QUANTUM UNCERTAINTY, QUANTUM PLAY, QUANTUM SORROW

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Abstract: I argue that intrinsic (as opposed to epistemic or Einsteinian) quantum uncertainty informs the elemental life experiences of random play and compassionate sorrow. These experiences, like Niels Bohr's quantum ontology, point toward unscripted novelty, fresh variation, and far-flung sympathetic interconnections. And in doing this, they allow the inner and outer feeling experiences to grow back together. As we feel the world sensibly—that is, touch it with our sense organs—it touches back in a way that engenders feeling-laden or sympathetic understanding.

Keywords: Erwin Schrödinger, Niels Bohr, Max Delbrück, Albert Einstein, Maurice Merleau-Ponty, uncertainty, music

INTRODUCTION

In his 1944 *What is Life?* Erwin Schrödinger offered an explanation of how living organisms realize large-scale order and stability in the face of microscopic disorder—the random motion of individual atoms. Schrödinger, a renowned physicist best known for his development of wave mechanics and his opposition to quantum uncertainty as interpreted by Niels Bohr, proposed that large populations of atoms achieve stability by virtue of their statistical reliability. When their collective action is added up, statistical fluctuations are so small as to give us lawful, orderly behavior. He called this the "order-from-disorder" principle and insisted that it ran counter to the randomizing or degenerative effects of the second law of thermodynamics, which would seem to prompt the expectation of rapid breakdown of order in living systems.

But this was just a first pass at the question of life for Schrödinger, and one that in his mind did not really answer the question. The problem was that at the molecular level, the site of gene replication, there are relatively few atoms. One might expect, then, that at this level disorder would prevail and genetic mutations would proliferate far beyond their observed frequency. This expectation, however, overlooks the quantum character of the atoms making up the molecules that transfer genetic information, said Schrödinger. Owing to their discontinuous nature, atoms and their constituents are locked into discrete states that promote gene stability. Moreover, such "a well-ordered association of atoms"[1] might well embody a structure that compresses all of an organism's genetic possibility. The mechanism for hereditary transfer, in other words, might involve more than mere repetition of the same as is found in growing crystals: it might involve a "miniature code" that "precisely correspond[s] with a highly complicated and specified plan of development and . . . somehow contain[s] the means to put it into operation."[2]

All this, Schrödinger added, presupposes an organism's absorption of "negative entropy" (now sometimes called "free energy") from its environment—food, sunlight, and other energy stores. Thus life: the streaming of energy into a system whose quantum-stabilized genes encode and transfer large quantities of hereditary information.

Reviewing *What is Life?* in 1946, H.J. Muller, a Nobel laureate geneticist, stated that the book made little contribution to scientific understanding because Schrödinger had read too narrowly on the subject, was not up-to-date in his exposition, and occasionally garbled biological concepts. Muller also predicted—correctly, as it turned out—that its primary value would lie in "furthering the much needed liaison between the fundamentals of the physical and the biological sciences."[3] The book played an important role in pointing physicists toward biology, and in whipping up enthusiasm for biology among budding scientists searching for a career path. The confident exposition, leaning as it did on the already fabled quantum revolution and delivered by one of the architects of that episode, was "polarizing" to impressionable young men like James Watson,[4] who did not know enough biology at the time to spot its limitations.

But before Schrödinger expressed interest in biology, Bohr had staked his own claim by encouraging students to move into biology where they could apply quantum principles. Max Delbrück, the best known of Bohr's protégés in this regard, accordingly switched fields with the aim of revolutionizing biology by means of a "radical physical explanation."[5] Such explanations had driven the quantum revolution, and, along with other physicists, Delbrück saw biologists as too conservative to think radically.

Bohr had set the tone here. His explanations, or at least his interpretations, were too radical for Schrödinger and Einstein, who rejected Bohr's proposition of ontological uncertainty. Quantum uncertainty, they held, is a measure of our ignorance, not an intrinsic feature of the world. But as early as 1933, just several years after the end of the quantum revolution, Bohr generalized his notion of intrinsic uncertainty beyond physics. In a lecture entitled "Light and Life" he articulated a kind of biological uncertainty principle by explaining that the "minimal freedom" which allows nature to operate in ways that attract our interest also enables nature to escape our scrutiny once it becomes

1. Erwin Schrödinger, *What is Life? The Physical Aspect of the Living Cell* (New York: The Macmillan Company, 1945), p. 61.

2. Ibid., p. 62.

3. H.J. Muller, "A Physicist Stands Amazed at Genetics," *The Journal of Heredity*, vol. XXXVII, no. 3 (Feb 1946), pp. 90-92.

4. James Watson, "Growing up in the Phage Group," p. 239, in John Cairns, Gunther Stent, and James D. Watson (eds.) *Phage and the Origins of Molecular Biology*, expanded ed. (Plainview, NY: Cold Spring Harbor Laboratory Press, 1992), pp. 239.

5. Max Delbrück, "A Physicist Looks at Biology," in Cairns, Stent, and Watson (eds.) *Phage and the Origins of Molecular Biology*, p. 22.

overbearing.

> In every experiment on living organisms, there must remain an uncertainty as regards the physical conditions to which they are subjected, and the idea suggests itself that the minimal freedom we must allow the organism in this respect is just large enough to permit it, so to say, to hide it ultimate secrets from us. On this view, the existence of life must be considered as an elementary fact that cannot be explained, but must be taken as a starting point in biology, in a similar way as the quantum of action, which appears as an irrational element from the point of view of classical mechanics, taken together with existence of the elementary particles, forms the foundation of atomic physics.[6]

For Bohr the quantum of action was a site of intrinsic and irreducible uncertainty: improved technology or more powerful analysis could not touch it—could not turn it into certain knowledge—because of its innately probabilistic character. Somewhat analogously, the rational finger of science cannot touch the free and irrational spark of life.

But this limitation, Bohr insisted, need not be taken as a strike against science. With the help of his complementarity principle one could yet manage the paradoxes associated with intrinsic uncertainty. Chief among these in the quantum realm was wave-particle duality, the capacity of particles to manifest themselves as waves under certain circumstances. From a classical (pre-quantum) perspective this was unthinkable, but Bohr saw the contradictory manifestations (particle and wave) as complementary opposites. Each completes the other; each brings the other to realization by virtue of their oppositional mutuality. Conceivably, life and non-life similarly complete or complement one another.

Einstein characterized complementarity as a "tranquilizing philosophy" that lulls the scientific mind to sleep.[7] In spite of this criticism, the principle has achieved near-canonical status owing to the experimental vindication of Bohr's outlook *vis a vis* Einstein. Ironically, Bohr's approach, as practiced by Delbrück, did not achieve striking success in biology. The DNA double helix, Watson and Crick's mechanism for explaining gene replication, solved the problems that Delbrück had hoped to solve, but without the mind-bending paradoxes he had come to expect from quantum mechanics. "Upon the discovery of the DNA double helix," he later stated, "the mystery of gene replication was revealed as a ludicrously simple trick. In people who had expected a deep solution to the deep problems of how in the living world like begets like it raised a feeling similar to the embarrassment one feels when shown a simple solution to a chess problem with which one has struggled in vain for a long time."[8] Bohr was also disappointed with the Watson-Crick denouement and at one point enigmatically suggested that things, complementarity-wise, could have turned out differently.[9]

6. Niels Bohr, "Light and Life," *Nature*, vol. 131 (1933), p. 458.

7. See Arthur Fine, *The Shaky Game: Einstein Realism and the Quantum Theory*, 2nd ed. (Chicago, IL: University of Chicago Press, 1996, p. 18.

8. Max Delbrück, *Mind from Matter?* (Palo Alto, CA: Blackwell Scientific Publications, Inc., 1986), p.237.

9. A.P. French and P.J. Kennedy (eds.), *Niels Bohr: A Centenary Volume* (Cambridge, MA: Harvard University

Were they still alive, Bohr and Delbrück might be encouraged by the growing realization that gene replication is more subtle and complex—more mysterious—than it first seemed upon discovery of the DNA double helix. Reflecting on the promise of that momentous event in 1953 and what began to transpire toward the end of the twentieth century, Evelyn Fox Keller writes: "For almost fifty years, we lulled ourselves into believing that, in discovering the molecular basis of genetic information, we had found the 'secret of life'; . . . And we marveled at how simple the answer seemed to be. But now, in the call for a functional genomics, we can at least read a tacit acknowledgement of how large the gap between genetic 'information' and biological meaning really is."[10]

Motivating this shift in outlook, says Keller, is our changing understanding of the gene. Once viewed as self-contained, mechanical, static, and aloof from outside influence, it is now being re-seen as active, teleological, self-evolving, and intimately and expansively patterned into its biological environment. This development, in Keller's mind, is not altogether surprising inasmuch as genes (even before their empirical discovery) were modeled on classical atoms: they were to be the elementary units that never change while giving rise to change at higher levels through their ceaseless combination and recombination. While Keller does not point it out, the parallelism is inescapable. Just as the classical atom broke down in physics, the classical gene is now breaking down in biology.

I don't know whether Bohr would see this latter breakdown as an opportunity to invoke his complementarity principle. Owing, however, to his appreciation of the way language channels scientific thought, he allowed for alternative or complementary ways of portraying quantum phenomena, and this is what I now want to pursue in the interest of demonstrating quantum uncertainty's centrality to everyday life. Bohr once remarked to Werner Heisenberg that "when it comes to atoms, language can be used only as in poetry." The mind-wrenching insights of quantum physics could not be contained within the bounds of ordinary scientific discourse, and consequently one had to turn to poetry for "images and . . . connections" that would facilitate understanding.[11] Here I attempt two such images, which, I hope, will bring quantum uncertainty forward as an essential aspect of lived experience.

QUANTUM PLAY

One of the revolutionary aspects of quantum theory is its emphasis on unpredictability or randomness. At the level of atomic and subatomic particles, it is said, some events happen at random. That is, they have no precisely defined cause or causes, but simply "pop" into existence. This implies that if somehow we could step back in time to replay a particular event, it might well turn out differently. Such random events are not fated or determined by prior events.

Press, 1979), p. 319.

10. Evelyn Fox Keller, *The Century of the Gene* (Cambridge, MA: Harvard University Press, 2000), pp. 6-7.

11. Werner Heisenberg, *Physics and Beyond: Encounters and Conversations*, trans. Arnold J. Pomerans (New York: Harper & Row, 1971), p. 41.

This notion hit early 20th-century physics like a bombshell. The classical view was that physical events were entirely predictable—if not in practice then at least in principle. The universe could be likened to a huge pool table dotted with trillions of billiard balls. Each ball was an atom, and, given the laws of physics and knowledge of every atom's location and velocity at a given instant, one could work out the entire history of the cosmos. Logistically, this might well be impossible, but theoretically it was plausible because physical reality was thought to be an aggregation of inert particles mechanically impinging on one another in a ceaseless flow of cause and effect.

With quantum physics, this conceptually tidy, sharply-detailed picture goes out of focus. In some instances it becomes difficult to talk of separable events and particles; things get blurry and confused, i.e., interfused. In part, this is because randomness erodes the principle of causality. A tight, well-defined causal link between an event and prior events does not always exist. And without every link in place, science cannot become omni-science, cannot, even in principle, come to know the end from the beginning.

For some physicists of the era, this new outlook was hard to accept because it was so contrary to their deterministic vision of nature. But a little reflection suggests that classical physics' loss of absolute certitude opens space for the kind of poetic uncertainty that informs human experience. Most people have been to a movie or play whose dialogue was overly formatted or too predictable. Every remark seems to follow logically from the preceding remark. There are few if any miscues, false starts, coughs or sneezes, offbeat responses, verbal slips, or unexpected shifts in conversational mood or direction. Such dialogue quickly becomes tiresome because it lacks the little surprises that randomly interrupt real conversation. Those surprises may distract but they are also a source of novelty or variation.

Music also depends upon the element of surprise or randomness. A melody line that initially pleases soon becomes boring unless it is modified or "recreated" in a surprising way.[12] Such random re-creation is part of the recipe of life. Claiming that "the world is embodied music," Arthur Schopenhauer wrote that "Melody is always a deviation from the keynote through a thousand capricious wanderings, even to the most painful discord, and then a final return to the keynote."[13]

Quantum randomness, then, can be seen in positive, life-affirming terms. An event may lack a cause but still have a rhyme or poetic purpose, and that purpose may be the introduction of novelty to keep the world interesting. Indeterminate quantum entities like electrons and photons may be understood as little packets of surprise. They do not overwhelm us with chaotic change—they do not drown out the world's melody line—but they do infuse variation. And the light touch, the grace with which they bestow their random novelty, bespeaks life, just as a script spiced with occasional random elements bespeaks human conversation. Perhaps *random* is not quite the right word here, for

12. Martin Gardner, "Mathematical Games: White and Brown Music, Fractal Curves and One-Over-F Fluctuations," *Scientific American*, vol. 238, no. 4 (April, 1978), pp. 16-32.

13. Arthur Schopenhauer, *The Philosophy of Schopenhauer*, edited by Irwin Edman (New York: Random House), pp. 208, 263.

it suggests mindless chance or accident, and life is at odds with mindlessness. In one physicist's opinion, Arthur M. Young, *play* is the better word:

> Since the quantum of uncertainty manifests in particles and atoms in random fashion, it may be thought of as an accident, but this designation becomes inappropriate in later stages when higher organisms develop and invest the intrinsic randomness with a highly competent organization; for in this case, the intrinsic randomness seems more like "play" than accident, much as, in childhood, play results in mere accident, but in later life play can refer to the activity of a skilled athlete or a gifted virtuoso.[14]

Taken individually, quantum eruptions of "play" appear haphazard, but taken cumulatively, they seem to spell life. Little quantum hits of surprise add up to wholes greater than the sum of their parts. Young goes on to remark that "There is in all creation this transcendence of what is strictly rational or implied by its antecedents, and the word 'play' comes a little closer than the word 'accident' to describing the cause of new creations."[15] The random or uncaused event may be informed by the playful purpose of infusing novelty into a theme that would otherwise become monotonous or deadening.

Not only that, but random or playful re-creation can be redemptive. What now seems senseless or random may in time acquire meaning; odd and jarring notes sometimes find a rhyme. Jazz musicians know what it's like to reach for rhyme while playing notes that sound random and arrhythmic, even crippling. Eventually, however, the music heals itself at a higher turn of the spiral. A similar self-spiraling dialectic might be said to inform life. Over time the chaos or noise of unexpected setbacks gathers into rhythms of meaning, even as new chaos threatens to break those rhythms apart so that they may mend again at a higher level. Inasmuch as the uncertainty associated with this chaos is intrinsic—that is, absolutely unscripted and hence truly fresh and original—it may be said to be the free play, the give, the slippage, the wild card, the unsystematic element that keeps life interesting and meaningful.

QUANTUM SORROW

Play, however, is a concept that does not stand by itself. Normally it is juxtaposed with work—its familiar opposite—but here I juxtapose it with compassion-induced sorrow, which might be regarded as its mood or humor opposite. Man "alone suffers so deeply that he *had* to invent laughter," wrote Nietzsche,[16] suggesting that while laughter is liberation from sorrow, laughter and sorrow are, at bottom, a single package. Schopenhauer hints at this unity when he insists that music is sustained by a thousand capricious or playful wanderings from a keynote "even to the most painful discord." Perhaps, then, it is not

14. Arthur M. Young, *The Reflexive Universe: Evolution of Consciousness* (Lake Oswego, OR: Robert Briggs Associates, 1976), p. 30.
15. Ibid.
16. Friedrich Nietzsche, *The Will to Power*, trans. Walter Kaufmann & R.J. Hollingdale (New York: Vintage Books), p. 56. Original emphasis.

surprising that in the quantum scheme of things, there is poetic space for pain or sorrow, just as there is for play. And quantum sorrow, as it were, points back to the way we visually experience the world.

People often remark that quantum physics gives us a soft-focus vision of nature; no hard-edged boundaries but rather a kind of impressionistic blurriness. Underpinning this new view of reality is the recognition that perfect objectivity is impossible. No one can be the magisterial spectator who watches the world from a distance. In realizing this, we edge away from the classical ideal of dispassionate spectator knowledge toward the quantum suggestion of passionate or even compassionate experience.

It is a truism that quantum physics' soft-focus, relational vision of nature compels us to rethink our assumptions about how we know the world. Actually, the significance of quantum physics extends even further than this: it encourages us to *feel* or *re-feel* the world. The classical pretense of aloofness spurs a sense of pure thought, even impassibility, but once that pretense is shattered, feeling or emotion reasserts its centrality. If we are blurring into the world as we look at it, we are poised to feel it in an expansive way that blurs the distinction between tactile sensation and inner emotion. Under the auspices of quantum theory, in other words, the outer and inner feeling experiences are allowed to grow back together, for the notion of remote, dispassionate observation is scuttled. As we touch the world with our senses, it touches us—our emotions—with its drama. Science, then, is a passion that spills us into the passion play of nature. The physical witness of this spilling is tear-blurred vision, which answers to the quantum ontology of a blurred, interpenetrating world.

According to Maurice Merleau-Ponty, this dynamic of mutual touching—mutual, interactive, interblending feeling—is elemental. "There is a human body," he wrote, "when, between the seeing and the seen, between touching and the touched, between one eye and the other, between hand and hand, a blending of some sort takes place."[17] And this blending thickens into human experience, although indeterminately so. The interblending cross-situates us in a universe that retreats at our imperialistic touch. If, however, we are willing to let the universe touch back, life's playful or indeterministic novelty reasserts itself.

To make this point, Merleau-Ponty invokes his well known hand-touching-hand illustration.[18] One hand can touch the other, but neither can simultaneously feel itself touching and being touched. Each mode of experience short-circuits the other so as to keep things perpetually unresolved and in unceasing, ever-deepening alternation. What comes out of this fissile reversibility, says Merleau-Ponty, is the rupture or dehiscence of living experience. That is, the back-and-forth dissolution of both ends of the relation—subject and object—opens out as perceptual apprehension. It is this dissolution that softens the boundaries between things and enkindles our humanity—saves each of us,

17. Maurice Merleau-Ponty, "Eye and Mind," trans. C. Dallery, in *The Primacy of Perception*, (Evanston, IL: Northwestern University Press, 1964), pp. 163-164.

18. Maurice Merleau-Ponty, *The Visible and the Invisible*, trans. A. Lingis (Evanston IL: Northwestern University Press, 1968), p. 9.

in Merleau-Ponty's words, from having "an almost adamantine body, not really flesh, not really the body of a human being."[19]

Prefiguring this outlook and echoing Plato's view that understanding is combusted of the fusion of inner and outer light, Goethe wrote:

> In the contemplation of nature you must
> Regard the One as All;
> Nothing is within, nothing is without.
> Grasp thus without delay
> A holy open secret.[20]

Classical or pre-quantum physics assumed that knowing and feeling are distinct, mutually-interfering experiences—I think most clearly when my feelings are put on hold. But quantum theory helps us understand that all is one: experience should not be cut in half to satisfy an erroneous worldview that would turn truth-seekers into emotional blanks, people with "almost adamantine bodies" who unfeelingly take in nature without being touched or moved by it. Indeed, quantum theory calls forth the suggestion that we know reality best when we melt emotionally, for there seems to be a melting, diffusive quality to reality at the quantum level. There is, moreover, an expansive, relational quality that is best understood through reference to emotional experience. When one is moved by compassion, tear-blurred vision signals sympathetic expansion and the dissolution of boundaries that normally protect us from each other's inner experience. "One drop of pity is enough to lift our doing beyond intellectual distinctions," wrote Johan Huizinga.[21] That same drop of pity can also denote interpenetration or participation: as we melt tearfully, our egos melt or liquefy into the wide otherness of "outside" reality.

Martin Buber writes of a rabbi so pure of heart he had to "restrain his spiritual vision" by putting on spectacles, "for otherwise he saw all the individual things of the world as one."[22] With matter-of-fact 20/20 vision, it is easy to "cut up" the world into separate things. But tear-blurred, compassion-laden vision gives us a better picture of reality because it, prefiguring quantum physics, suggests that things are not distinct or separable. The paradox, of course, is that by seeing less clearly we see more clearly, but this contradiction holds only as long as we neglect the idea of inner or spiritual light. If tears give us revelatory sight, it is because they issue up from inner light or emotion, so we feel the world emotionally as we feel or experience it sensibly—these two feelings or lights intermingle. When King Lear asks the recently-blinded Gloucester how he

19. Merleau-Ponty, "Eye and Mind," p. 163.

20. Johann Wolfgang von Goethe, "Epirrhema," in *Werke: Hamburger Ausgabe*, edited by E. Trunz, 14 vols. (Hamburger: Christian Wegner, 1948-1960), vol. I: 18-19. Quoted in Walter Heitler, "Goethean Science," in *Goethe's Way of Science: A Phenomenology of Nature*, edited by David Seamon and Arthur Zajonc (Albany: State University of New York Press, 1998), p. 59.

21. Johan Huizinga, *Homo Ludens: A Study of the Play-Element in Culture* (Boston, MA: The Beacon Press, 1955), p. 213.

22. Martin Buber, *Hasidism and Modern Man*, ed. and trans. by Maurice Friedman (New York: Harper Torchbooks, 1958), p. 78.

manages to get by, Gloucester replies that he now sees the world "feelingly."[23] He gropes his way along but he also understands life more deeply, more sympathetically than before. With his eyes intact and relying solely on outer light, he was a spectator of the drama he now participates in, and that participation gives him new powers of seeing and understanding.

If there is a mystery or paradox here, it is one we have all experienced many times, and perhaps for that reason, it has been iterated away. According to Schopenhauer, compassion is not only the very coin of unconditional love but also the means by which "the distinction between I and not-I vanishes."[24] We normally assume that one person can only guess at another's inner experience. Perhaps we cannot read each other's thoughts very well, but on occasion we are readily drawn into each other's emotional states. And once drawn in, we do not feel that we are reading anything, because reading presupposes objective distance or standing back. Rather we feel we are co-participating, which is just what the words *compassion* and *sympathy* connote: the sharing of passion or pathos to the point of single but expanded identity.

Milan Kundera calls this "emotional telepathy."[25] Given its deep familiarity and our sense that rational thought should always govern emotion, we have tended to disregard it in developing our theories of nature. But quantum physics may be the point at which the pendulum begins to swing the other way, thereby compelling us to take a wider, more relational, and more sympathetic view of things. Subatomic particles are even said "to *feel* at a distance."[26] My intent is not to propose that particles are sentient (although occasionally this suggestion comes up), but to observe that the reaching for emotional or poetic language to make sense of particle behavior signifies a breakdown of the traditional metaphor of a clockwork or mechanical universe. Particles do things we would never dream of them doing in pre-quantum or classical physics. They register themselves in random, playful ways, and they interact with one another in ways that bespeak far-flung sympathetic connections. If life has an expansive quality about it—a tendency to largeness and fresh variation—that quality can be found in the intrinsically uncertain quantum entities that constitute our world.

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23. William Shakespeare, *King Lear*, Act IV, scene vi.

24. Arthur Schopenhauer, "On Ethics," *The Wisdom of Life and Other Essays*, trans. Bailey Saunders and Ernest Belfort Bax (New York: M. Walter Dunne, 1901), pp. 269, 267.

25. Milan Kundera, *The Unbearable Lightness of Being* (New York: Harper & Row, 1984), p. 20.

26. Abner Shimony, "Implications of Bell's Theorem." Paper presented at SUNY-Albany Physics Colloquium, October 1982. Quoted in John A. Schumacher, *Human Posture: The Nature of Inquiry* (Albany, NY: State University of New York Press, 1989), p. 142. Emphasis added.