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Address by the laureate Siri Hustvedt

I will begin with a story. In January of 2017, I gave the Grand Rounds Lecture in Neurology at Brigham Young Women's Hospital and Massachusetts General Hospital in Boston. After the talk at Mass General, I was treated to lunch with a group of scientists doing research on Alzheimer's disease and dementia, after which they gave me presentations of their work. I asked them questions and then they asked me questions. A young scientist wanted to know why I thought someone like him should read philosophy, literature, and history. What would he do with this knowledge? I told him that I wasn't encouraging him to read expansively simply because he would be more charming company at cocktail parties, although this would surely be the case. "I think it is important," I said, "because it will help you in your own work, specifically in designing better models for your research."

The idea that scientists need not worry about the questions that pester philosophers, novelists, and historians has a long history and turns on complex questions of truth and cosmology. When I address people working in the humanities, I recommend that they read in the sciences, biology in particular, as a necessary part of understanding what the human species actually is. Although it is true that interdisciplinary studies of one sort or another are popular these days, it is also true in my experience that these collaborations are often less than successful. Although epistemologies are rarely discussed, the big problem of how we know what we know, the underlying assumptions that guide research in various disciplines, often serve as invisible barriers to meaningful discussion.

We live in a world of extreme specialization and expertise, in the sciences but also in every academic field. When I was working toward a PhD at Columbia University in English literature, the nineteenth century was my designated field, and I wrote my dissertation on Charles Dickens. There are Dickens specialists. The scholarship is enormous, and I plowed through scores of critical works on Dickens to prepare myself. In the end, I discovered there were only three that really mattered to me. One of them, a brilliant essay by Dorothy Van Ghent, *A View from Todgers*, published in 1950, is only twenty-pages long.

Mostly, I drew insights from other disciplines: philosophy, psychoanalysis, and linguistics. In the work of the linguist, Roman Jakobson, I found a description of pronoun loss in patients suffering from Broca's aphasia, a disorder that causes various kinds of language impairment, which helped me think through questions about language and the self, a problem obsessively explored in Dickens' books. There are many bracing quotes that turn on language and identity from *Our Mutual Friend*, the last book the author lived to finish, but I will cite two. When the hero, John Harmon, gives an account of his near drowning, he says, "There was no such thing as I." Another character, Mr. Dolls, a miserable drunk, repeatedly describes his situation this way: "Circumstances over which had no control." Mr. Dolls never uses the first-person pronoun.

Dissertations on Dickens are understandably regarded as less urgent matters than research on cancer or Alzheimer's disease, AD. The scientist who queried me about the benefits of outside reading was working on models that might make sense of the damage to brains he detected in scans. He wanted to be able to "read" the structural as well as functional brain changes in these patients that create the well-known memory deficits of the illness. He and his colleagues are on the look out for "bio-markers." It is clear that neurons degenerate in AD and neuronal synapses are disturbed. Amyloid plaques in the brain have been implicated, but there is no way at present to stop the inevitable memory decline. As with so many diseases, both genetic and environmental factors have been implicated. This is from a 2018 paper on Alzheimer's Disease: "However, current AD models have their limitations, which include not explaining the effects of mechanistic pathways and cytotoxicity." [Hassan et al, *Computational modeling and biomarker studies of pharmacological treatment of Alzheimer's Disease*, Molecular Medicine Reports 18 (2018): 639-655] You don't have to understand what cytotoxicity is to glean that they are still looking for the "mechanisms" involved.

While reading a book by Jessica Riskin, an historian of science at Stanford, *The Restless Clock: A History of the Centuries Long Argument Over What Makes Living Things Tick*, I ran into the following quote from a person who attended a meeting of the Leipzig Association of German Natural Scientists and Physicians in 1872: "Present day science does not worry about the whole. It thus no longer strives for a world view." Instead, a researcher must devote himself "to one science, nay, often to only a part of one science. He looks neither to the right nor to the left so that what is going on his neighbor's field may not prevent him from burying himself in his specialty to his heart's content." (257) One of my heroes from the same period, Hermann von Helmholtz, a German biophysicist, took the opposite view. He was against breaking up science and did not approve of divorcing natural science from philosophy, literature, and history. His reading of Kant had been crucial to his own development as a scientist. Helmholtz, whose work has been resurrected recently, especially his idea of unconscious inference, lost that particular battle. Specialty remains at the heart of the day-to-day business of science.

In the neurosciences, I have discovered time and time again that people working on memory at the molecular level do not intersect with those who are trying to understand memory through synaptic connectivity. They may not even be able to read each other's research. Further, a scientists or a team of scientists may specialize in a particular brain locus and study it and its relation to other brain areas: the insula, the cerebellum, the temporoparietal junction, the TPJ, or the hippocampus, to give a few examples. I have also noticed that scientists become attached to their specialties, to their loci and from time to time aggrandize the importance of these parts in their papers.

The role of the hippocampus in explicit or declarative memory began to emerge through studies on the famous patient HM that began with Brenda Milner in the 1950s. An atrophied hippocampus is characteristic of Alzheimer's. Milner's patient, Henry Molaison, who is now dead, suffered from intractable seizures after a brain injury, submitted to surgery to fix the problem, during which he lost much of his hippocampus, but also surrounding areas. As a result, he was unable to retain memories. Henry Molaison was affable and articulate. He held on to his short-term memory—he could repeat back a series of numbers—and he was able to learn new motor skills, although he couldn't remember how he had learned them. If you are a person who cared about this worm- or seahorse-shaped structure in the brain and read papers on the subject, you would have noticed the names of the same authors reappearing again and again, and also that the descriptions of the hippocampus's role in the brain were dependent on whether the team of scientists was studying people or rats.

In human beings, the hippocampus became linked to autobiographical memory, and later to future thinking and the imagination. In rats it was tied to spatial navigation. My interest in the age-old connection between memory and imagination and my passion for the Italian philosopher Giambattista Vico, who argued in *The New Science* (1744) that the two are part of the same faculty, has meant that I have pounced on all the papers published in the last fifteen years on this subject, which has further meant that I have run into the same authors working on the problem, among them, Demis Hassabis, Sinéad Mullally, and Eleanor Maguire. Although it would be wrong to say they have cornered the market on the connection between memory and imagination in the human brain, it would also be impossible to dig into the question without them. In a 2007 paper I have cited a number of times, Hassabis, Maguire and company demonstrated that hippocampal damage affects not only memory, it disturbs imagination. [Hassabis, D. Kumaran, S.D. Vann, E. Maguire, "Patients with hippocampal lesions can't imagine new experiences," PNAS 104 (2007): 1726-31.]

On the other side of the hippocampus story are place cells in rats. In 1971 O'Keefe and Dostrovsky discovered these remarkable pyramidal neurons whose firing is dependent on the particular place in a maze an animal finds itself in. Scientists have spent years studying these cells as the possible secret to animal learning and the generation of an internal cognitive spatial map. Rats can be manipulated in ways that human beings can't. The poor critters have been run ragged through mazes and subjected to seizure causing drugs and various brain lesions to promote scientific discovery. What the laboratory animals can't provide us with, of course, are the details of their autobiographical memories or fantasies—whatever those might look like if they have them at all. It isn't clear what creates the human ability to recollect ourselves as others in the past and throw ourselves into an imaginary future, but it is obviously more highly developed in human beings than any other animal. The scientists working on either side of the rat/human hippocampal divide found themselves in two different camps. What does the hippocampus do? Does it do one thing for rats and another thing for people? That would be odd since we share this distinctive brain part. Was it for memory or spatial representation?

I can report with confidence that none of the scientists on either side of human/rat gulf referred to artificial memory systems in their work, the mneumonic techniques that were developed in the ancient world to enforce memory. A person could learn how to memorize a long speech or retain a long list by imagining taking a walk through a large building or palace she knew and marking each place sequentially with a vivid image. Years ago, when I began reading papers on the hippocampus in both rats and human beings, I immediately thought of Frances Yates's extraordinary book *The Art of Memory*, in which she traces artificial memory systems from the Greeks into the early modern period and the advent of the scientific method in the seventeenth century. There is a long tradition of linking imagination, memory, and spatial navigation in the West.

In a lecture I gave at a conference that was held at the Berlin School of Mind and Brain at Humboldt University, I noted the hippocampus controversy, artificial memory, and wondered what made the scientists think it had to be either one function or the other? In a 2016 paper, Hassabis and Maguire, explain that for a couple of decades, the two lines of inquiry, rat and human, existed independently, and no one bothered to link them until the early 2000s. In the paper, after noting the conflict, they propose Scene Construction Theory, which integrates the two. ["Scenes, Spaces, and Memory Traces," *Neuroscientist 22* (2016): 432–439] My purpose here is not to explain this theory to you, although it's a good one. Instead, I am emphasizing the striking historical precedent for making the link between space and memory. Explicit memory and mental space are intimately bound in artificial memory systems. Indeed, no one who had read both hippocampal research on rats and people and Frances Yates' book could help but make the connection well before the scientists seem to have come around to it. An example of synthesis made possible only if you leave the confines of your discipline.

A further question, however, is why did people believe the hippocampus served either spatial representation or autobiographical memory? Why were they looking for a single function? Was it only because the scientists didn't look to the left or to the right? Is it because once you are dug into your field, it will take a bulldozer to extract you from your ditch? Are we simply talking about a turn in thought in the late nineteenth century that not only divorced the natural sciences, *Naturwissenschaft*, from what we now call the humanities and the social sciences, *Geisteswissenschaft*, but also divided science into fields so isolated from one another, they often have little contact? In fact, the story is much longer. We are talking about an inherited mode of thought in science, one that has been both fruitful and fraught—the idea of mechanism.

The word "mechanism" and "mechanistic" in biology are omnipresent. The author of the Alzheimer's paper acknowledged that crucial mechanistic pathways in the disease remain unknown. Mechanism implies cause. What are the mechanisms involved in this terrible form of memory erosion? The word mechanism comes from machine. The assumption is that the brain, like all physical systems, can be understood in mechanistic terms. This understanding of the world was essential to what came to be called the Scientific Revolution, the familiar idea that the universe functions as a great clockwork. The Aristotelian cosmology in which form or soul animated matter was replaced by universal laws of matter and motion that could be described mathematically. Galileo's study of free fall motion was exemplary. Every spring and wheel and particle inside Nature's machinery has a specific function, and if one can penetrate the role of each part, the secrets of the whole will be revealed. In the seventeenth century, mechanistic explanations did not sacrifice the supernatural. They often preserved God, as Riskin points out. God was an active presence in nature or the one who kicked the whole natural universe into gear.

Descartes famously argued that the human mind is made of a different substance from the body, but he accepted mechanistic explanations for animals and everything else, and he believed fervently in the truths to be gained from mathematics, geometry in particular. "If," he wrote in a letter to Mersenne, "somebody were to know perfectly what are the small particles of all bodies and what are their movements and their relative positions, he would perfectly know the whole nature."[Letter to Mersenne, in *Oeuvres*, 497] There was no difference between an elaborate automaton of a dog and the living creature except that the latter was admittedly more complex than the former, and therefore all its inner workings had not yet been described. Descartes' exemption for the human mind, however, meant that unlike the body, the mind was not divisible. It couldn't be broken down into the explanatory particles he assigned to bodies.

Thomas Hobbes, on the other hand, materialized and mechanized everything. Descartes excluded human minds from the material world and kept God in the picture, which meant his problem was to make sense of how this immaterial thing—mind—could play any role in a material body at all. Hobbes had to explain how matter could move and think. He did it through motion, although his explanation that sensual reality—sight, hearing, taste, touch, and smell—are caused by an external body or object pressing on the sense organs is admittedly a pretty contorted one. Human reasoning for Hobbes was computation, a step-by-step, algorithmic deliberation that consisted of motions in the brain, which were divisible into constituent components and worked according to the same laws that applied to the natural world in general.

And yet the seventeenth century problem of mind and body, what they are and how they work remain with us. Physicists have been no more successful than philosophers in solving this problem. "The hard problem," as David Chalmers coined it in 1994, has not died. Similarly, the "big question" in mathematics is still with us: Is the universe inherently mathematical or is mathematics a construct of the human mind? The answer to that question is hardly trivial. If the universe can be reduced to mathematics, a Theory of Everything, a fantasy alive and well in physics, is theoretically possible. It has not yet been realized.

If everything is material or to use the word of choice after quantum, physical, it must all be made of the same stuff, which means that living systems are no different at bottom than machines. But then how does matter think, or to put it in contemporary terms, how does matter become conscious? In artificial intelligence, the faith that something like the human mind can be built with sensors and wiring and silicone parts goes on despite decades of abject failure. Allen Newell and Herbert Simon's famous hypothesis in their 1976 paper was this: "A physical symbol system has the necessary and sufficient means for general intelligent action." In other words, a mind is not dependent on the material in which it is instantiated. Computation of symbols is what counts. Once we get the mechanisms of information processing right, machines will come to life. Biology is not important. This is neo-Cartesian thinking. The mind is not the body, or; an artificial body will do. The assumptions driving the hypothesis are rooted firmly in seventeenth-century natural philosophy.

I am not arguing that remarkable feats have not been accomplished in AI, but rather that nothing remotely resembling ordinary human wakeful or sleeping consciousness has been produced, despite massive effort. Mechanistic thinking implies a form of reductionism now, just as it did then. Everything in nature can be broken down into its parts and then described as cause and effect. The author of the paper on Alzheimer's admits that the current model is deficient because it lacks an explanation for an important causal mechanism involved in the disease. The scientist in the lab at Mass General was puzzling over the same question: how could he come up with a more refined model that might begin to describe what he was looking at. The idea is that at bottom, there is a machinery of memory, each part of which can be isolated and then clarified as responsible for this or that aspect of remembering.

The confusion over what the hippocampus "does" is intrinsic to a mechanical, reductionist mode of thought that is often more implicit than explicit in science. A scientist does not think through why she is searching for the mechanism for this or that or why it should reveal a singular rather than a plural function—that's just how it is. Further, our hypothetical scientist is working in a tradition that has a long history of success. Mechanistic, reductionist thought has led to countless breakthroughs. Crick and Watson's discovery of the structure of DNA, that came to be known as the Central Dogma and described as a code or blueprint for life, and which comprises a series of steps so famous that many can recite it: DNA to RNA to Protein, is a mechanistic one. In their model the genetic information flowed neatly in one direction. The Grand Dogma has a step-by-step, clear and distinct perfection Descartes would have admired.

Although the discovery remains momentous, the Central Dogma does not perfectly describe biological reality. Genes do not act as a code, and the information does not flow in one direction. Genes are inert without their cellular environment. They are not solely responsible for an organism's traits. It turns out to be far more complicated than Crick and Watson believed. I cannot resist making the additional comment that Rosalind Franklin's research was written out of the story of the double helix until recently. Although the cultural resistance to female intellect defies logic and reason, it goes on nevertheless. Maybe human cognition cannot be reduced to a series of logical steps.

It is not hard to see the mechanistic and reductive similarity between the Grand Dogma and the Physical Symbol System hypothesis. A form of determinism is built in—one thing causes another and then another and complexity increases, but this chain moves in a single direction. Creativity, surprise, and agency find no place in this thought. All of nature is a machine. Machine metaphors for physiological functions are old, and they can help us imagine more vividly how something works. On the other hand, the comparison can begin to limit the imagination, or, even worse, the comparison becomes dogma. This happened to the idea that the brain is a computer, an information-processing device. The brain does process information, of course, but what was once a metaphor became literal. Since so much remains unknown about actual brain function and there is no agreed upon model for how it does work, the leap to turn this model into reality was, at the very least, premature.

The brain as a computer is now familiar, but Helmholtz compared the organ to a telegraph and Henri Bergson used the image of a central telephone exchange. William Harvey (1578-1657), who discovered blood circulation, compared the heart to a pump, a comparison that has lasted in the annals of medicine. Harvey's heart pump greatly impressed both Descartes and Hobbes, and is often thought of as a primary example of mechanistic thought. Harvey, however, was not a mechanist. He was what would now be called a vitalist, although that word didn't become popular until later and in the nineteenth century became a term of abuse. Vitalism is a theory that posits something beyond the laws of physics and chemistry as explanatory of life. It became an object of scientific scorn because it seemed to imply some kind of soul, animal spirits, or God as an animating principle in living things. As Thomas Fuchs points out in his book, *The Mechanization of the Heart*, it was Descartes, not Harvey, who turned the heart into a machine. Harvey was a vitalist. He believed that living beings and parts of living beings were invested with life and action. For Harvey, blood was a self-moving, internal natural force. (Thomas Fuchs, *The Mechanization of the Heart: Harvey and Descartes*, trans. Margorie Grene, Rochester, N.Y.: Rochester University Press, 2001].

What I am at pains to suggest here is that metaphysical assumptions are essential to scientific inquiry. In metaphysics, explanations for first principles are sought—what is being, knowing, substance, cause, identity, time, and space? A metaphysician attempts to create a true or truer picture of the world. The Alzheimer's researchers are looking for models that will help answer questions that are framed by inherited assumptions and methods. The questions they ask, the hypotheses they pose, and the experimental results they must interpret are circumscribed by their anticipations that become predictions. This is the nature of a hypothesis. Indeed, if an experiment reveals something too surprising, something that cannot be explained, it may well be shunted aside, pushed away as an anomaly. In *The Delusions of Certainty*, I quote Michael Polanyi, "We often refuse to accept an alleged scientific proof largely because on general grounds we are reluctant to believe what it tries to prove." He cites Pasteur as a shining example.

Because I am an observer of science, not a scientist, and because I spent most of my early intellectual life in disciplines that were guided by other assumptions, I would often ask my scientist friends simple questions. Are all thoughts computations? Why do you use the words "neural correlates" or "neural underpinnings" when you speak of brain processes? Why are you looking for the neural correlates of consciousness and not just consciousness if the two are the same thing? Why can't the hippocampus be involved in both spatial representation and autobiographical memory? Can anyone even have an autobiographical memory without a spatial context for it? None of my memories of my own past take place *nowhere*. All of my mental images include space. What I discovered was this: Many of these hardworking, highly intelligent, well trained scientist friends had no answers for me.

We are creatures of the Scientific Revolution and its grand narrative, from Galileo to Newton to Darwin to Copenhagen to the present, but there are always counter stories along the way. There are always those who objected and whose stories vanished in the historical sweep of accepted dogma. The foundational debates of the seventeenth century continue to haunt us because a dominant narrative does not make the problems with it go away, and the holes in the story are bound to reappear at moments of stress. I think this is a moment of stress.

There were a number of non-mechanistic philosophers of the period, many of whom receded after the triumphant narrative of the scientific revolution became established. Stories can never be told forward, as the narrator, Leo Hertzberg, of one of my novels, *What I Loved*, points out. They can only be told backward. One of those all but forgotten seventeenth-century philosophers has seen a striking revival in the last forty years: Margaret Cavendish, the Duchess of Newcastle. Although she had some admirers, she was also ridiculed in her day. Undisguised ambition in a person of her sex was repugnant. I dare say it still is. The notion that intellect or mind and the inductive method itself are masculine and nature feminine has deep roots in that period. Frances Bacon fully explicated the idea in his text, ***The Masculine Birth of Time***. An ambitious, reasoning woman remains an affront to deeply engrained structures of Western thought.

Cavendish is a figure in one of my novels, *The Blazing World*, and she appears along with Descartes, Hobbes, and Vico as a "touchstone" philosopher in *The Delusions of Certainty*. She was a monist, who believed all of nature, including human beings, is material—but she didn't believe it functioned mechanically. Nature is not made of inert matter, she argued, but is self-moving and every part stands in some crucial active relation to other parts. She rejected atomism and opted for a plenum—there is no vacuum in nature. Further, for Cavendish, minerals, vegetables, animals and people are a comingling of animate and inanimate matter in varying degrees. Everything in nature is more or less alive and is in constant motion, but this motion is not divisible by means of geometry. She rails against man's hubris, his preening sense of his superiority over other creatures as a fundamental error. Her warning has an ecological significance, especially in the present.

I recently finished a lecture on Cavendish for The Margaret Cavendish Society that I will deliver in early June. In it, I demonstrate how her thought relates to urgent questions in the philosophy of biology today. Cavendish was hardly clairvoyant. She was responding to the debates about mind and body in her own age, debates that refuse to die. While I was rereading her works of natural philosophy (she also wrote poems, plays, biography, and a work of fantasy fiction called *Blazing World*), I was struck by how her ideas anticipate the increasingly noisy objections to mechanistic, reductionist, deterministic theories of life. In Cavendish, the body thinks.

Embodied cognition has become a rallying cry in cognitive neuroscience. According to its advocates, the mind is embodied, embedded, enacted, and extended. These principles, also called the 4Es, mean different things to different people, and in some circles mechanism is fully preserved, but the idea that thought cannot be lopped off from a moving body, that thinking does not equal computation, and that bodies are in constant interaction with their environments and are not only shaped by them but actively shape them is crucial to what has been called a paradigm change in cognitive science.

Embodiment, however, does not instantly solve the problem of how a material body thinks? Does consciousness emerge as systems become more complex? Complexity theory and emergence are big these days. If so, how does that work in biology exactly? What do we mean by *agency* in nature, long a taboo subject because it smacked of vitalism. Is a single-celled bacteria an agent? It seems to "know" a lot. What about organs and migrating cells inside a body? Are they agents? What is an individual in biology? Can you separate an individual organism from its environment? How are living systems different from highly refined but dead machinery? Maybe, as many argue, biology can't be reduced to the laws of physics. Maybe epistemology plays an important role in the answers we get. Maybe, as John Dupré, a philosopher of biology, argues organisms are not things but processes. Maybe looking at dynamic processes and not at discrete things in biology changes what we discover. Can new computational models describe biology? Karl Friston has proposed an ingenious computational model for brain processes founded on three inspirational sources: Freud's energic model of mind, Helmholtz's unconscious inference, and Bayesian statistical prediction. At present, no one knows how well the model relates to actual neurons. And yet, this may be a case of what George Box declared to be true: "All models are wrong, but some are useful." Indeed, as I traveled through the history of the mind/body problem, I was impressed by how the dynamic character of the thing observed is made static or more static in the model. Perhaps this can't be helped. But how much gets left out? Current work in epigenetics suggests that at the molecular level, things get more and more complicated rather than simpler and simpler. And if you turn your attention to embryology, the realities of fetal development and cellular exchange orchestrated by the still mysterious placenta between mother and fetus, it becomes necessary to question the whole idea of what is a discrete unit in biology and how we might even begin to define such a thing.

Maybe Alfred North Whitehead, the mathematician and philosopher, was right in his assessment of the seventeenth century. In *Science in the Modern World* (1925) he argues that it was founded on "misplaced concreteness," on accepting mathematical abstractions as reality. He is dramatic. "Thereby," he writes, "modern philosophy was ruined." Whitehead developed an organic process philosophy to counter what he understood as the failings of modern science. Whitehead is popping up a lot these days in my reading. In Whitehead's universe, influenced by early quantum theory, everything is alive, not to the same degree, but some form of mind and subjectivity is present throughout, just as it is in Cavendish's much earlier version of the natural world. In the twenty-first century, panpsychism has gained a dignity it hasn't had for some time. I suggest this is the result of dead ends in the logical conundrums of the mind-body problem. What do I think about panpsychism? I don't know.

We have come round now to the young scientist wondering how philosophy, literature, and history might be of use to him. He was searching for ways to create a model that might help penetrate the processes that produce terrible memory loss in so many people. Would interrogating the assumptions driving his methods help him? Am I suggesting the poor man adopt a whole new epistemology? No. Changes in method may come as a result of contemporary debates, but my point here is subtler. Experience has taught me that while immersive study in several fields inevitably creates skepticism about a single dogmatic approach to a problem, it also engenders a flexibility of mind that makes it possible to see what those who have never looked to their right or to their left cannot see because they cannot imagine it.

Knowledge arrives in many guises, and one sort of knowledge informs other sorts. And, in light of the bewildering search for mechanisms or causes, sometimes what is needed is a shake-up, a whole new way of looking at the problem. I would recommend Charles Dickens' novel, *Our Mutual Friend*, to the young researcher. Dickens, after all, is a writer who made a deep impression on Niels Bohr. The physicist compared atoms to plum puddings with jumping raisins. In Dickensian metaphysics, all the ordinary perceptual boundaries break down completely. Doors have noses, and people turn into things. His universe jiggles and shifts as the animate becomes inanimate and the inanimate becomes animate. One of the characters in the novel, Mr. Wegg, makes a visit to a bone and rag shop in London to ask after "himself." Mr. Wegg has lost a leg, you see, and Mr. Venus, the shopkeeper is in possession of the old bone. "How am I?" Mr. Wegg says to Mr. Venus, referring to his missing part. If that exchange doesn't make you wonder about parts and wholes and what is living and what is dead—if it doesn't make you rethink inherited assumptions about how it all works, I don't know what will. I do know that reorientation, sometimes of a radical kind, is necessary for creative thought, whether it is in science or in art.

Siri Hustvedt