Noam Chomsky
Language and Limits of Understanding

The great humanist and linguist Wilhelm von Humboldt once described the core property of language as "infinite use of finite means." The comment has been frequently quoted since I cited it 50 years ago, with insufficient explanation. And probably for that reason, almost always misunderstood. Humboldt was referring to the *use of language*. Investigation of that topic reaches far beyond the effort to understand the nature of the finite means that are put to use. The gap is enormous. It becomes clear when we look closely at how Humboldt's aphorism has been investigated -- at what has been achieved in the course of the intense and productive inquiries of the past years, and what remains shrouded in mystery that has remained impenetrable for centuries, and perhaps always will, yielding some insight into what may be critical limitations on human understanding.

By the mid-20th century, progress in mathematics and logic provided quite general understanding of how an infinite system can be characterized with finite means, rather in the way that Euclid's axioms yield proofs of an infinite number of theorems of geometry – though it is worth bearing in mind that even this classical special case was not fully clarified until a century ago. By the 1950s, the general problem was well understood. Every computer is based on these ideas. And it also became possible to apply the same ideas to the study of human language, and by so doing to try to capture at least a part of Humboldt's insight. But it is important to stress: Only a part.

The linguistic counterpart to the axioms of geometry or arithmetic would be a system of rules that determine the sound and meaning of each of the expressions of a particular language, say the sound and meaning of the sentence I am now speaking, along with infinitely many others. Each such sound-meaning pair, over an infinite range, is determined by the finite system of rules that constitute my knowledge of my language – and as a side remark, it has been learned in recent years that the externalization need not be sound.

Evidently, there is no limit on the length or complexity of the linguistic expressions that can in principle be used and understood by someone who knows a language, given sufficient time and memory, just as there is no limit on the size of the numbers that a person can add, in principle. But there is an immense gap separating knowledge of the rules and ability to use them in any reasonable way. Otherwise, number theory and geometry would reduce to understanding a few axioms, instead of being among the most difficult and sophisticated areas of human thought. Proving a theorem is a creative act, and the same is true, at some level, of the sensible use of linguistic expressions. That was the question that concerned Humboldt, when he spoke of infinite *use* of finite means.

Two centuries before, the question deeply concerned Descartes, and in fact played a central role in Cartesian philosophy. Descartes took his main task to be to provide firm foundations for what was then called "the mechanical philosophy," the founding doctrine of modern science, which held that the world is a machine, basically a machine of the kinds that were being constructed by the master artisans of the day and that stimulated the 17th century imagination much as computers do today. Descartes believed that he had essentially solved this problem, but he recognized that there were phenomena of the universe that transcended the limits of mechanical explanation. The most striking example, Descartes proposed, is the normal use of language: the ability of every human, but no animal or machine, to use language as we all do routinely, freely producing expressions that are new in our experience and perhaps in the history of the language, doing so without limit and in ways that are appropriate to situations but not caused by them, and are independent of our internal state: with the internal state and circumstances fixed, we can choose to talk about the weather or about Cartesian science – and we somehow know which utterances are appropriate to given circumstances.

The difference between "appropriate to situations" and "caused by situations" is crucial. It establishes the divide between humans and machines – or animals, which Descartes held to be machines, incapable of free, independent, and creative action as all humans are, apart from severe pathology.

It should perhaps be mentioned that similar ideas lie behind the libertarian concepts developed by Rousseau, Humboldt, and others. They adopted the idea that a creative capacity is at the core of human nature, and hence concluded that any social or educational or economic system that represses or controls it is fundamentally illegitimate. The same concerns lie behind Adam Smith's sharp critique of division of labor, far less known than the passages in which he extols its contributions. And there is a rich resonance beyond, until the present. But to pursue these directions would carry us too far afield.

Descartes was a working scientist. Accordingly, to account for what lies beyond the limits of mechanism, he had to introduce a new principle, a kind of creative principle, in addition to the mechanical principle that governed the rest of nature. In the metaphysics of his day, the new principle was a second substance, mind, res cogitans, the thinking substance, which is distinct from body, the physical and material world, governed by mechanical principles. The scientific problem that he and others then faced was to determine the character of this new substance and to show how it interacts with the mechanical world. That is the mind-body problem as it was cast within the modern scientific revolution, providing a new version of traditional problems of body and soul.

The project is now commonly ridiculed as postulating a “ghost in the machine.” But there was nothing ridiculous about it. It was sound science. Cartesian observations about the creative aspect of language use, and other free acts of will and choice, are correct as far as we know, and do indeed lie beyond the bounds of mechanism, even though for reasons that were not suspected at the time. So it made good sense to postulate a “ghost” that inhabits the human machine.

Cartesian scientists turned to the experimental task of determining whether another creature possesses a mind. They designed complex tasks, and concluded, reasonably, that if a creature could pass the hardest tests, then we should conclude that it does indeed have a mind like ours. The question was taking on considerable practical and ethical significance at the time. Europeans were just beginning to be acquainted with strange creatures from across the seas – orangutans, negroes, Indians, and others. Those with minds would have to be Christianized and saved. As a number of distinguished historians of philosophy have pointed out, these conceptions established at least a weak barrier against racism. Mind did not admit of degrees: a creature either had a mind or not; there was no such thing as a partial mind.

The Cartesian tests for possession of mind have some resemblance to the popular contemporary enterprise of determining whether machines can think. The term “machine” in this context refers to a program for a computer, not the computer itself, which can only function as a large paperweight if it lacks a program to execute. The standard approach to the topic today is called “the Turing Test,” derived from the “imitation game” devised by the great mathematician Alan Turing, one of the founders of the modern theory of computation. “The imitation game” was designed to determine whether a computer program can fool people into thinking that the responses it produces to queries are from a human. The extensive efforts to “pass the Turing test” typically overlook Turing’s warning that the question whether machines think is “too meaningless to deserve discussion,” though he felt that the exercise might still be useful, perhaps as a challenge to develop more advanced computers.

While the Turing Test has some similarity to the Cartesian tests, it is a far less serious enterprise. The Cartesian inquiries were authentic science: an effort to determine whether an object has a certain property, namely mind, like a litmus test for acidity. The Turing Test has no such significance, as Turing made clear.

While the Cartesian project was quite a sensible one, including the postulation of the ghost in the human machine, it did not last long. It collapsed very quickly in a way that was a great surprise at the time, and is often misunderstood today. Isaac Newton, who studied Descartes's physics in depth, demonstrated that it did not succeed in its goal of providing firm foundations for the mechanical philosophy. And much more significant, he showed that the failures could not be remedied: not only is mind not governed by mechanical principles, but nothing else in the world is either. There are no machines in the sense of the Galilean revolution, the only clear sense of the notion. The framework of early modern science from the time of the Galilean revolution could not be sustained.

That was no small discovery. The framework that was refuted provided the very criterion of intelligibility and the primary conceptual basis for abandoning traditional scholastic science. Galileo scholar Peter Machamer observes that by adopting the mechanical philosophy, and thus initiating the modern scientific revolution, Galileo had "forged a new model of intelligibility for human understanding, [with] new criteria for coherent explanations of natural phenomena." For Galileo, true understanding requires a mechanical model, a device that an artisan could construct, hence intelligible to us. Thus Galileo rejected traditional theories of tides because we cannot "duplicate [them] by means of appropriate artificial devices," and his great successors adhered to those high standards of intelligibility and explanation.

It is therefore quite clear why Newton's discoveries were so stridently resisted by the most prominent scientists of the day, leading to a debate that persisted long after. Christiaan Huygens described Newton's fundamental concept of attraction at a distance as an "absurdity." Leibniz charged that he was reintroducing occult ideas similar to the sympathies and antipathies of the much-ridiculed scholastic science, and was offering no *physical* explanations for phenomena of the material world. Newton largely agreed. He stated very explicitly that he could provide no physical explanation for gravity; that is the context of his famous statement that I make no hypotheses. Newton furthermore agreed that the notion of action at a distance is "inconceivable." It is "so great an Absurdity, that I believe no Man who has in philosophical matters a competent Faculty of thinking, can ever fall into it." By invoking the principle, we concede that we do not understand the phenomena of the material world. As Newton scholarship emphasizes, "By `understand' Newton still meant what his critics meant: `understand in mechanical terms of contact action'." Nevertheless, gravitational attraction is a fact, Newton stressed. He explained that it is necessary to invoke this absurd and mystical notion, this non-mechanical principle, to account for falling bodies, planetary motions, the tides, or any of the physical phenomena that early modern science addressed. For the rest of his life he sought to discover a way around the absurdity, and failed, as did his successors.

The concept of mind, however, survived the Newtonian revolution untouched. Newton did not exorcise the ghost, as commonly believed; he exorcised the machine. It is also commonly believed that Newton showed that the world is a machine. He did not. Rather, he showed that it is *not* a machine, but is governed by non-mechanical principles. Newton did lay the basis for a different conception: that the world obeys certain rigid laws, and is therefore mechanical in the sense in which a computer carries out a mechanical procedure. That is a very different notion of "machine" and "mechanical," a notion foreign to the founders of modern science, Newton included.

Newton's discoveries contributed to the lowering of the goals of science that was already taking place through the 17th century, the recognition that we must abandon the hopeless quest of showing that the world is intelligible to us; it is not. Rather we may seek intelligible explanatory theories that will provide the best account of the workings of the world, which remain mysterious in a deep sense: *unintelligible*, as Galileo and the founders of modern science understood the goals of true science.

The more limited goals imposed by Newton's discoveries were not entirely new. They have roots in an earlier scientific tradition that had abandoned the search for the "first springs of natural motions" and other natural phenomena, keeping to the more modest effort to develop the best theoretical account we can. The distinguished historian of philosophy Richard Popkin refers to this approach as the "constructive skepticism…formulated …in detail by Mersenne and Gassendi," and developed further in David Hume's "mitigated skepticism." As Popkin describes this conception, science proceeds by "doubting our abilities to find grounds for our knowledge, while accepting and increasing the knowledge itself" and recognizing that "the secrets of nature, of things-in-themselves, are forever hidden from us," an approach that "was to have a great history in more recent times," he writes.

As I mentioned, the ghost was left intact by Newton's discoveries, and with it the creative aspect of language use, the primary criterion for mind in experimental Cartesian philosophy. Newton was concerned with the matter. He speculated that what he called "spirit" might be the cause of all movement in nature, including the "power of moving our body by our thoughts" and "the same power in other living creatures, [though] how this is done and by what laws we do not know. We cannot say that all nature is not alive." Going a step beyond, John Locke added that we cannot say that matter does not think, a speculation called "Locke's suggestion" in the history of philosophy. Just as God had added inconceivable effects to motion, Locke argued, it is "not much more remote from our comprehension to conceive that God can, if he pleases, superadd to matter a faculty of thinking." Locke found this view "repugnant to the *idea* of senseless matter," but held that we cannot reject it. Since after Newton there is no intelligible concept of "matter" (or body, physical, etc.), we cannot dismiss the possibility of living or thinking matter.

Locke's suggestion was taken up through the 18th century. Hume concluded that "motion may be, and actually is, the cause of thought and perception." Others observed that "thought, which is produced in the brain, cannot exist if this organ is wanting," and that there is no longer a reason to question the thesis of thinking matter. Therefore "It is necessary to consider the brain as a special organ designed especially to produce [thought], as the stomach and the intestines are designed to operate the digestion, the liver to filter bile," in the words of the 18th century French physiologist Pierre-Jean-George Cabanis. Just as foods enter the stomach and leave it with "new qualities, [so] impressions arrive at the brain, through the nerves; they are then isolated and without coherence. The organ enters into action; it acts on them, and soon it sends them back changed into ideas, which the language of physiognomy and gesture, or the signs of speech and writing, manifest outwardly. We conclude then, with the same certainty, that the brain digests, as it were, the impressions, i.e., that organically it makes the secretion of thought." As Darwin put the matter succinctly, "Why is thought, being a secretion of the brain, more wonderful than gravity, a property of matter?"

It is interesting to see how these ideas are treated today. The last decade of the 20th century was designated as "the Decade of the Brain." It concluded with a volume of studies by distinguished brain scientists, summarized by neuroscientist Vernon Mountcastle. He wrote that the leading thesis of these researches is that "Things mental, indeed minds, are emergent properties of brains," though we do not yet know how these emergences take place. Other prominent scientists and philosophers have presented essentially the same thesis as an "astonishing hypothesis" of the new biology, a "radical" new idea in the philosophy of mind, "the bold assertion that mental phenomena are entirely natural and caused by the neurophysiological activities of the brain," opening the door to novel and promising inquiries, a rejection of Cartesian mind-body dualism, and so on.

All of these proposals are rather odd. They all reiterate, in virtually the same words, formulations of centuries ago, after the traditional mind-body problem became unformulable with the disappearance of the only coherent notion of body; for example the conclusion of the eminent scientist-philosopher Joseph Priestley in the late 18th century that properties "termed mental" reduce somehow to "the organical structure of the brain," a conclusion stated in different words by Hume, Darwin, and many others, and a conclusion that is almost inescapable, it would seem, after the collapse of the mechanical philosophy.

With the belated revival of ideas that were reasonably well understood centuries ago, the theory of mind can be pursued in many ways. And like other branches of science, with an eye to eventual unification of these endeavors, whatever form it may take, if any – often, in the past, unification has taken very surprising forms, the unification of chemistry and physics in my lifetime, for example. The enterprise renews the task that Hume undertook when he investigated what he called "the science of human nature," seeking "the secret springs and principles, by which the human mind is actuated in its operations," including those "parts of [our] knowledge" that are derived from "the original hand of nature" -- in our terms genetic endowment. This inquiry, which Hume compared in principle to Newton's, had been undertaken in quite sophisticated ways by English neo-Platonists, in work that influenced Kant. In contemporary literature, the general inquiry is renamed "naturalization of philosophy" or "epistemology naturalized"; or sometimes cognitive science.

To summarize briefly, I think it is fair to conclude that the hopes and expectations of the early scientific revolution were dashed by Newton's discoveries, leaving us with several conclusions. One conclusion is that while our cognitive faculties are vast in scope, they are nonetheless intrinsically limited. Some questions that we might like to explore may well lie beyond our cognitive reach; the standards of success may have to be lowered, as has happened before -- dramatically, with the collapse of the mechanical philosophy. Another conclusion is that the mind-body problem can be put to rest, there being no realistic alternative to Locke's suggestion. Adopting it opens the way to the study of mind as a branch of biology, much like the study of the body "below the neck," metaphorically speaking. A great deal has been learned in the past half century of revival of traditional concerns of the early scientific revolution and the Enlightenment, but many of the early leading questions have not been answered, and may never be.

It is also worth bearing in mind that this last conclusion, strongly suggested by Newton's work, was quickly understood by leading thinkers. In his history of England, David Hume reflected on the scientific revolution, and in particular on the crucial role of Isaac Newton -- "the greatest and rarest genius that ever arose for the ornament and instruction of the species." Hume concluded that Newton's greatest achievement was that while he "seemed to draw the veil from some of the mysteries of nature, he shewed at the same time the imperfections of the mechanical philosophy; and thereby restored [Nature's] ultimate secrets to that obscurity, in which they ever did and ever will remain."

Others agreed. In his classic 19th century history of materialism, Friedrich Lange observed that we have "so accustomed ourselves to the abstract notion of forces, or rather to a notion hovering in a mystic obscurity between abstraction and concrete comprehension, that we no longer find any difficulty in making one particle of matter act upon another without immediate contact,…through void space without any material link. From such ideas the great mathematicians and physicists of the seventeenth century were far removed. They were genuine Materialists [who] made immediate contact a condition of influence." This transition, he writes, is "one of the most important turning-points in the whole history of Materialism," depriving the doctrine of much significance, if any at all. The conclusions are commonplace among historians of science. Fifty years ago Alexander Koyrė observed that despite his unwillingness to accept the conclusion, Newton had demonstrated that "a purely materialistic pattern of nature is utterly impossible (and a purely materialistic or mechanistic physics" as well). Newton's mathematical physics required the "admission into the body of science of incomprehensible and inexplicable \`facts' imposed up on us by empiricism," by what is observed and our conclusions from these observations.

These conclusions about the limits of understanding seem to be radically incompatible with the views of leading contemporary scientists and philosophers. In one highly regarded recent study, physicist David Deutsch argues forcefully that the search for explanations, which is the root of all progress and distinctively human, not only conforms to universal laws of nature but is unbounded in scope: progress in seeking good explanations need never come to an end. Deutsch's conclusion seems to conflict with the claim of David Hume and many others since that Newton left a veil over fundamental mysteries of nature, restoring Nature's "ultimate secrets to that obscurity, in which they ever did and ever will remain."

But the appearance of inconsistency is deceptive. Like post-Newtonian scientists generally, Deutsch and others who speak of the unbounded ability of humans to seek explanations have tacitly abandoned the quest for intelligibility that was the driving force of early modern science, from Galileo and on through Newton. Fundamental mysteries of nature may remain forever as unintelligible to us as action at a distance was for Newton and the great scientists of his day, and still is to us, but Newton's explanations are quite intelligible, though they have exactly the fundamental gap that he, Leibniz, and others recognized: they do not provide a physical basis for the explanations – nor does anything since. The goals of science have been radically lowered.

A new question arises, however. Why should we assume that the capacity for explanation is unbounded? There is a line of thinking that goes back to the great 19th century philosopher-logician Charles Sanders Pierce, and is quite common today, which holds that the Darwinian theory of evolution guarantees this result. Natural selection provided the intellectual capacities to solve the problems that nature poses to us. The belief that there may be questions beyond our cognitive reach is derided as "mysterianism," which the theory of evolution puts to rest.

These are very strange conclusions. Humans were not selected to develop quantum theory, or anything else beyond practical problems of life, if even these. How cognitive capacities emerged is as much a mystery as the emergence of the creative aspect of language use, the basic criterion of mind for the Cartesians. Perhaps we will be able to account for the means that are used, but as I mentioned, that leaves us far short of the Cartesian-Humboldtian goal, or of the mysteries that Hume recognized.

If anything, Darwinian evolution suggests that even the human quest for explanation is bounded. Darwin and his successors have sought to show that humans are organic creatures, part of the natural world. Therefore, like all others, their cognitive capacities have scope and limits. There are birds with fantastic memories, far beyond human capacity. But they cannot deal with very elementary numerical or linguistic problems, contrary to much contemporary illusion – just as they cannot swim. Scope and limits are intrinsically related. Scope requires rich structure, which in turn imposes limits. There is no reason to expect that humans somehow miraculously escape these general properties of the natural world. Hume's "mysterianism" may well reach far beyond the necessary abandonment of the search for intelligibility that animated the early scientific revolution. Nature's ultimate secrets may remain impenetrable to our quest for explanations, and our cognitive limits may render us incapable of even asking the right questions.

For what it is worth, such conclusions seem to me very plausible on intellectual grounds, and also, I have to admit, rather appealing as well.