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The bell & the buzzer: on the meaning of science

To seek the meaning of science is to seek its human significance. At first glance, that seems problematic because modern science characteristically calls into question many of our all-too-human preconceptions in its effort to discover the truth. Still, to those who care for it, science can have a compelling, human quality. It is a quest, and as such has common elements with other heroic journeys.

Jason and the Argonauts knew they were seeking the Golden Fleece. But scientists seek something that is unknown and hidden – the ultimate laws of nature. The elusiveness of this goal conditions the search and the searchers. Even setting aside the complex effects of science on the world, to seek the meaning of science, like the scientific quest itself, is to seek something unknown, to gather seemingly disconnected stories and perspectives fully aware of their discontinuity. As with science itself, our story emerges as much in the gaps as in what we can connect.

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Modern science is a newcomer, barely four hundred years old. Though indebted in deep ways to Plato, Aristotle, and Greek natural philosophy, the pioneers of the 'new philosophy' called for a decisive break with ancient authority. In 1536, Pierre de La Ramée defended the provocative thesis that "everything Aristotle said is wrong." Francis Bacon and René Descartes criticized scholarship that remained in thrall to the ancients. This adversarial stance implied a problematic relation to the established order. In spite of Bacon's efforts to persuade his king to support his fledgling scientific research efforts, King James mockingly compared Bacon's words with the peace of God that "passeth all understanding." Though later rulers came to value the powers that science gave them, they recurrently turned against its ever more expensive projects of 'pure' research.

To render the new philosophy more comprehensible to an audience steeped in classical learning, Bacon often resorted to reinterpretations of ancient myths. He compared science to the Sphinx because each, "being the wonder of the ignorant and unskillful, may be not absurdly called a monster." His irony implies that this superficial view has its own truth, though it also must be considered within a larger, deeper perspective. Here the concept of depth is crucial, for the essential innovation of modern science has been to disclose the secrets and depths of nature. Though this has become a familiar image, it represents a radical departure from Aristotle's view that nature is fundamentally open to human understanding, not hidden. Instead, Bacon turned to alternative insights, to Heraclitus's enigmatic teaching that "nature loves to hide" and to Isaiah's recognition that "thou art a God that hidest thyself."

We have only begun to estimate the effect on human understanding of this quest for the depths. Bacon envisaged that the new philosopher, as a "skillful Servant of Nature," would wrestle with Proteus, "the messenger and interpreter of all antiquity and all secrets," whom he identified as "Matter – the most ancient of things, next to God." Bacon emphasized that this ordeal of experiment was to be heroic testing, not the torture of a slavish and submissive victim. Bacon also anticipated that the evidence that emerged would be enigmatic, even enciphered. He judged that "the universe to the eye of the human understanding is framed like a labyrinth," requiring a new kind of interpretation akin to the then emergent art of codebreaking. Bacon did not anticipate the form this decipherment would take – symbolic mathematics – though he mused on the unexplored possibilities that lay beyond the mathematics he knew, convinced that the future would far outstrip any anticipation. He guessed that this extraordinary quest would have deep effects on the seekers, penetrating the nature and wellsprings of their passions as they scourged and tested their own intensely felt theories, no less than they vexed nature with experiments.[1]

Bacon anticipated that the votaries of his 'new philosophy' would prick their desire to know with the spur of self-questioning. Fired with visionary excitement, they should nevertheless try to undermine their own dearest theories, lest they fall victim to self-delusion. He compared this dilemma to struggling with the Sphinx's menacing claws: "distraction and laceration of mind, if you fail to solve them; if you succeed, a kingdom." If they solve her riddle, the seekers will discover the secret sources of power over the political and natural worlds, thereby facing the deepest possibilities of corruption. In such works as his unfinished *New Atlantis*, Bacon framed the hope that these "sons of science" (as he called them) would emerge triumphant from this ordeal whose tragic possibilities he also sensed.

Four centuries later, we continue to wonder at this unfolding drama, trying to gauge whether Bacon's hopes were vain or whether they might yet be sustained. Kepler, Newton, Darwin, and Einstein bore out many of Bacon's anticipations, both in the heroic tenor of what they attempted and achieved but also in the peculiar difficulties their quests raised for their desires. Einstein speaks for all of them: "I want to know God's thoughts. The rest is trash." Those who seek such knowledge must wrestle with something beyond the human.

Consider the paradoxical demands that Bacon anticipated. On one hand,

1 My book *Labyrinth* (Cambridge, Mass.: MIT Press, 2000), drawing on the important work of John C. Briggs, *Francis Bacon and the Rhetoric of Nature* (Cambridge, Mass.: Harvard University Press, 1989), treats these Baconian themes and their relation to the work of Kepler, Newton, and Einstein.

the seekers must be cold, impersonal, testing each theory mercilessly. On the other, they must be filled with ardor, on fire to imagine radically new insights into the depths. Their imaginations must be feverish enough to conjure up ever more daring flights of fancy, but then cold enough to try to annihilate their own creations. This paradox threatens to unravel the seekers' selves and to paralyze their desires. As a result, their humanity may be hostage to their integrity as 'scientists' or 'physicists.'

These names, only coined in the 1830s, replaced the older term 'natural philosopher,' which Isaac Newton and Michael Faraday had applied to themselves. Our literary representations of this new breed are similarly recent. Consider the 'mad' scientists inspired by Mary Shelley's *Frankenstein: or, The Modern Prometheus* (1818). The original Victor Frankenstein is sensitive and intelligent, deeply affected by the early death of his mother. "The world was to me a secret I desired to divine," he recalls. "Curiosity, earnest research to learn the hidden laws of nature, gladness akin to rapture" are his earliest recollections, blending intellectual with passionate response. After a youthful infatuation with alchemy and magic, he encounters the wonders of modern chemistry and is seized by the desire to "explore unknown powers, and unfold to the world the deepest mysteries of creation." His obsessive quest eclipses ordinary human love and even makes him forget his own family. His only offspring is his creature, a monstrous man-child who disappears into inhuman isolation and whose delicate sensibility turns to cruelty as his sufferings transpose Rousseau's noble savage into a dark key.

The mad scientist is also akin to Goethe's Faust (Part I, 1808), who wants to know the inmost secrets of the world but sickens from the emotional aridity of his erudition and develops an inordinate desire to control the world as a surrogate or perhaps cure. Goethe's Mephistopheles, a hedonistic *grand seigneur,* deplores the conflicted desires of his protégé: "You can't get the Doctor out of your system [*Dir steckt der Doktor noch im Leib*]." The mad scientist cuts a tragicomic figure because of his obsessions and his dislocation from the ordinary human world. Hair disheveled, erotically unfulfilled, he sells his soul for delusive dreams of power.

Thus far, the mad scientist is a kind of parody of Bacon's forebodings. Nevertheless, the parodic exaggerations point back to the emotional dilemma that Bacon more subtly discerned when he pointed to wounded seekers such as Oedipus as archetypes of the new philosophers. In Bacon's account, Oedipus solves the Sphinx's riddle not despite but because of his wounded, limping feet. And Bacon did not allude to the tragic sequel – incest and parricide – as if *his* Oedipus has emerged triumphant, blessed by his wound and thereby bestowing blessings. Perhaps Bacon imagined a more positive and heroic version of the ancient story, whose foreboding power he must have known. He went on to depict benign scientist-priests as the hidden rulers of his scientific utopia, the *New Atlantis,* who conceal even from their wise king scientific discoveries they deem too dangerous.

Here again popular imagination follows with its own version of the scientist as magus. Einstein's wild hair is not the mad scientist's coiffure but a secular aureole, bespeaking his superhuman intelligence and wisdom. A Jew fleeing race hatred, he defies its threats. He is even (if wrongly) credited with the atomic bomb, but he is saddened and wounded by the use of that bomb. He is an advocate of peace, a rebel against the establishment that reveres him, offering a new vision of human potentiality. His casual dress and dislike of wearing socks reflects his liberation from convention, an anti-style adopted by students since the 1960s. Like all true myths, the scientist-magus lives on, as does the wounded hero: Stephen Hawking's popular appeal reflects the fascination with a powerful intellect struggling to overcome a crippling physical disability.

Besides these exceptional stories, studies show that scientists suffer from illness and disability during childhood far in excess of the general population.[2] Scientists bear the mark of their struggle, but they also may attain compensatory powers. Between the extremes of magus and mad scientist, consider the *nerd*. About 1957, MIT undergraduates began referring to 'gnurds,' studious grinds, especially in science and engineering. The nerd is emotionally immature, socially isolated, unfashionably dressed, and erotically unattractive. He is the scientist as *Unmensch* and scapegoat, the locus of feelings of confusion, inadequacy, and mistrust that modern science can excite. Though he tends to be the butt of comedy, there is a certain pathos about his human incapacity.

The nerd is a figure in contemporary mythology, but he is not without antecedents. What is known of Descartes's persona fits the category. His mother died when he was very young; he was a sickly child, emotionally remote from his father. At age eight he became a boarding student at a Jesuit *collège*, where he excelled. Such institutions fostered a new kind of self-discipline that bred overzealous students who read by moonlight, spent all their money on books, and neglected their health – proto-nerds, if you will.[3] Descartes added the crucial element by turning this intensified and interiorized studiousness not toward humane letters and classical scholarship but toward a new mathematics and natural science, and he did so in phases of his life in which he notably shut himself off from other people for long periods of time. His intense aloneness deeply marks important passages in his philosophical works. He shut himself up in a stove-heated room to make his fateful experiment on himself, to get rid of all his opinions "all in one go, in order to replace them afterwards with better ones, or with the same ones once I had squared them with the standards of reason."

Of course, calling Descartes the first nerd grossly ignores his personal refinement, elegant prose style, sly wit, even his surprising career as a soldier of fortune. I only want to point to a certain constellation of qualities that link him with continuing elements in the modern mythology of science. Consider, for instance, the 1701 frontispiece to Descartes's posthumous works, depicting him as Faust, seated in his study, surrounded by mathematical instruments, illuminated by the ostentatious rays of the light of nature shining into his chamber. Though Descartes was melancholic, the figure in the frontispiece has a debonair smile of self-satisfaction. This Faust is not tormented or agonizingly conflicted, but quietly triumphant even in his isolation. Descartes chose as his motto *bene vixit bene qui latuit* – "he lived well who hid well" – and gazed at the world through the mask of a scholar

2 See Anne Roe, *The Making of a Scientist* (New York: Dodd, Mead, 1953), and Gerald Holton, *The Scientific Imagination: Case Studies* (New York: Cambridge University Press, 1978), 229 – 252.

3 See Stephen Gaukroger, *Descartes: An Intellectual Biography* (Oxford: Clarendon Press, 1995), 15 – 37.

who outwits the world in the hidden fortress of his mind. On the other hand, he hid in a kind of inner exile from the outer world, and placed just this separation between mind and body.

The nerd, the magus, and the mad scientist are modern mythic figures, somewhat disheveled descendants of Bacon's attempts to reenvision ancient myth. In different ways, they live out the implications of the project to find out what is hidden behind nature. Yet this presumes a basic split between manifest and underlying realities, which Bacon had already discerned but whose full dimensions only emerged much later. Nature is more protean than Bacon dreamed: Proteus merely assumes different shapes; nature shifts between whole realities.

Indeed, no one could have anticipated the way quantum mechanics transformed our sense of reality. Consider a particle observed at point A and time t_A, then at point B and time t_B. The laws of quantum mechanics assign to each possible path connecting A and B an 'amplitude,' a complex number that depends on the 'action,' the difference between kinetic and potential energy summed along that path. Where Newtonian mechanics had allowed only one possible path (that of least action), quantum mechanics allows all possible paths, each weighted by its action. The net amplitude is the sum of the separate amplitudes for all the paths. But this is a complex number, not directly observable. If you take the absolute square of the net amplitude, the result is a positive real number that tells the total probability of that particle appearing at point A and time t_A, then at point B and time t_B.[4]

Einstein satirized quantum theory's reliance on probability in his aphorism "God does not play dice." He insisted on the necessity of distinguishing the constituents of the world and following their individual careers. But ironically Einstein was a great practitioner of the statistical method, a pioneer in applying statistical concepts to fundamental physics, as when he used the observed jittering of microscopic particles (Brownian motion) to deduce the size of the atom. Einstein also pioneered the new statistics of quanta in advance of the full flowering of quantum theory in 1926. But in these cases, he always sought a nonstatistical underlying theory.

The essentially probabilistic character of quantum theory emerges as we compel subatomic matter to respond to experiments built to human size. In so doing, we exert an unavoidable and uncontrollable (though limited) influence on what we observe, an influence that always bears the mark of our observation. As Werner Heisenberg put it, "the object of research is no longer nature in itself but rather nature exposed to man's questioning, and to this extent man here also meets himself." We are no longer grappling only with the protean forms of matter in the labyrinth. Commenting on Heisenberg's insight, Gerald Holton evoked the possibility that we traverse "the labyrinth with the empty center, where the investigator meets only his own shadow and his blackboard with his own chalk marks on it, his own solutions to his own puzzles."[5] Here even the dice-playing God has disappeared, or never

4 Any complex number z can be written as $z = a + bi$, where a and b are real numbers and i is $\sqrt{-1}$. Then the absolute square of z is defined to be $|z|^2 = (a + bi)(a - bi) = a^2 + b^2$, a positive real number.

5 See Gerald Holton, *Thematic Origins of Scientific Thought*, 1st ed. (Cambridge, Mass.: Harvard University Press, 1973), 34 – 36.

come, leaving only a mocking echo to taunt us.

Well before these issues emerged in physics, Darwin's account of natural selection pointed to the randomness at the heart of biology. Under the urbane, cheerful civility of *The Origin of Species* lies an abyss. Contrary to common opinion, identifying us as ambitious apes was not Darwin's greatest scandal; after all, the doctrine of original sin also undermines human pretension, holding that nature fell with our fall. No, our relation to the primates merely reveals us to be *nouveaux riches* trying to live down our humble origins. Far more disturbing is Darwin's veiled but unmistakable disproof of divine providence, though he himself remained faithful to the older tradition of natural theology and did not draw this more radical conclusion.[6] Nevertheless, in flat contradiction of any "special providence in the fall of a sparrow," Darwin's nature is utterly heedless. No purpose or direction guides natural selection; there is only the battle to survive and (far more important) to prevail in reproduction.

As a result, the process of the origination of species constantly hides and even annihilates those origins, not purposively but through random carnage and mere oblivion. If so, what is hidden about that process is not some divine secret or intelligible law, but a blind, implacable play of random variations in mindless competition. Indeed, in Darwin's account, mind itself emerges randomly in the course of that struggle.

Darwin did not merely present an alternative account to Genesis; he undermined any account not based on chance. In so doing, he tacitly questioned the presumption that physical science excludes randomness and natural selection. To be sure, he himself raised no such question, but gradually physicists raised it themselves.

James Clerk Maxwell, a religious man, would not allow Darwin's theories to be discussed in his presence. In 1872, Maxwell took pains to deny that atoms evolved, since they show no evidence of variation or selection, no "missing links" or signs of evolution or change, "as though they had all been cast in the same mould, like bullets, not merely selected and grouped according to their size, like small shot." Likewise, Maxwell noted the perfect likeness of atomic spectra on Earth and distant stars, "like tuning-forks all tuned to concert pitch," all cut to a universal measure, "the double royal cubit of the Temple of Karnak." For him, this was powerful testimony to the perfect workmanship of the divine Manufacturer. Implicitly, Maxwell wished to exorcise the ghastly specter of Darwinian randomness from any intercourse with the universality of physical law. Yet his reaction indicated that the Darwinian possibility was present in his mind. Maxwell took the observed equality of atomic properties and spectra as positive evidence for the unity of the universe and the sameness of its constituents. So far, no evidence has emerged to contradict either of those propositions.

But now consider Andrei Linde's suggestion that, rather than there being only one universally valid set of physical laws, there are many different universes, each with its own laws of nature, each randomly different from the other. Linde's "chaotic inflationary universe" calls into question the presumption that there is a unique set of God's thoughts, the physical laws of a unique universe.

6 See John F. Cornell, "God's Magnificent Law: The Bad Influence of Theistic Metaphysics on Darwin's Estimation of Natural Selection," *Journal of the History of Biology* 20 (1987): 381–412.

His proposal that multiple universes have randomly different physical laws still lacks any observation that might confirm or deny it. Yet his hypothesis is not merely a perverse possibility but follows the probabilistic direction of quantum mechanics. Uncomfortably, we remember that once we presumed the Earth was unique, central. Is the assumption that there is *any* unique universal physical law another childish dream from which we must awaken?

Here the crux may be the randomness of the physical laws differentiating these universes. Such 'laws' appear ungrounded on any principle or necessity. If random, they cannot be God's thoughts, because they are not the product of *any* thought, much less that of God. In the 'many worlds' interpretation of quantum theory put forward by Hugh Everitt in 1957, each possible path is a world unto itself. At every instant, an infinite array of branching paths leads into the future, though at any time we only experience *one* of these possibilities, the fork we happen to have taken. Linde's suggestion takes this idea a step further: alternative universes may not be absolutely separated (as in the many worlds view), but extremely distant. To be sure, Everitt's many worlds may be simply alternative versions of the same universe, while Linde's universes may have no relation to each other, since their physical laws are fundamentally (if randomly) different.

The bizarre quality of these suggestions shows why Einstein would have wanted to exclude them from God's thoughts. (In contrast, Niels Bohr thought we have no right to tell God what to do; surely the Old One may gamble without our consent.) Yet I think that this problem has a deeper resolution stemming from the interpretation of amplitudes and probabilities first articulated by Max Born in 1926. So far, we have treated 'reality' as a single level, whether encompassing one universe or many. But quantum mechanics operates on *two* levels, even in the simplest examples. First is the inner level of the amplitudes. Since these are complex numbers, they are not observable. Nevertheless, they follow strictly deterministic mathematical equations (like those of Erwin Schrödinger or Paul Dirac) as they unfold in time. Second is the outer level of probabilities. These are positive real numbers predicting the results of actual observation and experiment. However, these probabilities do not, like their constituent amplitudes, follow deterministic mathematical equations; this is the very meaning of probability as opposed to certainty. Despite randomness on the level of observation, the inner level of quantum mechanics is deterministic, not random.

This may give the key to our problem: wherever there is randomness, consider another level of reality that weights the manifold of possibilities. In the case of Linde's universes, let each universe and its space-time be represented by a single point in a superspace and by a corresponding amplitude for its formation. Seek then the equation (now in superspace, not ordinary space) that describes the evolution of each sort of universe. God only appears to be gambling if we look only at one level of reality. To make sense of this, we must give up a simple, unequivocal sense of 'reality.'

Einstein was not willing to pay this price; he thought that physics should deal with observation and be determined unequivocally on that level. He hoped by some artifice of fields and geometry to account for quantum phenomena. His efforts met with no success, and quantum theory remains uncontradicted by any experiment so far.

This is a warrant to embrace the multiplicity of realities – not to resist them.

The idea of such multiple realities is not new. Mathematics has considered alternatives to Euclidean space since the early nineteenth century. In the early twentieth century, John von Neumann showed that quantum theory is most naturally formulated in Hilbert space, an infinite-dimensional manifold of 'state vectors.' Economic models routinely rely on 'spaces' of high dimensionality, each dimension a different economic index. Yet we speak of the Dow Jones Index going 'up,' as if it were an object in ordinary space.

But these are only *representations*, whose relation to reality was Immanuel Kant's deep concern. His *Critique of Pure Reason* (1781) separated *phenomena* (the world as it appears to us) from *noumena* (the ultimate nature of things in themselves). By dividing reality in this way, Kant sought to protect Newtonian physics from David Hume's skeptical question: What guarantees that physical law and causality are valid, beyond our expectations based on past experience? To this, Kant conceded that we cannot know by pure reason *anything* about things in themselves. Physical law applies to phenomena alone. In his vivid image, we live on an isolated island (the phenomena) surrounded by vast, unfathomable depths (the noumena). The coherence of our science depends on the built-in categories of the human mind, rather than the unknowable depths of nature.

Kant's two levels of reality are comparable to those of quantum theory. Observable appearances are like probabilities; noumena are like amplitudes. However, Kant denies that pure reason can acquire any knowledge of noumena, but the inner, unobservable quantum amplitudes are perfectly intelligible, totally determined by fundamental equations. Ironically, it is the outer level of observation that is probabilistic, not completely knowable. In this way, quantum theory shares Kant's divided view of reality but takes it in a very different direction. This dialogue between physics and philosophy has only just begun.

Every reality has its price and its value, which we need to gauge. The possibility of illusion is ever-present, for the multiplication of 'realities' lends each one of them a certain quality of unreality, of deceptiveness through being an alternative or a part, not a whole. The difference between levels of reality cannot be dismissed; probabilities are not the same as amplitudes, though we must pay heed to both. Here, Bacon reminds us that we must not merely gaze aimlessly at the varying shapes of Proteus.

First and foremost, we have to wrestle with the premise that reality could be multiple. Is not the concept of 'reality' singular, unique by its very definition? Out of several 'realities,' must not one of them be the most fundamental, the real reality? So at least Einstein seemed to assume. Yet the two levels of quantum theory both seem necessary because neither can be reduced to the other. If we consider amplitudes more fundamental, we dismiss the observable world and its inescapable probabilities. Since each of us is composed of roughly a hundred trillion trillion (10^{26}) atoms, we take for granted prejudices based on our sheer size. Because of this, we tend to identify 'reality' with the familiar world of distinguishable, macroscopic individuals. But on the atomic scale, there are no such individuals.[7] This subverts our 'common-sense' assumptions about

7 I have discussed this at length in *Seeing Double* (Cambridge, Mass.: MIT Press, 2002).

reality and is at the heart of quantum theory.

However, our argument does show the problem of insisting on wholly incoherent, separate 'realities,' for probabilities and amplitudes are deeply connected because the one is the absolute square of the other. Perhaps then the better term for them is 'levels of reality.' Bacon held that the "hidden God" of scripture delights in our search into his divine abyss. Perhaps it may be naive or outmoded to speak thus about the hidden levels of reality. Yet what more secret mark could sign a book of secrets?

What unites these divergent realities may be nothing other than the human mind itself. The effort to connect the disparate, to mediate between our inner and outer worlds, is precisely the struggle of consciousness. Here, it is crucial that there is no formula that connects them, that our experience is irreducibly multiform. In the face of this, our efforts of thought aim to bridge these gaps and grasp a seamless whole. Certainly it is the ambition of most philosophical systems to resolve the blooming confusion of the world into consonance.

In contrast, Plato reminds us that the basic notion of 'system' misses the essential character of our experience, which is closer to dialogue than monologue. Science works by drastically oversimplifying the world, cutting out everything that cannot be mathematized. Our quest for meaning must bracket this unsparing simplification within a broader perspective that struggles to grasp some larger wholeness, if only by trying, and failing, to connect the disparate pieces. In the moment of failure, we feel most clearly the leap between levels. That surprising, sinking, excited feeling may be the essence of thought as felt experience, rather than as bare abstraction.

The felt character of this divided world, which is the inner dilemma of the scientist, reaches out to touch all who partake in the insights of science. Unlike the common stereotype of cold abstraction, the real problem is that the process of scientific thought is so hot to grasp something radically new, yet deliberately chilled to temper and chasten merely wishful thinking. The simultaneous feeling of opposites, of hot and cold together, results in a kind of shiver, exactly the feeling Einstein remembered in old age about his earliest memory – looking at the compass in his father's hand and realizing that "something deeply hidden had to be behind things." Such a *frisson* goes beyond pain and pleasure to indicate the powerful experience of new insight, and signal a drastic departure from common humanity. It is, I suggest, a deep element of the inner perils and exaltations of the scientific experience.

There is a curious parallel in behavioral psychology. Consider Ivan Pavlov's famous experiments conditioning dogs to expect food after a bell is rung or an electric shock after a buzzer sounds. When both the bell and buzzer sound simultaneously, most dogs exhibit strong signs of anxiety, unsure whether they are to be fed or shocked. However, at that juncture a very few dogs suddenly cease to be conditioned to *either* stimulus. Under the paradoxical stress, it is as if the scales fall from the dogs' eyes to reveal bell and buzzer as meaningless constructs. Through their peculiar experience of cognitive dissonance, those few dogs have entered a new relation to 'reality,' precisely because they fully experienced its doubleness, if not duplicity. Perhaps they enter into complete canine cynicism and disillusionment about their trainers' deceitfulness. At least, they are intractable to further conditioning.

Like Pavlov's dogs confronted with the simultaneous sounding of bell and buzzer, scientists subjected to contrary yet superimposed levels of reality may suddenly cease to regard any single level in the way they had been conditioned. They may feel:

> like some watcher of the skies
> When a new planet swims into his ken;
> Or like stout Cortez when with eagle eyes
> He stared at the Pacific – and all his men
> Look'd at each other with a wild surmise –
> Silent, upon a peak in Darien.[8]

The crisis comes not from one level but from the deeply felt dissonance between many. If they can withstand the resultant emotional stress, they may experience a sudden realization. What then? Perhaps they will recognize the one, true level of reality, of which all other levels are merely distorted reflections. Perhaps they will turn away in disillusionment, as if such discord mocks all meaning. Or perhaps in the very multiplicity they will recognize a new, dissonant polyphony.

Einstein once remarked that "the real nature of things, that we shall never know, never." Max Planck also believed that "science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are part of nature and therefore part of the mystery that we are trying to solve." Even so, Planck considered that the chief attraction of science is "the pursuit of the unknowable." In the struggle to know what may be unknowable, our mind and nature wrestle on all levels. The bell and buzzer are sounding ever louder. To what will we awaken?

8 John Keats, "On First Looking into Chapman's Homer" (1817).