{...}

Negative capability

> I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses. ... it is enough that gravity should really exist and should act according to the laws that we have set forth and should suffice for all the motions of the heavenly bodies and of our sea.
>
> — Isaac Newton: *General Scholium* to the *Principia Mathematica*.

I don't recall many evenings I spent in Fleming House that could be characterized as pleasurable. I remember the best meal I ever had there, for instance — a total accident: I slept through dinner, woke just in time to get into the kitchen before it closed, after everyone else had eaten and left, and got an entire apple pie and a pot of coffee from the cooks. Even they couldn't fuck that up. I never ate so well.

I also remember another when I got very stoned, stumbled back to my room, and read "The Eve of St. Agnes" in an extremely receptive state. This was one of the most profound aesthetic experiences of my life;[1] right up there with seeing Jeff Beck live at the old Shrine Auditorium and the moment when I realized why the Schrödinger equation said that the Hamiltonian was the infinitesimal generator of time translations and scrawled the words of Faust in the margin of the book that presented this

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[1] You must bear in mind my usual custom when in this condition was to do something like read a three-foot stack of Marvel comics. How Keats supplanted *Nick Fury, Agent of SHIELD* on this occasion I have no idea.

revelation, "Was he a god, who wrote these signs?"[2] — Subsequently I viewed Keats with a sort of reverential awe, and figured he and Yeats, among the modern poets whom I knew and understood, had the greatest power over the language. Had he lived, I thought, he might have rivaled Milton.

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Keats was also remarkable for having made, by way of careless aside, a rather deep contribution to the philosophy of science. I refer to the famous letter he sent his brothers (George and Thomas, 21 December 1817), in which he described a conversation with his friend Dilke in which, he said, "it struck me what quality went to form a Man of Achievement, especially in literature, and which Shakespeare possessed so enormously — I mean Negative Capability, that is, when a man is capable of being in uncertainties, mysteries, doubts, without any irritable reaching after fact and reason ... with a great poet the sense of Beauty overcomes every other consideration... ."[3] — This referred specifically to Coleridge, whom Keats thought had a pernicious tendency to overthink everything, but more generally is perhaps supposed to represent an appeal to intuition over reason.[4] — Which seems unlikely, because Keats had such a wonderfully clear head.

No, what Keats means is something different, as the reference to Shakespeare must indicate. — What Shakespeare could do, better than anyone before or since, was to invent characters

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[2] "War es ein Gott, der diese Zeichen schrieb." — Which signs disclose, furthermore, the hidden powers of Nature. — Exactly.

[3] Grant F. Scott (editor), *Selected Letters of John Keats*. Cambridge: Harvard University Press, 1958; pp. 60-61.

[4] I have no idea what the accepted theory is, though I have read several "explanations" of this passage which have absolutely nothing to do with what Keats intended.

completely true to life. And life, as we know it, is always unfinished, a snapshot captured *in mediaș res*; our state of knowledge is always incomplete; what Hamlet is doing is obviously true to Nature, but still mysterious, in that it doesn't make sense to us and *it doesn't have to*. Because in real life complete understanding always eludes us. — And the process of understanding is not *linear*: you often have to move forward and hope to resolve apparent paradoxes later. Not because explanation is impossible in principle, but because you must recognize that there are limits to your own knowledge and powers, and the reasonable span of your attention, and whatever the real explanation is, for the moment you can't provide it. You must be willing to settle for partial solutions to your problems, because everything can't be finished at once. — So what is truly realistic in the description of character is the unanticipated, the inexplicable; the element of surprise. Because (if you want to put it that way) any human being is a black box with many hidden degrees of freedom. What makes Hamlet seem so real is that he presents more questions than answers.

{...}

Again, because art is often better served by leaving something out — is even occasionally so defined, see Michelangelo on sculpture — the *lack* of an explanation is often more provocative: cf., e.g., the choice between the Lady and the Tiger, the contents of the briefcase in *Pulp Fiction*,[5] the nature of its original, the Great Whatsit in *Kiss Me, Deadly*, who is is telling the truth in

[5] About this, incidentally, Ebert admitted he did ask Tarantino, who said — no great surprise — he didn't know himself, and it didn't matter. — Precisely.

Rashomon, whether in *Point Blank* Lee Marvin is alive or dead,[6] what the Monolith was "really" doing in *2001: A Space Odyssey*;[7] and so on. Here you don't deny the possibility of a continuation, a resolution of the narrative; you simply recognize that that it is the *choice* that is interesting, not the selection.

{...}

Wittgenstein notoriously expressed a similar principle as "Wovon man nicht sprechen kann, darüber muss man schweigen," but his picture of language and what could be expressed in it was static, Parmenidean. The point here is Heraclitean: if it isn't possible to say anything that makes sense — that *adds* anything — then the artistically satisfying choice is to say nothing at all. — But everything is flux, and another story may be told later.

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In Hitchcock — setting aside the famous explanation to Truffaut of the MacGuffin, which shows he understood the principle quite as well as Keats did — a perfect illustration is the central mystery of *The Birds*: why do they suddenly want to kill everybody? — In the innumerable scifi movies modeled on this (and upon which of course this was modeled), someone in a white lab coat makes an entrance at the appropriate expository moment, waves a magic wand — Radioactivity! — later: DNA!

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[6] Steven Soderbergh, whose *The Limey* was a somewhat less ambiguous homage, interviewed John Boorman for the DVD edition of *Point Blank*, and of course Boorman said the same as Tarantino, i.e., Who cares? — One should note however that what could be called the Avenger/Revenge genre is deliberately ambiguous on this point: Edmond Dantes escapes the Chateau D'If only by being hurled into the sea in a burial shroud; Uma Thurman in *Kill Bill* is shot and effectively killed before she awakes miraculously from a coma; the protagonist of *The Crow* is literally an avenger returned from the grave; etc.

[7] Arthur Clarke, of course, less gifted with negative capability than Kubrick, wrote several unconvincing sequels to "explain" what it all meant.

now trending toward: Quantum Entanglement! — and Explains It All, in a fashion so absurdly vacuous that cultists later claim it is some kind of deliberate joke; though in truth screenwriters facing deadlines and running low on drugs rarely have the luxury of self-conscious postmodernism.

Hitchcock, however, scoffs at such irritable reaching after fact and reason.[8] — The Birds are malevolent. There may be a reason, but it isn't one we could understand. It suffices [Gloucester] that

> As flies to wanton boys are we to the gods,
> They kill us for their sport.
>
> {...}

But the most striking examples don't come from literature or film but the history of science.

Consider Copernicus, for instance. The modern reading of history completely trivializes how radical his system was; how absurd his ideas seemed. He threw out the Ptolemaic system of crystalline celestial spheres, which made a certain sort of sense and was internally consistent, and replaced it with another such system which didn't and was not. He raised questions he had to ignore because he had no answers for them: if the Earth revolves around the Sun, why don't we feel the motion? Why when I jump into the air on a moving planet do I land in the same place? If the Earth rotates about its axis then why isn't there a thousand-mile-an-hour wind at the equator? Why (if the world is really round) should bodies fall toward the center of the Earth, if

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[8] Indeed makes deliberate fun of these speeches in *North By Northwest*, when the Professor's long-delayed explanation to Cary Grant of what has actually been going on is drowned out by engine noise as they cross the airfield.

it isn't the center of the universe? shouldn't everything be falling toward the Sun instead? (What is the meaning of "down"?)

{...}

It is all too easy to make fun of the way the analysts of the period between the wars would have treated these questions: to say that "the Earth moves" is a simple category mistake, it is meaningless, what Moore would have called a howler — as follows from the logical grammar of "move", this simply isn't how the word is used. For when I walk to the grocery and back, e.g., my house is in the same place that I left it, it hasn't moved 67,000 miles in the intervening hour. And the counterargument that everything moves in unison and only relative motions can be observed is prima facie absurd, easily eliminated by Occam's Razor. — Moreover (anticipating assertions Copernicus didn't have the nerve to make) the objects we observe in the heavens are not physical bodies, because the same predicates do not apply to them: a star has a position on the celestial sphere and therefore can be located by providing two angles, but it does not have a *∂istance* (the absence of observable parallax proves that);[9] let alone a weight, degrees of heat and cold, an odor, a back side (the question "what does Sirius look like from the other side?" was manifestly meaningless)(here insert the embarrassing fact that we always see the same face of the Moon), etc. (One might say "Doubt thou the stars are fire" before even "Doubt that the sun doth move", but technically this too is a mistake, because they *cannot be* hot to the touch — they cannot be touched at all.) — If you examine the arguments his opponents made against Galileo, they are quite like the arguments Wittgenstein's disciples

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[9] The effect was not observed until the 19th century. The apparent movement of the nearest star from one end of the Earth's orbit to the other is less than a second of arc, 1/3600 of a degree. (In fact the arc-second defines the parsec, a bit more than three light-years. Proxima Centauri, the nearest star, is more than four light-years away.)

made against the idea that a machine could think: you simply aren't allowed to talk like that.

Which probably explains why the character of Simplicio in the *Dialogue Concerning the Two Chief World Systems* [1632] sounds so much like an ordinary language philosopher, though the really telling exchange occurs when Sagredo remarks to Galileo's mouthpiece Salviati his astonishment that the heliocentric system (he attributes it to the Pythagoreans) was passed over in favor of the Ptolemaic, and Salviati insists that he is amazed at just the opposite — "I repeat," he says, "there is no limit to my astonishment when I reflect that Aristarchus and Copernicus were able to make reason so conquer sense that, in defiance of the latter, the former became mistress of their belief."[10]

But what is he talking about here? — Negative capability.

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There is also an art of omission in scientific hypothesis, in other words. We advance in a state of partial knowledge, and must accept that we can't explain everything at once, that therefore there is an art to deciding what should be left out. And this represents an essentially *aesthetic* choice.

The Copernican hypothesis could only make sense after Galileo discovered inertia and Newton found the law of gravity. But Copernicus knew nothing of these, and had to make a blind leap into the unknown, following his intuition and his sense of taste.

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[10] Stillman Drake translation. — Feyerabend laid great stress on this passage in *Against Method*. Obviously.

Two principles that are often said to govern the formation of hypotheses are those of Occam and Popper. Occam says that one ought not to multiply entities unnecessarily, and thus the least hypothesis is best; Popper says that what distinguishes science from bullshit is falsifiability, the possibility that a statement can be proven wrong. Neither is incorrect.

But what history teaches us is that any radical step forward always involves introducing some preposterous hypothesis that seems to be at odds with everything we know; which thus is hardly minimal, and usually appears to contradict experimental evidence — which is already falsified.

With regard to Popper, the explanation is straightforward — experimental evidence is always more ambiguous than it seems, because it is presented not as bare summaries of measurements and facts, but interpretations of what those results mean; it depends on a process of pattern recognition — I look at the iron filings spread on the sheet of paper above the bar magnet and *see* that they are arranging themselves in lines of force — one assumes that all the relevant factors have been identified — the Moon would show its other side if it were not tidally locked by the gravitational attraction of the Earth — and so on, as usual you do not appreciate how complex all this is until you contemplate programming a machine to do it for you; and it is all, in a familiar sense, unstable under small perturbations.[11] Even a slight change in color or accent can turn the sketch of one thing into the sketch of another, the vase into a face, the top side of the cube into the bottom,

With regard to Occam, the point is a trifle subtler, but we might appeal to biological analogy: the genome is modified by point

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[11] From the Bayesian viewpoint one might say that probabilities are sensitive to changes in the choice of priors. Of course this is just the reason the Bayesian viewpoint is stupid.

mutation, which is minimal and gradual, but also by replacing whole segments of one strand of DNA with corresponding segments from another. Similarly the domains of two different conceptual schemes may overlap in such a way that we can segue from one to another, exchanging parts in the process.

The simplest examples are puns, or jokes ("A horse walks into a bar and the bartender asks, 'Why the long face?'"), or the counting arguments in mathematics where something is computed two different ways, the results are set equal, and a nontrivial result drops out; see for instance the proof of the group-theoretic Cauchy theorem from the class formula.

A more complex example might be the problem of which way is down: how can it possibly happen that everything doesn't fall to one distinguished center of the universe? But then you might abruptly remember that Nicholas of Cusa said the universe is a circle whose center is everywhere and its circumference nowhere, place the question in two different contexts simultaneously, and wonder, why can't *everywhere* be down?[12]

Or you might simply be staring at the Moon and have an apple drop upon your head.[13] In any case parsimony doesn't enter into it.

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[12] Cusanus did in fact make this connection, and thought gravitation was a local phenomenon, relative to a star or planet.

[13] According to Thomas Levenson [*Newton and the Counterfeiter*, Boston: Houghton Mifflin, 2009], whether the legend is true or not, the tree actually existed, and was preserved at Woolsthorpe after Newton's death until 1819, when it fell down in a storm. "A sliver of the tree ended up at the Royal Astronomical Society, and branches had already been grafted onto younger hosts, which in time bore fruit of their own." — And, presumably, supported no slight burden of metaphor..

Though Newton managed to rationalize Copernicus, there was a glaring omission in his System of the World: he had no explanation for gravity. He simply stated the law, and muttered the famous disclaimer "hypotheses non fingo." Leibniz gave him an enormous amount of well-deserved shit for this: action at a distance before Newton and after Einstein looked like the operation of occult forces. But Newton was fully conscious of what he was doing: he had entertained a vast number of ideas about the propagation of influences through some kind of ether and knew none of them worked.[14] Knowing that he couldn't fully explain it, but seeing — this is the more important realization — that he had a valid partial explanation, he recognized the limitations — not of science, but of scientists — to make explanations. — In more ways than one this was the first modern man. Newton even more than Shakespeare was the master of negative capability.

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[14] From Newton's third letter to Bentley: "It is inconceivable, that inanimate brute matter should, without the mediation of something else, which is not material, operate upon, and affect other matter without mutual contact; as it must do, if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one reason, why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent, and essential to matter, so that one body may act upon another, at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it." — A pretty clear endorsement of local causality from the guy who managed to convince everyone else to renounce it. — In fact in his earliest notebooks [see Richard Westfall, *Never at Rest*; Cambridge: Cambridge University Press, 1980] Newton had assumed the existence of currents of "subtle invisible matter" as the cause of gravity, and even attempted to design perpetual motion machines that exploited them. — In writing the *Principia* he had originally intended to posit universal attraction as something arising from the nature of matter, even though this idea was inconsistent with the mechanical philosophy that one body could only influence another by direct contact. After preliminary criticism by Huygens he had second thoughts, and was evasive in his final draft about the existence of forces generally, and agnostic about causes.

Newton *described* gravity; Leibniz objected he had not given a *reason* for it. Newton anticipated the objection, and recognized that there was no point in straining for reasons when they were still out of reach. — He pretended this represented a conservative unwillingness to go beyond induction, but he knew, obviously, this was preposterous: he had said every particle of matter in the universe attracted every other; from the standpoint of empirical evidence this was just a wild guess. But it was an elegant idea that explained everything that had been seen in astronomy, and predicted more, e.g. the return of Halley's comet. — Nonetheless there wasn't any *experimental* evidence to support the law of gravitation until Cavendish measured it in the laboratory at the end of the following century.[15]

And no *explanation*, of course, until Einstein formulated the general theory of relativity, and reduced gravity to the curvature of space. With the benefit of hindsight it is easy to see that several generations of mathematical progress were required, and the introduction by Faraday and Maxwell of the concept of the field, to make this idea — the most beautiful idea that anyone has ever had — possible. — The origins of gravitational attraction *had* to be a mystery to Newton and his contemporaries. They simply did not have the conceptual tools to resolve it.

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Newton invented the calculus first, but Leibniz invented it better. Unfortunately in so doing he introduced absurd and self-contradictory intermediate propositions about the ratios of infinitesimals to derive correct answers. Regarding this tissue of

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[15] His experiments were performed in 1797-98. His results were stated in terms of the density of the Earth, and he referred to his experiments as "weighing the world" rather than determining the gravitational constant, as we now think of it.

fallacies D'Alembert[16] is supposed to have told a skeptical student, "Go on, and faith will come to you." And faith was necessary,[17] because secure foundations for mathematical analysis were not discovered until the nineteenth century.[18]

Darwin made a broadly convincing phenomenological argument for evolution, but had no explanation for the mechanism of variation because of his fundamental misunderstanding of genetics.[19] The theory was only completed by Mendelian atomism (particulate inheritance) and molecular biology. — Again, until the missing details were filled in, reason had to conquer sense.

To illustrate his theory of electromagnetism Maxwell presented various mechanical models of the ether to motivate the choice of his field equations. This created some confusion with regard to which model was supposed to be correct, since the theory appeared to rely upon it. Hertz resolved the difficulty by declaring Maxwell's *theory* to be Maxwell's *equations* — i.e., by invoking negative capability to ignore the question entirely.

Einstein's most radical idea was the photon hypothesis [1905]; indeed this was an idea so radical he was reluctant to acknowledge it himself. Even his greatest admirers among his

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[16] Incidentally if you [Richard] look up your own academic line of descent, you will find that Rescher was a student of Church who was, etc., and the chain originates with the Prime Mover D'Alembert, an autodidact in the age before the invention of the doctorate. So in a way this is your ancestor.

[17] Berkeley had great fun pointing this out in *The Analyst*.

[18] A similar situation holds in contemporary mathematics with regard to the use of the Feynman path integral, which presents formal and conceptual difficulties not unlike those encountered with infinitesimals. About it Feynman himself said "One feels as Cavalieri must have felt, calculating the volume of a pyramid before the invention of the calculus."

[19] I.e., he believed the blending theory of inheritance.

contemporaries thought he had taken leave of his senses.[20] (Millikan was so convinced Einstein's explanation of the photoelectric effect was wrong that he spent a decade trying to disprove it.)[21] An *experimentum crucis* had settled between the wave and particle theories of light a century earlier, and the Maxwell theory of electromagnetism, which predicted light as a solution of the wave equation that could be derived from it, had confirmed it; indeed Einstein himself while coming up with the photon idea was simultaneously insisting, in the theory of relativity, that Maxwell's equations, from which Lorentz invariance and the invariance of the speed of light are deduced, were more fundamental than Newtonian mechanics. — Only with the observation and explanation[22] of the Compton effect [1924] was there direct confirmation of the existence of photons; and the subsequent recognition of the wave/particle duality was less a resolution of the contradiction between the two theories than an admission of the necessity of living with uncertainties, mysteries, and doubts.

Bohr in proposing his model of the atom [1911] hypothesized that it was like a miniature solar system, with electrons orbiting the nucleus in the same way that planets circle the sun, but with the additional condition that only a discrete series of orbits were permitted, with angular momentum a multiple of Planck's quantum of action, and only quantum jumps from one orbit to another allowed, not the continuous mission of radiation

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[20] See [19f] of Pais, *Subtle is the Lord*.

[21] Pais [18a] quotes him: "I spent ten years of my life testing that 1905 equation of Einstein's and contrary to all my expectations, I was compelled in 1915 to assert its unambiguous verification in spite of its unreasonableness, since it seemed to violate everything we knew about the interference of light."

[22] Note that in this instance as so many others the "result of the experiment" is stated as a formula, which [a] contradicts the prediction of the wave theory but [b] can easily be derived from the assumption that photons bounce off electrons the same way that billiard balls bounce off one another.

predicted by the classical theory; this ansatz miraculously reproduced the spectrum of the hydrogen atom, but it was a source of bafflement that such contradictory ideas could reproduce an experimental result no one could understand otherwise.

About his own efforts to find a physics consistent with the quantum conditions, Einstein said:

> All my attempts ... failed completely. It was as if the ground had been pulled out from under one, with no firm foundation to be seen anywhere ... . That this insecure and contradictory foundation was sufficient to enable a man of Bohr's unique instinct and tact to discover the major laws of the spectral lines and of the electron shells of the atoms together with their significance for chemistry appeared to me like a miracle—and appears to me as a miracle even today. This is the highest form of musicality in the sphere of thought.[23]

— i.e., with a great poet the sense of Beauty overcomes every other consideration.

Heisenberg in his memoirs reproduces a conversation with Pauli in 1922 in which he refers to Bohr's model as "[a] peculiar mixture of incomprehensible mumbo-jumbo and empirical success" — which, he admits, "quite naturally exerted a great fascination on us... ." — Pauli, the great critical spirit, characterized electron orbits as "myth", but admitted Bohr was right in some sense, and asked (says Heisenberg) what it might be.

Heisenberg reconstructs his answer:

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[23] *Autobiographical Notes*, pp. 45-47 of *Albert Einstein, Philosopher-Scientist*, ed. Paul Arthur Schilpp. New York: Open Court, 1949.

> Bohr must surely know that he starts from contradictory assumptions which cannot be correct in their present form. But he has an unerring instinct for using these very assumptions to construct fairly convincing models of atomic processes. Bohr uses classical mechanics or quantum theory just as a painter uses his brushes and colors. Brushes do not determine the picture, and color is never the full reality; but if he keeps the picture before his mind's eye, the artist can use his brush to convey, however inadequately, his own mental picture to others. ... It is not at all certain that Bohr himself believes that electrons revolve inside the atom. But he is convinced of the correctness of his picture. The fact that he cannot yet express it by adequate linguistic or mathematical techniques is no disaster. On the contrary, it is a great challenge.[24]

(Later Heisenberg meets the great man and discovers that Bohr himself doesn't believe in the literal truth of his model, and that his real starting-point is the stability of matter. But that of course is another story.)

When Heisenberg invented his matrix mechanics he thought it was a mistake that the quantities he associated with position and momentum did not obey the commutative law of multiplication. He went ahead anyway, assuming that his error could be corrected later. As it turned out he hadn't made a mistake, but instead had made a fundamental discovery. But that could only appear after he'd ignored the problem and pressed onward.

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[24] Werner Heisenberg, *Physics and Beyond* [transl. Arnold J. Pomerans], New York: Harper & Row, 1971. This exchange appears on pp. 35-37. The caveat here is that this is an English translation of a conversation that took place forty years before Heisenberg attempted to reproduce it.

Gell-Mann when he invented quarks pointed out their contradictory properties, their fractional electric charges, e.g., which had never been seen, and refrained from stating explicitly whether he regarded them as physical particles or mathematical abstractions; if the former, then some mysterious conspiracy on the part of Nature would have to prevent their escape from the nucleon to be observed directly. (This is the problem of quark confinement, now regarded as a mathematical theorem awaiting rigorous proof.) — Zweig, on the other hand, confirms that he worked from the assumption that quarks were real from the outset,[25] though he thought the most serious problem (later resolved by the introduction of the color charge) was the apparent violation of the spin-statistics theorem. — In this case the equivalent of the Compton effect was the discovery, in another series of scattering experiments which measured only electromagnetic interactions, that the hadron had pointlike internal constituents with fractional charges.[26]

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Another way of looking at it is provided by the Metropolis algorithm,[27] which exploits the (mathematical) metaphor of the energy[28] landscape: you are trying to find the lowest point; pick a direction at random, take a small step, and if you are somewhere

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[25] George Zweig, "Memories of Murray and the Quark Model." Talk presented at the Conference in Honor of Murray Gell-mann's 80th Birthday, Singapore, 24 February 2010; arXiv:1007.0494v1 [physics.hist-ph] 3 July 2010. Zweig details other technical objections made by Feynman which were eventually resolved.

[26] There was a brief intermediate fashion, promoted by Feynman, for a phenomenological "parton" theory which was agnostic about the identification of these constituents with quarks. Obviously that pissed Murray off no end.

[27] N. Metropolis, A.W. Rosenbluth, M.N. Rosenbluth, A.H. Teller, E. Teller: *Journal of Chemical Physics*, **21**, 1087 [1952].

[28] "Energy" can be defined almost arbitrarily; it is easiest to think of it as an altitude on a topographical map. (Though of course the map can be more than two-dimensional.)

lower, stay there; if you are somewhere higher, flip a weighted coin to decide whether you stay or go back. The weighting of the coin is determined by a parameter like a temperature, a sort of thermal jiggle which makes it more likely you'll take an occasional chance on jumping uphill. — Dialing the temperature up and down during the course of a search is called "simulated annealing", and all this provides one good way of avoiding the traps provided by local minima into which you might otherwise wander and, looking up in all directions around you, assume you had found the bottom of the topography rather than some kind of volcanic lake. — Similarly one might think of negative capability as a sort of strategy for avoiding consistency (which always runs downhill) and taking the occasional chance on an enticing mistake.

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Other variations on the theme:

— From a strictly logical standpoint, skepticism about evolution is justified: it is, after all, very difficult to understand how a bucket of chemicals can produce a living cell in a few hundred million years; it does seem preposterous. — *But it happened*. — Nature is smarter than we are (as Feynman always said), and she has fooled us again. — So the real problem is to figure out *how* this can be possible; not to construct superficially convincing refutations of what can be inferred from observable facts — entertaining though this merry sport may be.

— The reality of the mind-body duality; that it is not some contradiction that shows the unreality of one or the other, or the necessity of reduction of one to the other, but just another fact of nature we are still trying to understand. Here by and large "scientists" exhibit negative capability, "philosophers" do not.

— The traditional difference in attitude between physicists and mathematicians: the former are used to employing techniques lacking in logical rigor, sometimes to the extreme of apparent contradiction; the latter typically regarded this methodology as inherently unsound. The distinguishing characteristic is, again, negative capability.

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Every explanation is a gamble. You have to know when to quit, and remove your winnings from the table.

Any real novelty requires an existential commitment, a willingness to take the plunge. A suspension of disbelief at what may at first appear to be preposterous. — And may really be. There is an element of risk. It is not unlike diving off a cliff and hoping not to hit a rock.

James Franck, though a famous experimentalist, is supposed to have made the following beautiful remark: "The only way that I can tell whether a new idea is important is by the feeling of terror that seizes me." Nietzsche could not have put it better.