Grey Matters: The Synapse and Other Gaps

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Gaps are among the most meaningful of nonentities. Despite their emptiness, they do not reduce to nothingness, for they are defined by their relationship to something else. A gap, depending on the context and one’s viewpoint, might be regarded as a vacant breach or a bridgeable junction. Located just beyond the boundary of things tangible or discernible, gaps invite questions of possibility.

Consider the synapse. This narrow cleft between nerve cells constitutes a cellular discontinuity. The synapse forms a division between living cells. Its shape is the space between the edges of adjacent neurons which are anatomically and functionally distinct from one another. A molecule lingering within the synapse would lie outside the cell border in the narrow 20-40 nanometer void between one neuron’s presynaptic membrane and another neuron’s postsynaptic membrane.

The synapse is at the same time a nexus of potential continuity. Across its gap surge streams of encoded molecular signals. Highly specialized ion channels and receptors strategically positioned at the edge of the synapse coordinate a bustling flow of chemical messages from one neuron to another. Neurons then integrate excitatory and inhibitory information conveyed through their synaptic connections. From the collective activity of cerebral neurons joined via synapses emerge brain functions.

The word ‘synapse’ derives from the Greek words meaning ‘to clasp together.’ Physician and physiologist Charles Scott Sherrington, who sometimes referred to the brain as an ‘enchanted loom,’ coined the term ‘synapse’ in 1897. Sherrington reasoned that, since ‘there does not exist actual confluence of the conductive part of one cell with the conductive part of the other, there must be a surface of separation,’ or a ‘nexus between neurone and neurone in the reflex arc.’

Meanwhile, also at the turn of the twentieth century, physician and neuroanatomist Santiago Ramón y Cajal was focusing his microscope on the fine structural details of individual neurons, which, stained with Golgi’s silver
chromate technique, could for the first time be clearly seen. Observing that the neuron at one end issues forth a long slender axon, and at the other end reaches out in many directions with finely arborizing dendrites, Cajal proposed that neurons communicate with each other unidirectionally across tiny gaps. Cajal was the first to postulate that the brain comprises billions of discrete neurons rather than being arranged as a seamless multicellular web.\textsuperscript{2} Integral to what became known as the neuron doctrine was the discovery of the synapse.\textsuperscript{3}

The synapse itself would remain invisible for another half century. Although Sherrington inferred its existence from the electroconductive behavior of neurons, and Cajal extrapolated its dimensions from the filamentous outlines of almost-touching neurons, direct visualization of the synapse was beyond the optical resolution of the finest microscopes of the era. Definitive demonstration of the synaptic cleft came in the 1950s, once electron microscopy provided nanoscale magnification of intricate synaptic ultrastructure. Since then, numerous varieties of synapses have been described. The approximately 160 trillion synapses in the adult human cerebral cortex\textsuperscript{4} vastly outnumber the 200-400 billion stars in the Milky Way galaxy.

Identification of the synapse closed a gap in scientific understanding while opening the door to investigation of the neuron. Knowledge about neurons has informed the scientific basis of neurology and greatly enhanced the ability to diagnose and treat patients with neurological disorders. Knowledge about the brain continues to grow by staggering proportions. Now that every detail of the brain has become accessible to empirical investigation, there is, in principle, no longer any structure within the brain too small to image or any neural circuit too subtle to trace out.

And yet, there are other cerebral explanatory gaps which persist and perplex. After the synapse, perhaps the greatest challenge today is whether neuroscience can bridge the gap between brain and mind. Each scientific discovery adding to the molecular understanding of neuropsychology draws closer to the ambitious goal of a complete understanding of the brain. Each functional brain imaging study correlating particular thoughts to alterations in metabolic activity in specific cerebral pathways tightens the apparent link between brain and mind.\textsuperscript{5,6} One may wonder whether, once technology has brought the inner recesses of the brain fully within view, the mind laid bare will have yielded all its secrets to the scrutiny of neuroscience.

Somewhere within the narrowing gap between brain and mind is what Francis Crick, co-discoverer of DNA? s double helix, has called his ?astonishing hypothesis,? which is ?that ?You,? your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules.?\textsuperscript{7}

Crick is correct, up to a point. If he had claimed that mental states ?are represented by,? or ?correspond to,? nerves and molecules, then his statement would have been germane to his field of molecular biology. With the words, ?are in fact no more than,? he has stepped outside the jurisdiction of science and proffered a philosophical assertion which argues that all that is true and can be known about human consciousness is ultimately reducible to matter and its quantifiable interactions.

The philosopher Patricia Churchland, who writes about the brain from the position of eliminative materialism, argues that, ?The mind that we are assured can dominate over matter is in fact certain brain patterns interacting with and interpreted by other brain patterns.?\textsuperscript{8} Continuing, she writes, ?In all probability, one?s decisions and plans, one?s self-restraint and self-indulgences, as well as one?s unique individual character traits, moods, and temperaments, are all features of the brain?s general causal organization.?\textsuperscript{9}

There is much in the writings of Crick and Churchland that can be affirmed in regard to the relevance of recent scientific discoveries about the brain to higher cognitive functions. While the findings of neuroscience are necessary to explain the brain, it does not follow, however, that they are sufficient for a complete understanding of the meaning of human mental states that arise within the healthy brain. A thoroughly reductionistic model of the brain might require one to relinquish belief in personal agency, intentionality, moral knowledge of right and
wrong, conscience, and recognition of the sacred, and resign oneself instead to the belief that matter is the
supreme reality, and its accidental interactions humanity?s sole source of guidance.

Much rhetoric is needed to paint over the cracks that appear in the articulation of materialistic worldviews.
These cracks resist being filled with the stuff of materialism. What value can be placed on tenacious insistence
in materialism, if insistence is in reality nothing more than a momentary rush of neurotransmitters? How can
one validate as rational the assertion that free will is an illusion, if all thoughts, including the assertion and its
assessment, are no more than the product of a chain of necessary causation involving molecules and elementary
particles? Who could authenticate as truthful the claim that alternative explanations are false, if utterances are
merely sounds heard from the mouths of human automata?

Philosopher Daniel Dennett asks, ?But why should consciousness be the only thing that can?t be explained?? It
matters, of course, what kinds of explanation are permitted and which are excluded. This is also a question that
presupposes the existence of that which the question treats as hypothetical: explained to whom?

In attempting to close by abolishing the gap between brain and mind, Crick and others before him have exposed
the yawning crevasse of materialistic reductionism. Churchland, to her credit, with the words, ?in all
probability,? maintains at least an agnostic foothold on higher philosophical ground. A ceaselessly inquiring
mind that recognizes when certainty is warranted and when provisional conclusions are appropriate is less likely
to fall into reductionism?s confines.

Whereas physicalist interpretations of the mind-brain problem seek to reconcile brain processes with higher
mental states, dualistic interpretations from Descartes to Aquinas face the problem of explaining how personal
agency interacts with the material brain. Nonreductive physicalist anthropologies, which reject the possibility of
an immaterial mind, nonetheless bear the burden of explaining how agency as a nonlocalizable emergent
property can exert top-down causation on lower-level streams of material causation.

The temptation common to all these approaches to understanding the brain is to close the explanatory gap
prematurely. Some claim certitude from incomplete data. Others find their claims disproven once more data
emerge. Others appeal to extraneous categories of knowledge. Still others reason inconsistently or favor among
available options those conclusions that seem to make fewer moral demands personally.

A similar error characterized ?God of the gaps? apologetics, which invoked divine intervention as an
explanation whenever gaps were found in the scientific evidence. One problem with this approach is that many
of these gaps were eventually answered as science advanced, apparently displacing dependence on God.
Another problem with this apologetic is the suggestion that God?s influence can be seen only in what is not
understood, or in competition with natural forces, rather than seeing God?s sovereign hand in all of nature. This
kind of ?God of the gaps? reasoning is no longer accepted as valid within scientifically-informed Christian
apologetics.

Gaps are an intractable feature of the landscape of knowledge. Betwixt and between the known and the
knowable, gaps persist. A complete explanation of mind, matter and the universe remains persistently elusive to
human inquiry. Some of these explanatory gaps are like holes in a jigsaw puzzle awaiting the addition of more
scientific knowledge. Other gaps lie at the edge, above, or below the jigsaw puzzle. These gaps are open
opportunities to look beyond the empirical patterns to larger answers.

Cajal allegedly quipped that his scalpel could never find the soul. Taking for granted that his scalpel could
rightly divide the neuron, this should come as no surprise. Cajal?s postmortem brain specimens, dessicated and
fixed onto a glass slide, were silver-stained artifacts of life and not life itself. Even the study of living brain cells
with modern methods cannot be expected to prove or disprove the existence of the soul. Cajal?s scalpel may not
have touched the soul, but his pen wandered well into metaphor. In his memoirs, he wrote, ?As the entomologist
chasing butterflies of bright colors, my attention was seeking in the garden of grey matter, those cells of delicate and elegant forms, the mysterious butterflies of the soul, whose fluttering wings would someday? who knows? enlighten the secret of mental life.13

Gaps, in conclusion, illustrate both discontinuity and continuity. The synapse where one neuron ends and another begins is a double membrane of structural and conductive discontinuity. That is not the whole story, for signals flowing selectively across those gaps create a nexus of informational continuity. Communicating in concert, the sum of synapses signify something greater than the parts.

Neuroscience now peers into the gap between brain and mind. This gap, like the synapse, may be thought of as both continuous and discontinuous. The task of science is to seek to fill explanatory gaps. And yet, there are questions that science alone cannot answer with certainty. Though all of nature is subject to scientific investigation, not all that is true regarding the nature of things and minds can be apprehended through the scientific method. Science properly understood accommodates a creative tension between what can be seen and what is abstractly reasoned, between what is known and what can be imagined.

Gaps persist. They force us to seek answers more earnestly. Some answers come not as solved mathematical formulae but as wondrous epiphanies unwritable by equations but hintable through metaphor. Ignoring these gaps, one might measure the brain completely without fathoming the mind or contemplating its Maker.

References
10. The habit of ongoing questioning and testing against reality required for productive scientific inquiry may be compared to Paul?s admonishment in 1 Thessalonians 5:17 to ?pray without ceasing.? (NKJ)

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