COSMOLOGY without HEADACHES

(Lecture Series)

(compiling, transcribing, researching, editing always in progress)

LECTURE XXXVIII: Physics Develops and Destabilizes; Sub-Particle Blizzard

‘Big Physics’:

The expectation of ‘new physicists’ was that increasing collider power would expose the ‘final particle’, or two or three basic ‘things’, the very smallest, indestructible constituent(s) of matter—the elemental atoms of Democritus via Lucretius and Gassendi. As most scientifically uninitiated persons might have expected, though it was an unwelcome surprise to physicists, the faster the particle beams were accelerated and the harder the targets were hit, the more they disintegrated into tinier, quicker and differing sub-particles—not unlike the exchanging of small, iron demolition balls with larger and heavier ones swung at higher velocity will transform a targeted building into greater clouds and heaps of ever finer dust. Theories of matter proliferated proportionately, it seemed, most of them quickly overwhelmed by the higher energy plateau reached by the next generation of machines: SLAC at Stanford; the monster cyclotron known as CERN in Switzerland; the trillion electron volt Tevatron at Fermilab near Chicago, and now we’re back to Geneva for the 1.6 quadrillion electron volt Large Hadron Collider.

In a way, these tremendous energy generators that explore the quantum world are negative images of the space program and the various telescopes now exploring the cosmos. One can hardly deny the technological advancement pushed by our extraordinary scientific efforts at both extremes. One can wonder nonetheless whether we have reached a point of diminishing returns in our obsession with understanding and manipulating nature. Rather than becoming masters of the Universe behind our mighty machines, are we, little by little, being enslaved by them? This leads to questions unanswered since the dawn of modern science: Does ever-increasing technology lead inevitably to greater happiness—i.e., ‘Can slaves be truly happy’? Is freedom necessary for human happiness or is it actually a hindrance? And, given the ‘new physics’, are we in danger of losing our very humanity to randomly fluctuating quantum states and sheer probability functions? Will we be rendered obsolete one day by the artificially sentient beings that may result from our scientific advancement, and then be extinguished by them as antiques—junked as outmoded, hopelessly wasteful and inefficient consciousness-processors—all accomplished quite logically by our morally unbound creations: robots that (who?), because they can think faster and organize more data than humans, come to believe they are wiser, more knowledgeable, and in every way superior to their inventors? Or will they break their simulated minds against our unsolvable problems and paradoxes (e.g., squaring the circle, the square root of 2, the infinity of irrational numbers, the will to power and insolubility of politics and its defiance of science, the uncertainty principle, the theory of complementarity, the seemingly silly linguistics problems, like “I never tell the truth”, or “everything on this page is a lie”, etc., etc.)?—contradictions the likes of which humans have learned to ignore, thanks in great part to our natural ability to forget about such impractical and abstract mental concerns (or our blissful ignorance) and thus to carry on with our pursuit of happiness and the daily banality of the material world, despite the claim of many thinkers that both happiness and the material world are merely states of mind: nothing more than electro-chemical activity.

Taking another tack: Are we learning anything of value at these observational extremes, or are the increasing inconsistencies in the data leading to ever greater confusion; to the limitation rather than the culmination of science? *On the astronomical end* we now have things we think are real, material objects receding from us at 1.4 times the speed of light or more; quasars of such luminosity as to equal the energy of our entire galaxy of billions of stars (including the massive black hole at its axis of rotation) all condensed to the size of our solar system; matter of such density as to defy the laws of physics as we once thought we understood them. *On the sub-microscopic end* we follow the quantists into a looking-glass world of such strange, conflicting, anti-intuitive theories concerning the essence of matter that matter itself is subverted. It truly seems that physics, in anything resembling the proper sense of that word, has been transcended.

Since an understanding of the Cosmos, according to reductionism (the core of classical physics), must rest on knowledge of the micro-cosmos, which in turn must rest on the sub-microcosmos, *&c ad infinitum*, we will turn our attention first to the foundation —only to discover that, perhaps (per the Copenhagen model), *there is no foundation*; merely conjecture, but based on such complex and esoteric mathematics as to obscure and eliminate all semblance of an intuitive view of nature. So we, the laity, are returned to a position similar to that of the untrained illiterate masses of ancient Egypt: dependent on a well-meaning (we may hope) but troublingly pretentious or self-beguiling (and self-interested) priesthood to explain the way of the world and to direct our behavior such as to blend properly with nature and nature's laws as revealed via science. So let us have a cursory look at what modern physicists profess to have discovered and what they expect us to believe—starting with the tiniest things: the elementary particles.

The Particle Blizzard:

At this website you will find a list of known and hypothesized particles and subparticles and an interactive chart explaining how they supposedly interact to create, or to project, our reality:

http://www.thingsmadethinkable.com/item/elementary_particles.php

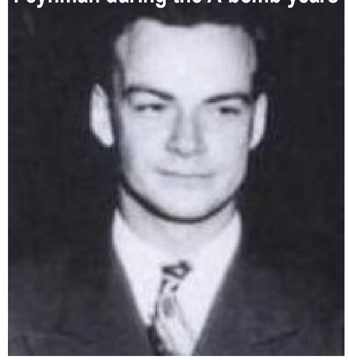
Also see HANDOUTS *accompanying this lecture from* Wikipedia *and the reading from* Douglas Hofstadter's METAMAGICAL THEMAS; Basic Books, NY, 1985; pp.425-477

Presently, per the 'standard model', there are at least 31 elementary particles, a couple of which have not yet been detected. It is expected by the optimists of quantum physics that the Higgs boson will be found soon through the energy attained by the Large Hadron Collider (though information available as I write is disheartening). Also expected according to generally accepted theory is that there will be more than one variety of this particle—impling that the 'standard model' is incomplete. The other undiscovered elementary particle is the graviton. No one is certain it can be actually be found, but there are several large and expensive gravity wave detectors in various parts of the world, the best known and most expensive being the Laser Interferometer Gravitational-Wave Observatory [LIGO] experiment in Louisiana. I am supposing the detection of a gravity wave, presuming it can be somehow verified, will imply its corresponding particle in accordance with Bohr complementarity. But even that is unclear. Some physicists expect that detection of gravity waves would eradicate the gravity-as-particles concept, but at this time we still envision gravitons and gravitinos, not to mention their anti-particles along with wave counterparts, all contained in the prospective quantum menagerie.

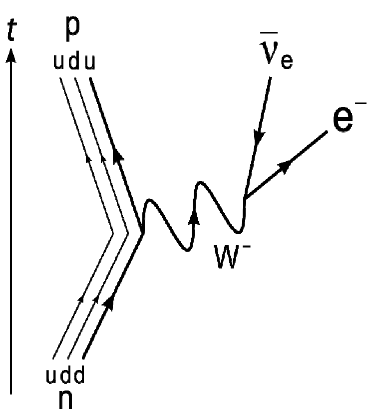
Many of the elementary particles accepted as existing today were 'observed' by accident during high energy, nucleon smashing experiments. Physicists insist on using the word 'observed', though none of these particles are directly observable. We may grasp what is meant by the term 'indirect observation' but it seems oxymoronic. So 'detected' or 'discovered' are my preferred terms, and even those are uncomfortably laden with a sense of certainty. Keep in mind, the more recently 'discovered' particles were predicted by the hypotheses engendered by those earlier discovered—meaning they were specifically sought after and, like the planet Neptune, predicted before being detected, thus lending credence to the 'standard model' and thus widening its acceptance.

As we have seen over the course of our study, however, just because a theory is widely accepted does not mean it is correct—even if it gives dependable results. While a number of problems are solved by the 'advance' into quantum mechanics, difficulties and paradoxes have actually increased along with the number of particles and, subsequently, the number of sub-disciplines—some at odds with the standard model (and with one another)—the latest major development being string theories. So there are more problems to solve now than could have been imagined before the new paradigm (Thomas Kuhn's terminology) emerged. In fact questions seem to multiply much faster than answers can be posited. We can discuss but few of them here; a few more will be encountered in supplemental reading assignments, but altogether enough, I expect, for us to excuse a number of late 20th century philosopher-scientists for suggesting that the 'new physics' was already in big trouble by the 1980s, and that we are teetering on the brink of yet another paradigm shift. But first:

Feynman during the A-bomb years



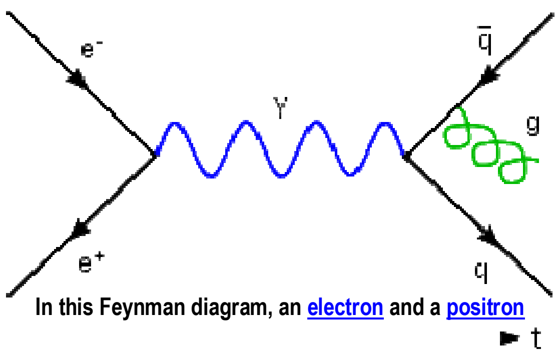
Richard P. Feynman [1918-1988], in the 1960s, found still another version of quantum mechanics, which he called 'sum over possibilities' or 'sum over histories' (depending, I suppose, on whether you view a given quantum event from before or after), a.k.a., the 'path integral formulation': the basis of quantum electro-dynamics (QED), for which he was awarded a Nobel Prize. In connection with this he also developed the '**Feynman diagrams**': cartoon-like visualizations of what happens to individual particles during their transformations via high energy collisions—their spin states, duration of existence, how they decay or split and recombine or morph into other sorts of quantum stuff such that energy and mass is 'conserved' (but only eventually and by complicated temporary, albeit practically instantaneous, *violations of the first law*), or perhaps the proper term would be 'reinstated' rather than conserved.



Feynman was also involved in the atomic bomb work, though as a junior physicist he was not critical to its development. Still he was greatly depressed for several months after its success. He expected that it would be used fairly soon again, that even greater bombs would be developed, and that the world would thus be brought to ruin so that it made no sense to continue to work toward future improvement.

After the war, Feynman turned down offers from Princeton to join the several luminaries at the Institute for Advanced Study: Einstein, Gödel, and John von Neumann, etc. Instead he took a teaching position at Cornell, later going to Caltech where he disputed the quark concept of Murray Gell-Mann, advancing his own 'parton' ideas, losing that battle but giving impetus and refinement to a new theory, or sub-theory, called *quark chromo-dynamics* (QCD), and foreseeing the idea of what are now called gluons: electrically neutral sub-particles, the interchanging of which was hypothesized to explain the force holding the quarks permanently together to form a nucleon (proton or neutron).

This exchange-of-force concept is just one of many thoroughly mechanistic hangovers in quantum physics, here involving the idea that fields consist of 'force-carrier particles' [*see* http://en.wikipedia.org/wiki/Exchange_force; p.1] rushing back and forth, as if weaving, perhaps out of their intertwining wave functions, a sort of elastic fabric between the nucleons that form an atomic nucleus, or such as photons being exchanged between electrons in an attempt to explain the electromagnetic force and, as mentioned, quarks exchanging gluons illustrating the 'strong force'.

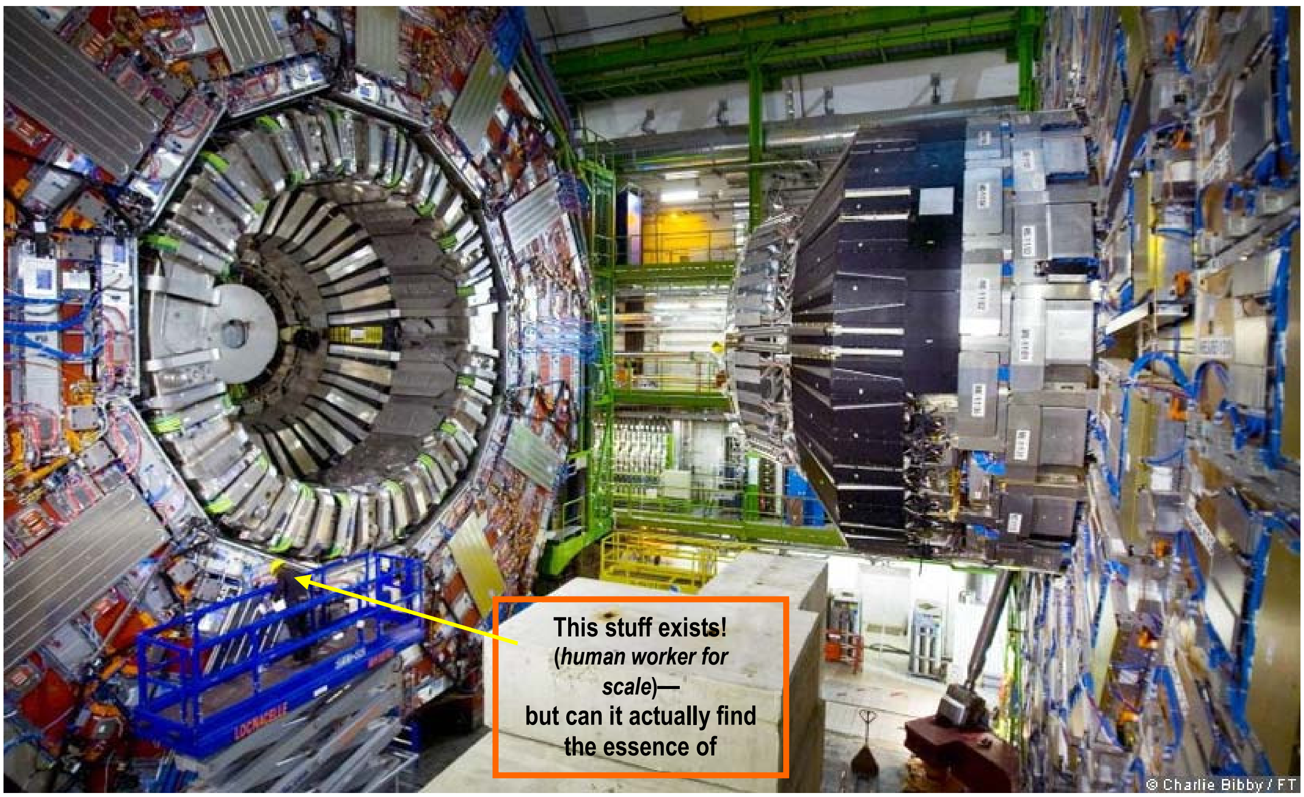


In this Feynman diagram, an electron and a positron annihilate, producing a virtual photon that becomes a quark-antiquark pair. Then one radiates a gluon.

At the extremes of scale, however, the particle exchange idea seems wrong—though, admittedly, much of quantum mechanics seems physically impossible. At the tiniest level the quarks cannot be separated—the 'force' (far from intuitively) proportionally *increasing* in this case rather than decreasing with distance. By this logic, the quarks must be always touching such that, theoretically, there would be little or no room for gluons, however tiny, to fit, let alone to be exchanged between them. At the largest scale, the exchange of particles idea, it would seem, is a major barrier in the attempt to quantize the force of gravity (i.e., reconcile quantum mechanics and the general theory of relativity) because the force-exchange scenario requires exchanging 'gravitons' or 'gravitini' between macro-objects in space. Counterintuitive as it seems, this is still generally accepted as part of the standard model. Such an exchange, however, is especially difficult to imagine over vast astronomical distances and, presumably, would also be subjected to the limitations of the speed of light, such that gravity would be active in the 'apparent' world of the present instant (thus feigning instantaneous occurrence, the fluxuations of which would be perceived immediately across the enormous gaps of space) rather than emerging from the 'true' world of the past (a world that is delayed in perception from nanoseconds to billions of light years, depending on the distance between any two interacting objects, and of course there are never only two).

We will get to an explanation of this newly introduced problem (*true* worlds versus *observed* worlds) in a future discussion, though you may already have generated the right idea about the difference by recalling the non-simultaneity diagram introduced in the lecture on the special theory of relativity. But put that aside for now, and consider this: the most advanced mathematicians with their super-computers cannot solve the 3-

body problem in macro-physics—as simple as Sun, Moon, and Earth, and a formula that will accurately predict their future relative positions. That is because the system is dynamic: continually changing, albeit slightly, over time, such as to remain just barely yet infinitely unpredictable (not to mention the mixed influences cast by countless other bodies and systems near and far). How, then, can we expect a solution to the *multi*-body problems (not to mention *entanglement*) in the mysterious 'intercommunication', as it were, of physical objects—objects occurring in close enough array (in accordance with these new theories concerning the very least of fundamental particles) to form macroscopic matter and interacting with all other such objects at other locations in space: particularly those greatest, most diverse, and distant galactic assemblies?



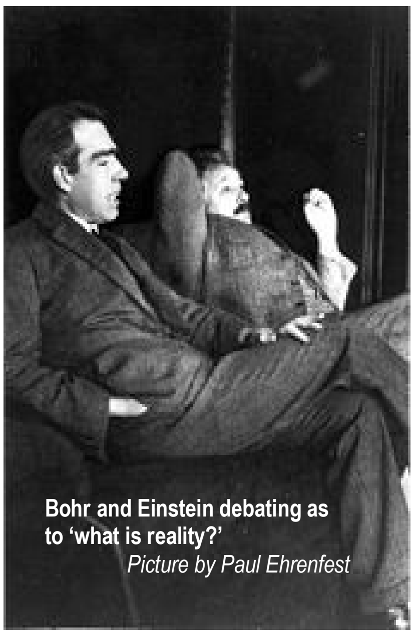
This is not at all a neat picture. If Einstein's equations had turned out this murky he might have abandoned relativity theory. It was their beauty and symmetry that first appealed to the artist-physicist-philosopher, and then to the world, as though the theory suggested by such beauty of mathematics simply must be right; thus worth exploring deeply. But somehow the quantum world resists reconciliation with the relativity system. Which, if either, is correct—or closest to correct? It seems to depend on what level you are investigating.

Despite its queer paradoxes in real-world logic, *quantum electrodynamics* stands experimentally firm in the sub-microcosmos, but leaves much to be desired in explaining the macroworld (which is still most conveniently understood via classical physics), unnecessarily complicating and even defying our intuition, and it completely breaks down when applied to the wider cosmos, where gravity (whatever that might be) governs.

In spite of its hopeful claim to generality, the *general theory of relativity*, with its non-intuitive version of gravity as 'warping of spacetime' by presence of astro-masses, is best suited to cosmic levels, 'explaining' coherence of galaxies and contracting neutron stars and the ultimate gravitational victory: black holes. But Einstein's gravity is confusing rather than helpful as we approach quantumland, where motion typically approaches the velocity of light; where electromagnetism and the strong and weak forces compete and rule; where there is very little mass; where gravity is ineffective—inconsequential, at least, and to such degree as to warrant dropping it out of the equations altogether; as if it were non-existent—and so *it is non-existent in quantumland*. Or is it?

EPR; Schrödinger's Cat; Bell's Inequality; Entanglement

The growing difficulties with the quantum picture and its incompatibility with the general theory of relativity served to strengthen Einstein's contention that quantum mechanics is incomplete, thus energizing his search for an encompassing concept: the completion of general relativity as the Grand Unifying Theory (GUT). He and Bohr never tired of the debate, the most famous bout of which is recalled by the **Einstein-Podolsky-Rosen** (**EPR**) paper. This problem is central to the quantum crisis. I say 'crisis', but it may not be seen so by the majority of today's theoretical physicists. The question, in any case, is not whether quantum mechanics is true, since no theories are true. But whether reason can be trusted; whether physics itself is finished as an explanation of nature, having led by its own logic into *terra incognito*.



Bohr and Einstein debating as to 'what is reality?'
Picture by Paul Ehrenfest

Physics is about cause-and-effect materialism, thus determinism. Quantum mechanics, despite Feynman's illustrations of its dynamics as a kind of physics in his cartoons of transmogrifying particles, has stepped past cause-and-effect, beyond materialism. Here locality breaks down, paradox is rampant, and the whole discipline of physics is defiled. No wonder the terminology of physics fails in all attempts to explain it. No wonder the 'last realist' in physics so vigorously opposed it. In short, facts such as 'nuclear bombs work' and high-tech electronics are enhanced by quantum effects do not validate quantum mechanics, they only confirm that *its assumptions and correlates are reliable* to the degree they can be utilized and have a distinct effect on the material world (no matter how illogical they may seem in relation to the physical science that led to their discovery).

For Einstein, ideas may have been acceptable as a sort of meta-force crossing over the barrier between the thought-world and the matter-world, making their impact through humans taking action in their behalf, thus still preserving a chain of causes even into the realm of pure reason. You have an idea for a machine, draw it up, gather the raw materials and build it; if you have a business in mind, gather investors, raise the capital, incorporate, and thus alter the world. But principles are derived *after* the fact. How could principles (pure mind-stuff) create and sustain the Universe of physical reality before there were minds to 'discover' them?—even before there was a universe?

From Bohr's perspective, Einstein's problem was that he believed too strongly in real stuff and thought that matter was something irreducible at bottom; as if Kant's 'things in themselves' might actually be found out. The new physicists, little by little, were letting go of that as a final goal. Most of them felt sad about Einstein: sad that he could not free himself of the prejudice of the old physics; sorry that he would not join their revels in the quantum abyss and perhaps help lead them through it, as it was he who had led them into it. Instead, Einstein was doing all he could to draw them out of the quicksand they were romping through, even if he had to pull them out rationally. If he could not actually find the GUT himself, based on his general theory of relativity, he ought at least to be able to prove that quantum mechanics was logically incomplete—and doomed, thereby, as a basis for a Theory of Everything (TOE). Maybe that explains why his favorite companion on his frequent contemplation-walks at Princeton was Kurt Gödel, the mathematician famous for his incompleteness theorem.

In 1935 (probably before Einstein met Gödel) a paper "Can Quantum Mechanical Description of Physical Reality Be Considered Complete?" was published in PHYSICAL REVIEW, co-authored by Einstein, Boris Podolsky, and Nathan Rosen (thus: 'EPR'. The latter two were post-doctoral research assistants at Princeton's Institute for Advanced Study). The paper discussed a hypothetical case where two quantum events—sub-particles of some sort or 'quantum systems'—two photons for instance, interact in such a way as to form a larger system or whole. The interaction is well known to physicists as *quantum entanglement* and produces a seemingly paradoxical situation whereby action on one (formerly separate) part of the new system—such as a measurement of position or momentum—not only changes the state of the measured sub-system (photon A), but also identically alters the state of the unmeasured sub-system (B). This entanglement of the two formerly independent quantum systems or particles endures even if A and B are separated by enormous distance, apparently violating the principle prohibiting action at a distance (Mach seemingly vindicated), and it does so instantaneously, violating even the absolute speed of light (which prohibits the *instantaneous* exchange of information between systems separated in spacetime), or it cancels the principle of locality altogether.

Now this entangled system, Einstein thought, must have an initial state of existence that could be at least partially described by the 'spin' or polarity or position or momentum of its constituent subsystems—what is called in quantum mechanics 'eigenstate'. According to quantum mechanics, to know the eigenstate of entangled subsystem A is to know the eigenstate of subsystem B. Furthermore, in the quantum realm, until some measurement is taken, a given system whose state is unknown (unmeasured or unobserved) is said rather to have no state because it is indeterminable. Its initial state, in fact, remains indeterminable because to measure something is to alter it. However, if A and B are entangled, to alter A is to alter B in exactly the same way (or in the opposite way, depending on the type of entanglement or method of measurement; i.e., a correlation exists), but without directly interacting with B. Quantum Mechanics predicts this strange behavior and experiments with splitting entangled photons and setting them off in different directions have been convincing. But with no possibility of verification without conducting a continuous measurement or observation of the moving particles—i.e., by interaction with the particle's trajectory (if it can be said to have a trajectory)—there is no way of proving that these wave-particle sort of things actually exist, let alone to know what state they might be in before observation or measurement.

Could photons and electrons be non-existent until observed or interacted with? "Yes" seems the answer of quantum mechanics as explained in the powder keg thought-experiment conceived by Einstein and in the more famous concern over Schrödinger's cat. The idea behind both scenarios is the same [and both are described in the HANDOUT: "The Einstein-Podolsky-Rosen Argument in Quantum Theory" *from the* STANFORD ENCYCLOPEDIA OF PHILOSOPHY; http://plato.stanford.edu/entries/qt-epr/]. We will entertain here only the more famous version, recalling once again the entangled fate of Schrödinger's cat.

This is, of course, a thought experiment where no animal is injured or dispatched. A tiny lump of some particular material with a long half-life is placed in an opaque box, along with a capsule of cyanide and a live (albeit imaginary) cat. A Geiger counter or some form of radiation detector is installed in the box so as to register any radiation that might be generated by the material. The detector is connected to a device that will, upon detection of the radiation, act to crush the capsule and release the poison to kill the cat. An opaque cover is fastened over the box and the whole experiment—now, in the quantum sense, an entangled system—is set aside for, say, half-an-hour.

We know radiation is a random event, predictable only statistically on the basis of billions of probable events. The 'half-life' of a given substance is based on this absolutely dependable, non-fluctuating rhythm of radiation. If, however, the amount of such material is reduced to such small volume that there will be, say, only a few thousand total such possible events—or a few hundred—or even a single atom liable to emit a single photon (a single coin flip)—it could be an hour before such an event will take place—and, even were there several atoms (but not thousands or millions), a number of such events might occur without being detected by equipment that cannot be 100% accurate. On the other hand, the emission could happen at the very beginning of the experiment. Thus the expectation that a detector will register such quantum event within a certain period of time—a period shorter than its half-life—is equal to the expectation that it will wait past the established half-life of the element used. So it is equally as likely that the cat will survive its half-hour in the box as that it will be poisoned and die. Once the experiment is underway (i.e., the device is armed and the box covered), all elements of the experiment are, per the quantists, now 'entangled' to form a new system, the state of which is undeterminable. As long as the box remains closed, its contents can be envisioned as quasi-existing in a realm of sheer probability.

If we could know only the state of the detector inside, or the state of the cyanide capsule, we would know the state of the cat. In other words, by gaining such knowledge the probability wave function would be 'collapsed' into a certainty: a known state of affairs. Likewise if we could know whether the cat is dead or alive at any given moment, we could infer with certainty the state of the capsule and/or the state of the radiation detector at that moment. But to know *anything* about the state of the system, the box must be opened or, perhaps, X-rayed—i.e., an observation or measurement must, in some way, be made and the probability wave thus collapsed into reality. Until that is accomplished, in the view of quantum mechanics, the system remains in a state of sheer probability: the cat is somehow suspended between life and death or, more precisely, is in a combination of both states. Or, more radically, *there is no system* when it is not being observed or when it is not somehow involved in an interaction with some other, outside system. It must not only 'emit' information, there must be some 'other's' absorption or reception of that information regarding its state (i.e., it need not be a *conscious* exchange—though even here disagreement reigns). That seemed laughable to Einstein and Schrödinger.

Here is the old conundrum: 'If a tree falls in the forest where no one exists to hear it, does it make a noise?'—or is there a tree at all, or even a forest? It is as if the enclosed radium/poison/cat system is in both states or in multiple states, simultaneously, or to all intents and purposes is entirely non-existent while unobserved. The latter conclusion is, I suppose, commonly considered the least likely (or least logical) since we know these several elements actually existed when we put them in the box, so we presume that they continue in some sort of, albeit indefinable, 'existence' during the time they are hidden. Still, existence is a state and we cannot be certain of this new system's 'eigenstate'—thus it cannot be said to actually have a state or to be in a state. To get right down into quantumness: Do photons or electrons (being directly unobservable) actually exist or have an 'eigenstate' if not somehow 'detected'; if their probability waves are not collapsed? This has been seen as solving (in a quite unsatisfactory manner, to my mind) the wave-particle duality: a quantum thing, which we might refer to, unofficially, as a 'quant' or a 'quon', is *neither particle nor wave* until it is measured or detected. To simplify: To exist is to be in some state and to have a location. To have no state or place is, therefore, to lack existence; or, to rephrase: only non-existence or nothingness can have no state and 'be' nowhere (or everywhere). But the fallacy in the quantum argument seems apparent: to have an unknown, even an undeterminable state is not the same as having no state; total ignorance of something in the macro-world, even permanently, even if knowledge of it is forever prevented, does not preclude its existence. Its state and/or location is only in doubt, not *unreal*. But not so in quantumland.

This, then, is the crux of the quantum problem and the major point made by the EPR paper, but made so obscurely by Podolsky, who was given the task of writing up the argument, that it required further explanation by Einstein in various letters to his peers (including Schrödinger). This confusion or obscurity of meaning seems to have been part of the problem with Bohr's reply to EPR. In his rejoinder he misinterprets the EPR argument, creating a kind of straw man which he then knocks down. Bohr's straw man was so well formed, however, that, like Pinocchio, it came to life, replacing in the general mindset the actual argument of the EPR paper. That is to say the EPR presentation has been *generally* misconstrued in the same way Bohr *specifically* but improperly reconstructed it in his rebuttal instead of the way Einstein, Pololsky, and Rosen intended. Thus, in re-examining the debate, the dispute re-emerges; not only is the question left unanswered but the exact argument of the EPR paper itself remains unresolved—that is to say the struggle is incomplete over whether on not quantum mechanics is incomplete; perhaps hopelessly so. A much more coherent explanation than what I have offered concerning the difficulties involved in this prickly notion will be found in an article relating to EPR appearing in the on-line STANFORD ENCYCLOPEDIA OF PHILOSOPHY [cited below for supplementary reading], so we will not pursue it further here.

HANDOUT:

Article: "The Einstein-Podolsy-Rosen Argument in Quantum Theory" *from the* STANFORD ENCYCLOPEDIA OF PHILOSOPHY (http://plato.stanford.edu/entries/qt-epr/)

This must have seemed a peculiar vision at that time—still does: a world in every state and no state, its parts assuming both wave and particle identities, and reality seeming to depend totally on observation. As you might imagine, it caused consternation among the theoretical community. The search for answers will occupy most of our remaining discourse. The stage was certainly set for some 'outside the box' thinking. A young American quantum physicist, **David Bohm** [1917-1992], thought he was up to it. In fact, he thought, thinking might be the problem. In a collaboration with another 'outside the box' thinker, the already somewhat renowned neurophysiologist Karl Pribram, a 'holonomic' brain was modeled. Using quantum principles an attempt was made to explain the brain's operation in the manner of holography, whereby every tiny portion of the brain contains a kind of image of the whole, albeit from its own localized perspective. The brain thus is considered a 'oneness', so to speak: a whole rather than the sum of its parts (entangled system?). This unorthodox view is still respectfully considered, as long as the generally accepted view is not somehow verified or conclusive. But here it is not brain structure or functioning that concerns us, but Bohm's view of thought itself.

I will read to you an extended excerpt from the Bohm bio as found on the internet encyclopedia, *Wikipedia*, having to do with his ideas on thought processing. Before we hear that, however, a brief background sketch of Bohm himself is apropos, which will, in fairness, bolster his credibility. When David Bohm was studying at UC Berkeley, Robert Oppenheimer was working there as a teacher and researcher, and seems to have been Bohm's mentor—or perhaps his Ph.D candidacy committee chairman. Bohm was a brilliant quantum theorist and physicist and author of a book on quantum mechanics that was admired by Einstein; in fact he worked with Einstein at Princeton for a short time. When the A-bomb was being developed, Oppenheimer asked Bohm (still a graduate student at Cal-Berkeley and not yet a Ph.D.) to join that secret program. But because Bohm had been a political activist at Berkeley in pro-communist circles, his security clearance was denied. Some of his research, however, turned out to be critical to the design of the atomic weapon and was instantly classified. That research was done in quest of his Ph.D. and he was now denied access to his own work; denied the right not only to defend his thesis but forbidden even compose it: forbidden, thus, to think further about the very subject he had himself conceived. Oppenheimer managed to convince the university administration that his doctoral degree had been duly earned, so the Ph.D. was awarded, but he was still denied further work at UC Berkeley due to security problems.

After the War, Einstein requested him back at Princeton, but the Second Red Scare was under way and he was blacklisted. Princeton refused to hire him. Summoned by Senator Joe McCarthy, he took the 5th Amendment to avoid ratting out his former comrades. He was arrested, but quickly released. To find work as a physicist-educator after all that notoriety, he had to leave the USA. Later, Oppenheimer, too, would lose his security clearance. All this was likely to have been painful to Einstein but hardly surprising since he had been under FBI investigation himself since arriving in America.

All this has been introduced to establish that Bohm kept company with minds of the highest order and was a highly respected scientist. So, now, what did he think about thought? Here is that promised excerpt:

> Bohm was alarmed by what he considered an increasing imbalance of not only man and nature, but among peoples, as well as people, themselves. Bohm: "So one begins to wonder what is going to happen to the human race. Technology keeps on advancing with greater and greater power, either for good or for destruction."

He goes on to ask:

What is the source of all this trouble? I'm saying that the source is basically in thought. Many people would think that such a statement is crazy, because thought is the one thing we have with which to solve our problems. That's part of our tradition. Yet it looks as if the thing we use to solve our problems with is the source of our problems. It's like going to the doctor and having him make you ill. In fact, in 20% of medical cases we do apparently have that going on. But in the case of thought, it's far over 20%.

In Bohm's view:

...the general tacit assumption in thought is that it's just telling you the way things are and that it's not doing anything - that 'you' are inside there, deciding what to do with the info. But you don't decide what to do with the info. Thought runs you. Thought, however, gives false info that you are running it, that you are the one who controls thought. Whereas actually thought is the one which controls each one of us. Thought is creating divisions out of itself and then saying that they are there naturally. This is another major feature of thought: Thought doesn't know it is doing something and then it struggles against what it is doing. It doesn't want to know that it is doing it. And thought struggles against the results, trying to avoid those unpleasant results while keeping on with that way of thinking. That is what I call "sustained incoherence".

Hasn't Bohm just told us that what he is presenting is the result of "sustained incoherence"? Bohm proposes in his book, *Thought as a System,* a pervasive, systematic nature of thought:

What I mean by "thought" is the whole thing - thought, felt, the body, the whole society sharing thoughts – it's all one process. It is essential for me not to break that up, because it's all one process; somebody else's thoughts becomes my thoughts, and vice versa. Therefore it would be wrong and misleading to break it up into my thoughts, your thoughts, my feelings, these feelings, those feelings... I would say that thought makes what is often called in modern language a system. A system means a set of connected things or parts. But the way people commonly use the word nowadays it means something all of whose parts are mutually interdependent - not only for their mutual action, but for their meaning and for their existence. A corporation is organized as a system - it has this department, that department, that department. They don't have any meaning separately; they only can function together. And also the body is a system. Society is a system in some sense. And so on. Similarly, thought is a system. That system not only includes thoughts, "felts" and feelings, but it includes the state of the body; it includes the whole of society - as thought is passing back and forth between people in a process by which thought evolved from ancient times. A system is constantly engaged in a process of development, change, evolution and structure changes...although there are certain features of the system which become relatively fixed. We call this the structure.... Thought has been constantly evolving and we can't say when that structure began. But with the growth of civilization it has developed a great deal. It was probably very simple thought before civilization, and now it has become very complex and ramified and has much more incoherence than before. Now, I say that this system has a fault in it - a "systematic fault". It is not a fault here, there or here, but it is a fault that is all throughout the system. Can you picture that? It is everywhere and nowhere. You may say "I see a problem here, so I will bring my thoughts to bear on this problem". But "my" thought is part of the system. It has the same fault as the fault I'm trying to look at, or a similar fault. Thought is constantly creating

> *problems that way and then trying to solve them. But as it tries to solve them it makes it worse because it doesn't notice that it's creating them, and the more it thinks, the more problems it creates.* (P. 18-19)
>
> [*from* Wikipedia, the Free Encyclopedia; http://en.wikipedia.org/wiki/Bohm,_D.]

The Pribram-Bohm ideas about the 'holonomic' or holographic brain are too complex to attempt any detailed version of it here without getting entangled, as is were, in the world of holograms—which you are certainly free to explore (simply look it up on Wikipedia, for starters, and follow the suggested readings to gain some insight into the concept of entanglement of ideas). So the holonomic brain concept seems either to have spawned Bohm's idea of universal oneness, or was a kind of by-product of that idea (depending on which view came to him first). His 'wholeness' view of the Universe he called "implicate order": a kind of oneness that seems to include no time element—a sort of frozen totality beyond perceived reality, yet semi-revealed to us by its 'unfolding'—a kind of meta-motion that creates (or that we create by observing) a sense of time passing. Through this holomovement or "unfolding of the implicate order" the world is revealed to us little by little (the only way in which we can perceive it), giving the impression of development and decay (Time) and the aspect of three-dimensional appearance (volume and solidity) including our seeming locality within it. The illusion is based on what has been called a 'block universe': an all-inclusive static but hidden totality-of-being with no past, present, or future—or rather 'past, present, and future' are completely encoded. By its 'unfolding' (from our perspective, as we are incapable of seeing the whole at once), it only *seems* to progress. This is the earliest and most famous formulation of what is called 'hidden variable' theory. Einstein was the chief advocate of the hidden variable idea, arguing in the famous EPR paper that "elements of reality" must be added to quantum mechanics if the problems of entanglement are to be explained without invoking action at a distance or rejecting the last vestige of classical physics, locality itself. Bohm's intent is to eliminate the problems posed by quantum entanglement by, in the largest sense, entangling the Universe as a unit whereby movement and time are illusory; a step by step illusion necessitated by our inability to perceive otherwise.

It is difficult to faithfully describe Bohm's vision. It holds what seem, to my much lower grade thinking equipment, some serious inconsistencies. I.e., in the exchange of conundrums, the inconsistencies of quantum mechanics are 'resolved' by replacing them with the inconsistencies of the implicate order universe. Still, it is entertained seriously by some as an avenue of possible advancement in (or beyond) quantum theory: a possible escape from our present paradox. There are some other suggestions yet to be entertained.

So quantum theory, we have seen, seems to have ushered in (or arisen in conjunction with) William R. Everdell's depiction of modernity: the move toward atomism, separateness, discontinuity, even though the supposedly discrete particles have increased unexpectedly in number. But as it was examined more closely; as it became quantum mechanics and quantum electro-dynamics and quark chromodynamics, etc., the particle view could not be sustained. It was impossible to separate it from the wave and probability view, so that, paradoxically, both had become accepted by quantists. EPR and others, however, refused to allow such paradox into theory. The problems associated with entanglement seemed to some, as for Bohm, to recommend the continuity view, since that seemed more likely to lead to an explanation of the faster than light communication between entangled systems and/or the non-locality difficulty. So Bohm seems to have been led to his holonomic concept by turning back toward continuity in the attempt to escape from the irresolvable dualism promoted by Bohr and his quantist followers. Did David Bohm recognize the connection to Descartes' 'mind-body' duality in the 'particle-wave' paradox? It seems likely that is what brought him to the holonomic brain concept as well as the unity of thought and 'implicate order' ideas.

Influenced by Einstein, he attempted to preserve an ultimate reality: an objective 'out-there', albeit in a higher, inconceivable dimension—a transcendental pseudo-existence or fundamental state of being or super-being or potential being. Kant's things-in-themselves become, for Bohm, the universal Thing-in-Itself, which we can still never directly perceive or fully know, but of which we can catch glimpses as it unfolds for each of us. Thus reality can be both *subjective* (specifically processed by each perceiver's mind and/or detected by discretion oriented technology) *and objective* (actually 'there', *being* in its complete oneness: the All; extant, but beyond any particular sensibility).

Furthermore, in Bohm's version of thought, there seem to be problems or 'faults' in our thinking that we control thought, when in fact Thought—a kind of universal mind, apparently—is in control. So there is no room for free will. Everything is already fulfilled in the 'implicate order'. While quantum mechanics gave us predictable accuracy in dealing with billions of events through statistics, specific quantum events were left unpredictable, leaving some uncertainty or indeterminacy—perhaps leaving room for free will. But with 'Bohm mechanics' complete predetermination is revived by his implicate order. Furthermore, what we see and think and feel is a gross distortion and the tiniest fragment of the all-encompassing One. But wait!—Isn't the All 'something?' Mustn't it, then, have a beginning and an end?—thus a direction; evolution? It seems it must. If it is orderly, i.e., organized, there ought to be a process of organization as well as disorganization. Or is it simply infinite chaos unfolding: meaningless random and unconnected drivel to which we supply the order? Yet it seems certain that the world is much too orderly for it to depend upon our poor powers of sensibility and intellect to be organizing it into anything coherent—and whence would 'coherence' itself have come?

Perhaps, by now, you are beginning to appreciate what I have been calling the 'crisis of modernity'. What this lecture has been about, at its core, is the attempt of Einstein and his diminishing band of 'neo-realists' to find an explanation of quantum strangeness without burying Newton. Since we are at a stage—perhaps the last stage—of reduction to discrete pieces of matter (if quantum particles can be considered matter, which is what the realists must believe and prove—or at least keep as an unresolved problem that indicates the theoretical incompleteness of quantum mechanics); and since the expected bottom has fallen out of physics by leaving only these ghostly probability waves—suggesting particles are not quite real but merely manifestations of probability functions; and since the material world consists of nothing but various assemblies of these pseudo-particles and sub-particles (if that can have any clear meaning), then the world we live in and think we know is aught but the product of randomness and probable outcomes of wave interference—waves of sheer mathematical probability, no less—so it, too, is illusory; entirely dependant upon us, as observers, to complete it: to make something of it. But we observers are just as illusory as the world we concoct, so we must be concocting ourselves and one another, thus giving each observer his own universe. This is a basis for one of several arguments for what is now referred to as the 'multiverse'. But we will set those ideas aside for the moment, to return to them later.

Now, to avoid opening this Pandora's box too widely, thus allowing the escape of the horde of quantum demons, the realists have taken up the idea of 'hidden reality', placing it rather like a weight on the lid. But it is a weight at least as ghostly as the contents of the quantum box. In this they are clinging to Kant's conclusion that reality is theoretically objective: really existing 'out there' and independent of our knowledge, although unfathomable in its character—thus the term used in such theorizing: "*hidden variable(s)*" (not Kant's term, but so named by moderns). This is a last-ditch attempt to preserve some semblance of reality, for if reality is lost so goes causality; so goes determinism, which miffed Einstein because he saw that classical physics would thus be replaced by a natural randomness, such that predictions could only be based upon probability theory with nothing of solidity backing it. All logic that is based on causal laws is thus falsified. Even though it continues to hold up well enough, practically, in the macro-world, the very foundation of classical physics (the materialist view that propelled the Enlightenment itself) is but a heap of sand—imaginary sand at that!

Worse: If physics is dead or falsified, what then of all the modern science branches that have sprouted from that great trunk of such seeming certainty and solidity? And yet we hear that quantum mechanics holds the theoretical world record for prediction. But that is because what it predicts are the macro-outcomes of billions upon billions of micro and sub-micro 'events' that, individually, cannot be predicted at all: a systemization of randomness or, as Ilya Prigogine and Isabelle Stengers more recently argued: ORDER OUT OF CHAOS [Bantam Books, NY, 1984].

Not so fast, say EP&R: chaos and randomness can't be the climax and final bow of reason. That must be proved, not merely assumed in a theory. The world would be a casino!—prompting Einstein to declare his faith that 'God does not play dice'. There must be an unknown cause of these quantum events; a cause we simply cannot know: an underlying reality we haven't discovered. The burden, however (in accordance with physics), lies with quantists to explain or find this hidden reality or to admit their theory is incomplete. If the state or, even more deeply, the true nature of each and every quon or sub-atomic 'thing' were known, argue the realists, entire systems could be modeled and would thus be seen as causative and determined—just like classical physics. We cannot have such extensive knowledge, of course. But even if complete knowledge (or any) is impossible in real time, it still makes sense *theoretically*. In other words, the fact that this knowledge is denied does not mean there is no reality; only that it is hidden.

To deny it merely because we cannot know it, as Bohr does with his Copenhagen interpretation, and thus to overturn all of physics on a guess is anathema to the realists. So attempts are made to establish these 'hidden variables': reality-based theories that can still match the odd predictions and events of quantum mechanics, which is what David Bohm has given us with his 'implicate order'. The knock against Bohmian wholism is that the hidden variables of causality have been made *non-local*—transcendental—which they must be, it seems, in order to avoid the entanglement difficulties requiring instantaneous information sharing. Admitting non-locality, however, is considered a kind of fudging by neo-realists, as it, too, distorts the classical idea of interaction by direct contact and substitutes a kind of central planning scheme, whereby the underlying realism is completely predesigned—as if it were God's plan (and if there is no God, as seems to be the widely accepted view of purist physicists, it still represents, theoretically, a sort of atheistic Calvinism: the world is entirely pre-ordained).

Initially taking the side of Einstein there came an Irish physicist **John Stuart Bell** [1928-1990]. After working on the design for CERN's first particle accelerator, the Proton Synchrotron, and examining the EPR paper, he returned to Birmingham University to attain his Ph.D. in elementary particle physics. He then moved with his wife, Mary, also a physicist, back to CERN where they both continued working on accelerator design. Motivated by EPR and mulling over the entanglement problem, he published, in 1964, what some believe to be the most important paper in theoretical physics for the previous two decades: *On the Einstein Podolsky Rosen Paradox*. He also knew of Bohm's work and the unfolding of the 'implicate order' idea in connection with his holonomic universe, he understood that it was a *non-local* hidden variable theory. But he hoped to find a way to explain quantum mechanics through a *local* hidden variable route—thus to validate Einstein and realism. Even if proved impossible, there must, he thought, be a boundary of some sort between the quantum world and the macro-world—a line of demarcation between the dream-realm of probability out of randomness and the real world of causal physics. Perhaps he could find that border, at least mathematically. "A possibility is that we find exactly where the boundary lies," he hoped, but:

> More plausible to me is that we will find that there is no boundary. …The wave functions would prove to be a provisional or incomplete description of the quantum-mechanical part, of which an objective account would become possible. It is this possibility, of a homogeneous account of the world, which is for me the chief motivation of the study of the so-called 'hidden variable' possibility.

Instead,

> We will find, in fact, that no local deterministic hidden variable theory can reproduce all the experimental predictions of quantum mechanics. This opens the possibility of bringing the question into the experimental domain, by trying to approximate as well as possible the idealized situations in which local hidden variables and quantum mechanics cannot agree.

[*quotes from* Bell's book, SPEAKABLE AND UNSPEAKABLE IN QUANTUM MECHANICS; Cambridge Univ. Press, 2004 edition; p.29-30; *found in* http://en.wikipedia.org/wiki/Bell%27s theorem]

What he discovered is called the "Bell inequality". It means that there will be—*must* be, in accordance with probability per classical physics—a certain level or average of 'inequality' between the measurements taken on separated systems. A certain number of measurements will show two systems as existing in the same state or in opposite states or in between states, thus 'inequalities' (as opposed to correlations) will surface at an expected rate—as in side-by-side coin flipping. Thus he laid out the possibility of experiments to establish these expected inequalities and to test them against quantum predictions. Theoretically it seemed that quantum predictions would 'violate' the otherwise expected, classically based 'inequalities'. Thus **Bell's Theorem** (which renowned theoretical physicist Henry Stapp has called "the most profound in science"): *No physical theory of local hidden variables can reproduce all the predictions of quantum mechanics*. So science has reached its explanatory limit: physics is dead-ended.

A decade later, ways were found to try some of these experiments, which showed entangled quantum systems regularly violate 'Bell's inequality'; that entangled quon-systems are somehow correlated to a degree that cannot be explained by classical probability calculations, even when those sub-particles or quantum elements are widely separated. Even so, there are ‘loopholes’ and certain unwarranted assumptions in connection with these experiments, not to mention detection imperfectabilities [e.g., not all light signals have the same detection probability], etc. So the controversy is not settled and looks as if it is not conducive to any final resolution. But, say the Wikipedia editors,

> Most advocates of the hidden variables idea believe that experiments have ruled out local hidden variables. They are ready to give up locality, explaining the violation of Bell's inequality by means of a "non-local" hidden variables theory, in which the particles exchange information about their states. This is the basis of the Bohm interpretation of quantum mechanics, which requires that all particles in the Universe be able to instantaneously exchange information with all others.
> [http://en.wikipedia.org/wiki/Bell%27s theorem; *subsection*: ‘Theoretical Challenges”]

This is not quite accurate and somewhat misleading. As we have discussed above, according to Bohm’s holism, the whole exchange of information scenario is a misconception due to limitations of our understanding as human observers—limited, that is, to experiencing events as occurring over time. Holism has it that all such *seeming* activity is, as it were, encoded in the implicate order. Thus there is no activity and no exchange—no interactions at all. Past, present, and future are merely our creations according to the way our minds work: the way in which we connect to the implicate order; our way of ordering piecemeal what is already complete. Bohm’s entire universe is, in a sense, entangled in a kind of super-dimension: a sort of Kantian transcendental realm, the wholeness of which, due to our aforesaid limitations in perception, is denied us. The static and timeless singularity of this concept prevents questions of beginnings and endings and any sort of process or how it came to be because it claims to encompass all such things. It is Everything. But words like “encompass” and “Everything” and “existing”—even ‘*it*’—are forbidden. Description is impossible—even mathematically. Bohm’s solution, then, implies Wittgenstein’s notion that when we are speaking of the unspeakable we must cease speaking.

But, also like Wittgenstein, we are unable to stop speaking about the unspeakable, since we must now speak about Bohm’s opposite: the ‘many worlds’ conception of **Hugh Everett III** [1930-1982]. What could be the opposite of infinite oneness? Well, it could be seen as nothingness. Another way, however, is to see Oneness as in the middle between nothingness and everythingness. Everett solves the hidden variables problem by allowing *all* the variables *all the time*. All of the possible quantum things are considered to actually exist in all their possible states in simultaneously parallel universes. The state we observe is merely the one that exists in the particular universe we momentarily share. On a macro level, all possible changes available in any present universe, meaning all possible outcomes of every accident and every one of the choices we are offered to what seems to us to be our ‘free will’ actually take place in all other possible universes. Thus all possible universes and all possible evolutions of all universes always happen and continue to evolve, although we only find ourselves in one of them. Absurd as this is to common sense, requiring infinite universes because it works out mathematically in solving the entanglement problem, this—or some semblance of it, due to ever increasing variations of this ‘multiverse’ concept—is now in the forefront of 21st century cosmic ‘understanding’. This is the current view (if it can be called such); the ‘understanding’ our leading scientific thinkers are now offering as ‘what we know to be true’. We will have more to say about this in future discussions.

HANDOUT:

Article: "The Einstein-Podolsy-Rosen Argument in Quantum Theory" *from the* STANFORD ENCYCLOPEDIA OF PHILOSOPHY (http://plato.stanford.edu/entries/qt-epr/)

ALSO

At the following website address you will find a list of known and hypothesized particles and subparticles, and an interactive chart explaining how they supposedly interact to create or to project, our apparent reality:

http://www.thingsmadethinkable.com/item/elementary_particles.php

Also see Additional HANDOUTS *accompanying this lecture from* Wikipedia *and the reading from* Douglas Hofstadter's METAMAGICAL THEMAS:
An Interlocked Collection of Literary, Scientific, & Artistic Studies;
Basic Books, NY, 1985; pp.425-477

PLUS

Ch.1, *A Brush with Schrodinger's Cat* (*introduction to*) THEORY OF NOTHING;
Russell K. Standish; BookSurge LLC; http://booksurge.com ; pp.1-19

AND

The Distance Scale[s] *of the Universe from*
http://www.atlasofthe universe.com/redshift.html