that religion

> consists of the belief that there is an unseen order, and that our supreme good lies in harmoniously adjusting ourselves thereto. (p 53)

He further suggested that this might derive from a feeling of being in the presence of something beyond the grasp of our normal five senses:

> It is as if there were in the human consciousness a *sense of reality, a feeling of objective presence, a perception* of what we may call '*something there*,' more deep and more general than any of the special and particular 'senses' by which current psychology supposes existent realities to be originally revealed. (p. 58)

The term "numinous" was first used to describe this feeling by Rudolf Otto (1917). He considered it to be the state of a creature in the presence of its creator:

> I propose to call it 'creature-consciousness' or creature-feeling. It is the emotion of a creature, submerged and overwhelmed by its own nothingness in contrast to that which is supreme above all creatures (pp. 9-10).

He also described it as the *mysterium tremendum* – "terrible mystery." The experience of the numinous varies:

> The feeling of it may at times come sweeping like a gentle tide, pervading the mind with a tranquil mood of deepest worship. It may pass over into a more set and lasting attitude of the soul, continuing, as it were, thrillingly vibrant and resonant, until at last it dies away and the soul resumes its profane, non-religious mood of everyday experience. It may burst in sudden eruption up from the

> depths of the soul with spasms and convulsions, or lead to the strangest excitements, to intoxicated frenzy, to transport, and to ecstasy. (pp. 12-13).

Otto described five "elements" of the numinous experience. First is "awefulness." In the monotheistic religions this is also called the "fear of God." Second is "overpoweringness," or *majestas*. This invokes the humility of the creature in the presence of his creator. Third is "urgency." This is the sense of an active will or living power in charge of the universe. Fourth is the idea that the numinous is "wholly other." In mysticism this is described as the experience of the void or nothingness. The abyss is a recurring image. The numinous

> has no place in our scheme of reality but belongs to an absolutely different one, and which at the same time arouses an irrepressible interest in the mind. (p. 29)

This idea leads to the fifth characteristic of the numinous: "fascination." The experience entrances as well as bewilders. Otto considered this the Dionysiac element of the numinous, that which we describe as intoxication or ravishment.

C. S. Lewis (1940) used the idea of the numinous to explain how one can believe in God when the existence of suffering makes the concept of an omnipotent and omnibenevolent God illogical. He described the feeling as being in the presence of a mighty spirit:

> You would feel wonder and a certain shrinking – a sense of inadequacy to cope with such a visitant and of prostration before it – an emotion which might be expressed in Shakespeare's words "Under it my genius is rebuked." This feeling may be described as awe, and the object which excites it as the *Numinous.* (p. 14).

In recent years, cognitive psychologists have considered the numinous under the rubric of "awe." This combines cognitive uncertainty and intense emotion (Keltner & Haidt, 2003):

> [A]we involves being in the presence of something powerful, along with associated feelings of submission. Awe also involves a difficulty in comprehension, along with associated feelings of confusion, surprise, and wonder.

A final aspect of the numinous that we might consider is the sense that one is being perceived as much as perceiving. This quotation is from Christian Wiman, a poet, in a book called *My Bright Abyss* (2013):

> At such moments it is not only as if we were suddenly perceiving something in reality we had not perceived before, but as if we ourselves were being perceived. (p. 82)

In summary, the experience of the numinous combines three main characteristics

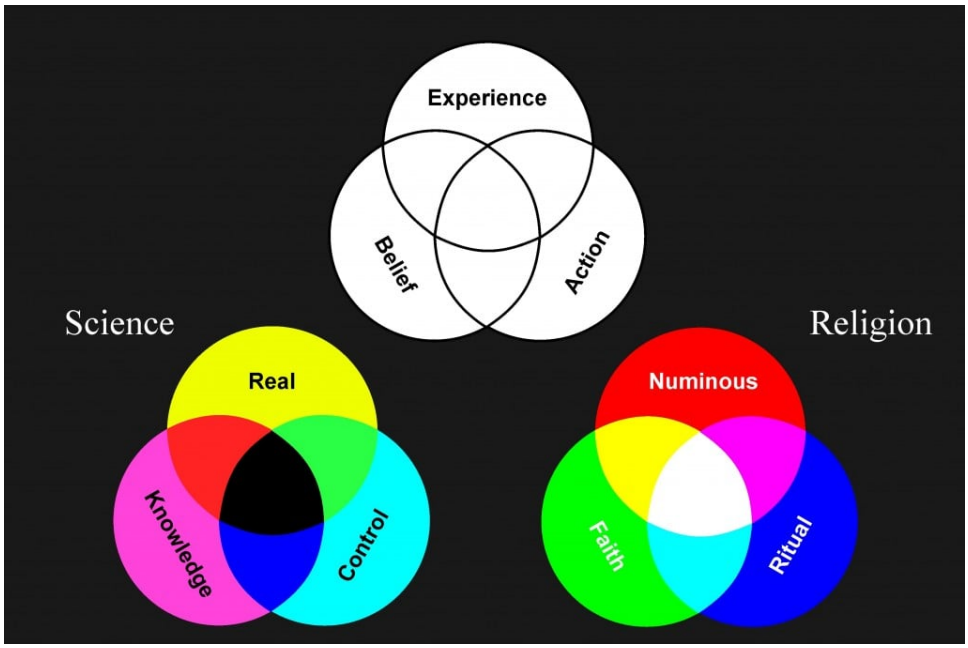
(i) a sense of being in presence of something beyond comprehension or control.

(ii) an intense emotional arousal, combining fear and wonder, like the feeling at the edge of an abyss.

(iii) a state of uncertainty and a need to do something about it.

The Context of Numinous Experiences

The experience of the numinous parallels the experience of the real world. In general we experience something, derive from that experience a set of beliefs, and then act according to those beliefs in order to gain more experience. This overlapping sequence is illustrated in the following figure, the upper portion of which derives from a similar representation by Lewis-Williams and Pierce (2005, p.25).



When dealing with the real world we create knowledge that then allows us to act within that world. The experience of the numinous leads to faith and faith lead to practices that bring about further interaction with the numinous. For example, revelations can lead to conversion to a faith that promotes prayer and meditation to enhance the experience of the numinous.

Michelanglo Merisi da

Caravaggio, 1601, The Conversion on the Way to Damascus, Church of Santa Maria del Populo, Rome.

An intense experience of the numinous can lead to a complete re-thinking of one's life. On the road to Damascus the persecutor Saul had a vision that led to him becoming the Apostle Paul:

> And it came to pass, that, as I made my journey, and was come nigh unto Damascus about noon, suddenly there shone from heaven a great light round about me.
>
> And I fell unto the ground, and heard a voice saying unto me, Saul, Saul, why persecutest thou me? (*Acts 22*:6-7)

The nature of Saul's vision is not known. Some have suggested that it might have been epileptic in origin. Yet the effect is perhaps more important than the cause.

Visions are not as common in our present day as they seemed to in the past. Nowadays, we have only the artistic representation of experiences from earlier times – the numinous at second-hand.

Once a religion is founded, behaviors are promoted to maintain the link to the original numinous experience. The mainstay of the Eastern religions is the process of meditation. The goal is to lose the self, to dissolve into the great sea of being. Western religions tend to prayer more than meditation. Communing with a personal God rather than dissolving in a Universal Force.

Gian Lorenzo Bernini, 1652, The Ecstasy of Saint Teresa, Church of Santa Maria della Vittoria, Rome

Though mainly peaceful, both prayer and meditation can become ecstatic. Saint Teresa's experience of the angel was as sexual as it was ascetic:

> I saw in his hand a long spear of gold, and at the iron's point there seemed to be a little fire. He appeared to me to be thrusting it at times into my heart, and to pierce my very entrails; when he drew it out, he seemed to draw them out also, and to leave me all on fire with a great love of God. The pain was so great, that it made me moan; and yet so surpassing was the sweetness of this excessive pain, that I could not wish to be rid of it. The soul is satisfied now with nothing less than God (Teresa of Avila, 1581, 29:17).

The numinous is not necessarily related to religion. The romantic revolution led to the search for the numinous in nature, often described as the "sublime:"

> And I have felt
> A presence that disturbs me with the joy
> Of elevated thoughts; a sense sublime
> Of something far more deeply interfused,
> Whose dwelling is the light of setting suns,
> And the round ocean and the living air,
> And the blue sky, and in the mind of man;
> A motion and a spirit, that impels
> All thinking things, all objects of all thought,
> And rolls through all things.
> *Lines Written a Few Miles above Tintern Abbey,* William Wordsworth, 1798

The term “sublime” has multiple meanings (Saint-Girons, 2014). In the context of Wordsworth’s poem it is used in the manner of Burke in his to mean something that evokes both terror and delight.

> Whatever is fitted in any sort to excite the ideas of pain, and danger, that is to say, whatever is in any sort terrible, or is conversant about terrible objects, or operates in a manner analogous to terror, is a source of the sublime; that is, it is productive of the strongest emotion which the mind is capable of feeling. When danger or pain press too nearly, they are incapable of giving any delight, and are simply terrible; but at certain distances, and with certain modifications, they may be, and they are delightful, as we every day experience. (pp. 13-14).

The numinous can come from drugs as well as devotion. Wordsworth’s friend Coleridge’s visions of *Kubla Khan* were induced by opium. In the latter half of the twentieth century psychedelic experiences became a common way to seek the numinous:

> Take me on a trip upon your magic swirlin’ ship
> My senses have been stripped, my hands can’t feel to grip
> My toes too numb to step, wait only for my boot heels

To be wanderin’
I’m ready to go anywhere, I’m ready for to fade
Into my own parade, cast your dancing spell my way
I promise to go under it.
Bob Dylan, *Mr Tambourine Man*, 1967

The near-death experience is another way to the numinous.The anoxic brain is likely awash in psychodelic chemicals. Yet, there is no doubt of the experience, or the memory of an ascent toward the light.

Numinous experiences of whatever kind tend to make people change their thinking. This can lead to a religious belief system or faith. Faith fosters practices, such as meditation, prayer, and asceticism, that promote further numinous experiences.

Psychological Studies of the Numinous Experience

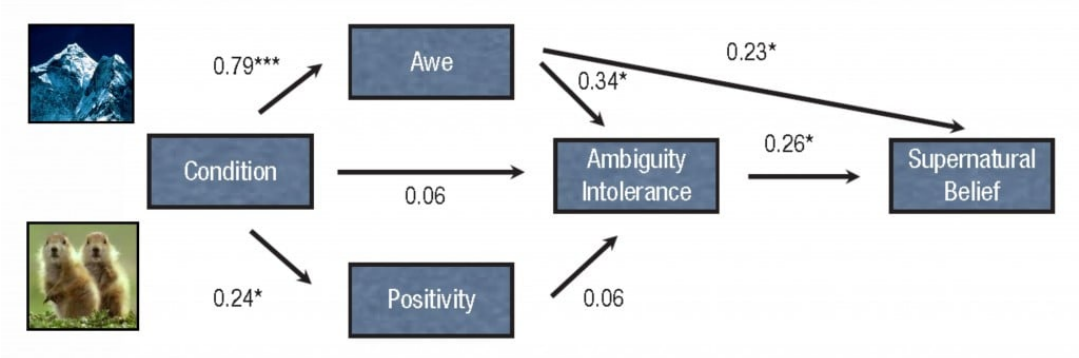
Keltner and Haidt (2003) reviewed our understanding of awe. Many different situations can elicit the mental state. We may awed in the presence of great natural beauty – sunsets, mountains, canyons, galaxies. Artistic creations can also elicit awe – paintings especially when large, music especially when loud, architecture especially when high. Great leaders and saints can trigger awe and devotion. Science can also bring forth the feeling – the ecstasy of theory rather than theology.

Awe has both emotional and cognitive characteristics. The two main emotions in the experience of awes are fear and wonder. Essential to the experience of awe is an incomplete understanding of what we are experiencing. The vastness of what we perceive overwhelms our cognitive ability. There is a pressing need to come to grips with the source of our confusion and uncertainty.

> [A]we involves a need for accommodation, which may or may not be satisfied. The success of one's attempts at accommodation may partially explain why awe can be both terrifying (when one fails to understand) and enlightening (when one succeeds).

The experience of the numinous often leads to a belief in supernatural powers. A recent psychological study by Valdesolo and Graham (2014) investigated how this comes about. Subjects were exposed to two conditions. In one they watched awe-inspiring videos of sunsets, mountains, canyons and galaxies. In another they watched humorous videos of animal behavior. Their emotional experience (awe, positivity or neutral) was quantified using simple scales.

Two questionnaires were administered. One determined the subject's ability to tolerate uncertainty: "I feel uncomfortable when I don't understand the reason why an event occurred in my life" Another determined the subject's belief in supernatural forces: "The events that occur in this world unfold according to God's or some other nonhuman entity's plan." A correlational analysis showed that awe induced by the experimental manipulation increased belief in supernatural forces in those that were less able to tolerate ambiguity.



The authors suggest that "in the moment of awe, some of the fear and trembling can be mitigated by perceiving an author's hand in the experience." In a related experiment, Kristin Laurin and her colleagues (2008) related the belief in God to the "desire to avoid the emotionally uncomfortable experience

of perceiving the world as random and chaotic." God is what we postulate to make the world make sense and to provide us comfort in the face of deep emotions.

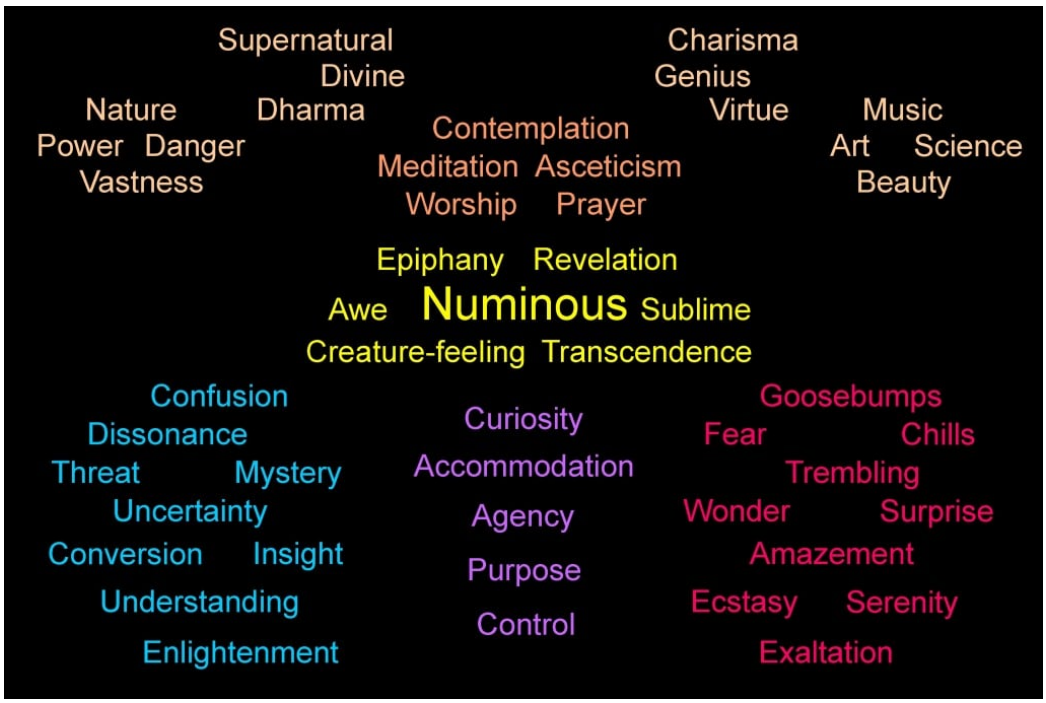
The numinous induces emotional as well as cognitive effects. However, we understand much less about our emotions than about our thoughts. The complex array of human emotions can be considered as mixtures of some primary states. Six basic emotions generally considered: happiness, sadness, fear, anger, surprise, and disgust. Other emotions were considered as combinations of these primary states. Thus hatred may be a combination of anger and disgust. In a recent paper describing computer algorithms for recognizing human emotions from facial expressions, Du and his colleagues (2014) have suggested that awe is a combination of surprise and fear.

Awe may be more complex. The experience of the numinous involves attraction as well as withdrawal: orientation toward as well as flight from, heart rate slowing as opposed to speeding. The *mysterium tremendum* is often also considered the *mysterium fascinans*.

Some categorizations of emotion include curiosity: that which leads us to explore our environment. Curiosity (or "interest") is an emotional state, personality trait or motivational drive that becomes manifest in a situation where there is either a lack of arousal (boredom) or a disparity between what one experiences and what one understands (information-deprivation) (Litman, 2005). Curiosity is prominent in children. The main facial aspects of curiosity are the fixed stare, widened eyelids and pursed lips (Reeve, 1993).I suggest that the numinous induces curiosity as well as fear and uncertainty.

The numinous is difficult to describe – indeed it is often

called ineffable, that which passes understanding. In the dark night of the soul a cloud of words appears as a possible summary of the psychology of the numinous:



The experience of the numinous can be induced (pale yellow) by natural beauty, by supernatural effects, by charismatic people and by works of art. It can be fostered by various religious behaviors (orange). The numinous induces both cognitive and emotional responses. The main cognitive effects (blue) are confusion and uncertainty. The main emotional effects (light red) are fear and wonder. We must try to cope with these effects through processes of accommodation (purple) so that we might reach enlightenment and exaltation.

Neuroscientific Studies of the Numinous

Unfortunately, we have not been able to determine specific brain concomitants of the numinous experience. Many regions are active and these interact in as yet unknown ways. The three main areas are the prefrontal regions, especially those active during the processing of theory of mind, the temporal regions, especially those related to emotions, and the

parietal regions, where different perceptual modalities come together.

Neurological approaches to the numinous have involved studies of both epilepsy and brain lesions. The numinous experience may be part of the aura of an epileptic attack. Fyodor Dostoyevsky suffered from epilepsy, and we presume that the seizures of Prince Myshkin in *The Idiot* reflect his own experience:

His mind, his heart were lit up with an extraordinary light; all his agitation, all his doubts, all his worries were as if placated at once, resolved in a sort of sublime tranquility, filled with serene harmonious joy, and hope, filled with reason and ultimate cause.

Although the origin of Dostoyevsky's seizures is unknown, most consider them as temporal lobe epilepsy. Surveys show that about 4 % of patients with temporal lobe epilepsy have religious or mystical experience either in the aura or in the post-ictal state (Devinsky & Lai, 2008). The experience is much more likely pleasant than not.

Attempts to trigger the numinous experience in normal subjects by magnetic stimulation of the temporal lobe (Persinger, 2002) have not been replicated (Granqvist et al., 2005). The stimulus levels were likely too low to have any neuronal effect, and the numinous experiences reported were probably related to suggestion rather than to stimulation.

Olaf Blanke and his colleagues (2004) studied five patients who reported out-of-body experiences and found lesions in the temporo-parietal region of the brain. This region where the different perceptual systems come together may be important in the representation of the self within a world. Losing oneself and becoming swept away in a more universal experience may therefore result from damage to these regions. This area of the cortex is very sensitive to anoxia since it is at the

furthest reaches of the cortical vascular supply. Some have suggested that the prophets who received divine revelations when they went up into the mountains might have been particularly susceptible to hypoxia (Arzy et al., 2005). A similar hypothesis can be made for the near-death experience.

The *electrical activity* of the human brain changes markedly during the numinous experience. Both alpha and theta activity significantly increase during meditation (e.g. Cahn & Polich, 2006; Cahn et al., 2013; Tsai et al, 2013). The problem is that we do not really know what these rhythms mean in terms of brain processing. Furthermore, we do not know whether the rhythmic changes are an essential part of the meditation process or simply a side-effect. The alpha rhythm is likely an idling activity generated when the visual cortex is not processing information. Theta activity can occur in drowsiness and in emotional arousal. In the sixties, seekers of the numinous trained their brains to increase their alpha rhythm. Whether or not such biofeedback brought forth revelations independently of the pharmaceuticals that were its frequent concomitants remains unknown. As well as changing the ongoing EEG rhythms, meditation also alters the electrical activity evoked or induced by external stimuli (Cahn et al., 2013). Again we have difficulty determining what this means for the meditative state because we do not really know what these changes indicate.

Functional MRI studies of the numinous experience are difficult. Mystic visions may not come easily in a multi-Tesla magnetic field. Many experiments have occurred and many manipulations have been made (a non-critical review is Fingelkurts & Fingelkurts, 2009). Some studies are woefully inadequate in terms of their design and analysis. Others are intriguing but founder on the difficulty of setting up experimental manipulations that can lead to a sense of the numinous within the confines of the magnet. Two sets of studies illustrate the problems.

Beauregard and his colleagues studied Carmelite nuns as they recalled mystical experiences (Beauregard et al., 2006, 2008). They found multiple regions active in comparison to the resting state, most prominently in the inferior frontal, temporal and parietal regions.

Kapogiannis and his colleagues used a much less effective manipulation – subjects either evaluated religious statements or discriminated fonts (Kapogiannis et al., 2009, 2014). Their only significant finding related to a belief in God's lack of involvement in the world. The brain only betrayed its lack of faith.

Perhaps the numinous is in the interactions of networks rather than the activity of neurons. Brain connectivity is likely as important as brain activity (Yeo et al., 2011). A recent study of meditation by Xu and his colleagues (2014) showed activity mainly in the default, frontoparietal, and limbic networks. The default network involving frontal, parietal and temporal regions is typically active during resting control conditions when the brain is not involved in the experimental task. Intriguingly, the default network was more active during meditation than during the normal resting state. Perhaps the default mode of the human cerebral cortex allows the experience of the numinous, at least in the sense of the brain freely thinking without external constraint. When we withdraw from the world and look inward, our thoughts often turn to matters of philosophy. As Alfred North Whitehead (1926) said "Religion is the art and theory of the internal life of man."

Overview

Although the numinous experience is the focus of scripture and the basis for religious belief, we have little knowledge of how it occurs. We have some understanding of the psychology that underlies the experience. Emotions of fear and wonder

combine with a cognitive state of confusion and uncertainty. The outcome of the experience can be some accommodation of our thinking to allow a larger view of the world. We know very little about how the brain mediates the numinous experience. This is unfortunate since it is so important. It is what changes lives.

Rainer Maria Rilke wrote about his experience of the numinous while looking at a torso of Apollo in the Louvre. His poem *Archaïscher Torso Apollos* (Rilke, 1908) concludes:

denn da ist keine Stelle,
die dich nicht sieht. Du mußt dein Leben ändern.

for there is no place
that does not see you. You must change your life.

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Apollo’s Gaze

The *Charioteer of Delphi* is a life-size bronze statue erected in 474 BCE to commemorate a victory in the chariot races of the Pythian games. The statue's left arm is missing; the reins held in his right hand are no longer connected to his steeds; the headband has lost its silver inlay. Yet the glass eyes and copper eyelashes are remarkably well preserved. The charioteer's head and gaze are inclined to the side. This is one of the first direct interactions between a work of art and the viewer. He looks at you as much as you at him. The look is piercing.

The statue likely portrays the winning charioteer. However, it may also represent Apollo, the divine patron of the Pythian games. Apollo was the sun-god, having assumed this role from the Titan Helios of earlier mythology. Apollo was a god of many facets: the god whose chariot carried the sun across the sky, the god of music and the leader of the muses, the god of prophecy and poetry, the god of light and truth. Though generally beneficent, Apollo was sometimes dangerous. The horses of the sun's chariot occasionally ran wild and caused widespread destruction. This has been attributed to Phaethon, the son of Helios, though these may both be manifestations of Apollo.

The gaze of the *Charioteer of Delphi* has been interpreted in different ways. Does he look right through you? Or does he notice you even though his main concern is elsewhere, perhaps with his master's horses, perhaps with his own thoughts?

Why do we find the eyes so striking? The eyes of others are highly among the most important stimuli we process. They tell us about the world, about ourselves, and about our colleagues. Human beings have evolved brain systems so that the eyes and the gaze of others can be efficiently processed.

The human eye differs from that of most other animals in that the sclera – the white of the eye – is clearly visible around the dark iris. Because of the clear contrast between sclera and iris, the direction of the gaze can be followed independently of where the head is looking. Other primates estimate what someone is looking at by the orientation of the head. Human beings assess the orientation of the eyes as well as the head. This ability is present in human infants of 12-18 months (Tomasello et al., 2007). Our brains therefore either inherit or rapidly develop neural systems that can specifically follow the gaze of other individuals. We track the gaze by where the dark of the eye is pointing. We are thus mistaken when tracking the gaze in photographs that have been contrast-reversed. This was elegantly demonstrated by Pawan Sinha (2000). In the following pair of stimuli, Humphrey Bogart appears to be looking in opposite directions:

This seems to be a cognitively impenetrable hard-wired system. Knowing that the photograph has been contrast-reversed does not prevent our mistaken impression of where the contrast-reversed Humphrey is looking.

The brain systems underlying the perception of eye and gaze involve the posterior superior temporal sulcus (Allison et al., 2000; Kingstone et al, 2004). This region of the

association cortex receives input from more general visual areas, and has connections to regions of the parietal cortex related to attention and to more anterior temporal regions related to object perception and emotion.

Gaze perception provides us with two main pieces of information. The first occurs when another person is looking directly at you. This tells you of another consciousness and suggests the possibility of interaction. For many animals the gaze can be a challenge; for human beings it is often a prelude to communication. The second type of information occurs when another person is looking at something or someone else. This tells you the focus of their attention, and allows you to share their thinking.

Eye and gaze perception facilitates the development of social cognition (Emery, 2000; Itier & Batty, 2009). The newborn infant prefers to see faces with eyes open than with eyes closed. The open eyed face is a signal for social interaction. Over the first year of life the infant learns to follow the gaze of another person and in the second year the infant can begin to share attention with another. The ability to understand the perceptions and intentions of another person – "theory of mind" typically develops by the time the child is 4 or 5 years old.

The appreciation of the visual arts is essentially experiencing how someone else sees the world. We share the gaze of the artist, and try to relive what it was that moved them to record their insight. This can be either enlightening or disconcerting. Much visual art has been framed by male artists for the appreciation of male viewers (Korsmeyer, 2008). How then does a woman regard a painting of Venus? As the male onlooker or as the female object? Art should not be appreciated in a manner that distances itself from sensual pleasure. Interpretation devoid of desire is empty. As Susan Sontag has said "In place of a hermeneutics we need an erotics of art" Art has multiple levels of meaning. The interaction

between the viewer and the nude should include both sensuality and sympathy.

In some paintings the artist includes a person that looks directly at the viewer. The artist (or the model) may thus try to see what you are seeing in the painting. Or to suggest that the viewer is being looked at as much as looking. Sartre (1943) was deeply concerned with the concept of looking. When we look at the world we see objects. These are separate from us, perceived rather than perceiving, objects rather than subjects. When someone looks back at us, we sense the inversion of the process: we are the objects of another's gaze. This proves our existence as an object in the world, and also indicates the existence of other subjects. Furthermore, it adds a sense of being evaluated. Who am I that I should be looked at? The interplay between "other as object" and "other as subject" provides us with an understanding (and an evaluation) of both ourselves and our fellows.

The perception of another is crucial to social cognition. Postulating that other people have minds like ours (or that we have minds like theirs) is the basis for communication. Theory of mind does not necessarily require vision or hearing to develop, but it is clearly facilitated by being able to see and hear another person.

The sense of another is perhaps related to our sense of the divine. As Sartre said, God may be "the concept of the other pushed to the limit." We term this percept (or concept) of the Absolute Other the "numinous." We can experience the numinous when we are in the presence of something or someone that transcends our normal understanding. Meditation and prayer are interactions between the human with the numinous. In many cases, people have described these in terms of being looked at or examined. Hans Urs von Balthasar describes prayer as submitting oneself to the gaze of God:

> God's gaze is not passive (otherwise it would not be a

> divine gaze); he does not merely ‘read off’ or ascertain: his gaze is creative, generative, originative, by his utterly free decree. ‘This is what, in my eyes, you are; this is what you mean; no other truth can have any validity but this, for me, for you, or for anyone else.’

This then may in part explain our fascination with the *Charioteer of Delphi*. We have become objects of a divine gaze. The human brain has a way of thinking that lets us see ourselves as we might be seen from a distant and objective viewpoint. Seen by an athlete at an ancient games, or by the god that was his patron. Examined *sub specie aeternitatis* – under the aspect of eternity.

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