5. The Field of Physics

The existing scientific concepts cover always only a very limited part of reality, and the other part that has not yet been understood is infinite. Whenever we proceed from the known into the unknown we may hope to understand, but we may have to learn at the same time a new meaning of the word 'understanding'.
—Werner Heisenberg

"Ideas come from space. This may seem impossible and hard to believe but it's true."
—Thomas Edison

The essential reality is a set of fields.
—Steven Weinberg

I have coined the term 'bisociation' in order to make a distinction between the routine skills of thinking on a single 'plane', as it were, and the creative act, which, as I shall try to show, always operates on more than one plane.
—Arthur Koestler

Dean: Welcome everyone. Look at this bright sun shining in on us today, reflecting on the metallic edges of the chairs. And notice the back and forth play of shadows the light makes. It's an unusually beautiful day, and we are going to bring a new light to our study of evolution this hour with the help of very special guests. We have a specialist from the physics department, Professor Rein Watson whose work is unique. Professor Hawking recommended him as the key colleague in his department who could to talk to us about physics in evolution. You could also say that he leans toward our interdisciplinary way of thinking.

Professor Watson graduated from Princeton University and specializes in particle phenomenology, and also, let me see, what other specialties? *(looking at notes):* "broken symmetries; the foundations of quantum mechanics; non-Western and Medieval scientific traditions; the role of history and philosophy of science in physics education; the role of science in liberal education; the connection between science and religion." Welcome! *(to Prof. Watson)*

And we also have his top graduate assistant, Stewart Perry, to speak on physics and the arts. Mr. Perry is finishing his doctoral dissertation on this subject. So, we have a very promising session ahead.

The Dean does not know that Mr. Perry has spent time in a hospital suffering from schizophrenia. Years ago he had had auditory hallucinations, a few bizarre delusions and disorganized speech, but he has since been recovering very well and is dedicated to graduate studies. His experience with what psychiatrists call "disassociation" had led him to his dissertation. Mr. Perry is studying theoretical physics and artistic structures.

Professor Watson believes Stewart Perry is brilliant, and all tests show this to be true. There is a *radiance shining through this young man, and Prof. Watson is impressed by his creativity.*[1]

Dean: Prof. Watson, I suggested before class that you might give us a brief version of how physics evolved. This helps students ask questions about how your field is connected to evolution. But could you start us off first with a brief definition of physics? Make it simple so that we can understand.

Prof. Thank you. I am so glad to be here. *(to students)* Please, *do* ask me questions at any point along the way. I know the Dean wants everyone to participate.

Well, here's a brief definition. …

Physics is the science of matter, energy, force, and motion and all their interactions. It covers a vast territory of fields -- like mechanics, acoustics, optics, heat, electricity, magnetism, radiation, atomic structure, nuclear phenomena, and more. We have no theory of evolution but I think we can add some ideas to your study. That's the short version.

The Dean asked me to give you a short history of our field to acquaint you with some of our founders. He said you are studying the question: "Who are we?" A very interesting question![2]

Let me begin our story in ancient times when physics began with philosophy. The Dean told me that you have discussed philosophers like Thales of

Miletus, who said: “All things are full of gods”; and also Aristotle who interpreted his statement as referring to a physical movement within nature.[3]

Aristotle describes physics as a study of matter in motion. The Greek title of one of his treatises refers to "nature" (from the Greek *physis*) as "the ability of something to set itself in motion." Natural things are capable of moving, growing, acquiring qualities, displacing themselves, being born and dying. So Aristotle saw something changing but not evolving in the sense that we think of evolution today. He wondered what the cause and purpose of matter could be. *(Pauses)*

Dean: Aristotle is one of our heroes because he had the ability to think across such vastly different fields, such as ethics, politics, rhetoric, drama, and religion. University fields are so specialized today that few people engage in this kind of near-universal thinking anymore.[4]

Prof. I agree. Physics is so deeply specialized that many of us do not talk to one another. So it has too long a specialized history for me to tell the whole story. I will say that the field began in ancient times when it developed along with arithmetic and astrology.[5]

But let me “fast-forward” and mention the break of physics from religion in the seventeenth century.

This event is most significant for our purposes.[6]
(*The Dean's head nods Yes.*)

Isaac Newton's publication of the *Philosophiae Naturalis Principia Mathematica* in 1687 was a dramatic break from religion. It set physics apart as a secular field and changed its course in history. Others, like Leonhard Euler and Joseph-Louis Comte de Lagrange, and William Rowan Hamilton, followed him in this path, but it was Newton's Law of Gravitation that placed physics on a scientific foundation far apart from the scholasticism of his day.

After Newton, we see seventeenth and eighteenth century scientists such as Robert Boyle, Stephen Gray, and Benjamin Franklin creating a basis to understand electricity. In 1800, Alessandro Volta invented the electric battery, which provided a way to generate a constant electric current. In 1808 John Dalton discovered that atoms of different elements have different weights, and he put forward a scientific theory of the atom. Then Hans Christian Ørsted observed the deflection of a compass needle by a nearby electric current and proposed a connection between electricity and magnetism.[7]

By the early 1830s, Michael Faraday was demonstrating that magnetic fields and electricity could generate each other. He showed how electrostatic phenomena and lightning were all different manifestations of electrical phenomena. In 1831 he advanced the principle of electromagnetic induction and demonstrated how a moving magnet induces an electrical current in a conductor. This laid the basis for developing electric motors and electric generators.[8]

Dean: So, you could say that this study of physics was "taking off" in the 19th century.

Prof.: Well, yes, since we are skipping the early history. In 1864 James Clerk Maxwell proposed equations that described the relation between electricity and magnetism and showed how light is an electromagnetic wave.[9]

Then, toward the end of the century, things really got moving. In 1895, Wilhelm Conrad Röntgen studied X-rays, which turned out to be high frequency electromagnetic radiation. Henri Becquerel discovered radioactivity in 1896, which was then advanced by Pierre and Marie Curie.

In 1897, J. J. Thomson deduced that cathode rays were composed of negatively charged particles, which he later interpreted as electrons. Philipp Lenard then showed that the particles -- ejected in the photoelectric effect -- were the same as those in cathode rays. Their energy was independent of the intensity of the light, but was greater for short wavelengths of the incident light.

In 1895, Henri Poincaré published his *Analysis situs*. This was a systematic treatment of topology, the beginning of algebraic topology. (I should say "topology" is the study of the properties of figures that are independent of size or shape and are not changed by stretching, bending or twisting.) In 1901, his research took different directions, including differential equations and multiple integrals.

During this development, Poincaré was introducing the principle of relativity. He was the first to signal the Lorentz transformations, of which I could speak later, if you like. *(The Dean gives a brief nod.)* He had obtained "perfect invariance" of all of Maxwell's equations, indeed, the final step in the formulation of a theory of special relativity.[10]

Dean: You've listed quite a few of the historical contributions to the development of physics. And now I see a way to bring your presentation of them into our previous discussion. Members of our class have been talking about the meaning of the concept of transformation across a number of disciplines. Could you say something more about these Lorentz transformations?

Prof. The Lorentz transformations were the equations of special relativity, published in 1897 and 1900. These equations convert between two different observers' measurements of space and time, where one observer is in constant motion with respect to the other.

The ability to describe light in electromagnetic terms became a springboard for Albert Einstein's publication of the theory of special relativity in 1905. *(He pauses, wondering how to explain the profundity of this discovery to students.)*

In 1900, Max Planck published his explanation of blackbody radiation. His equation assumed that "radiators" – by that I mean devices that radiate energy -- could be quantized. Quantum mechanics then came indicate the study of mechanical systems at minute or atomic levels, i.e., levels not quantifiable in terms of everyday levels of energy that we thin of as "reality." Planck, Einstein, and Niels Bohr developed quantum theories to explain other experimental results, like the photoelectric effect. You don't have to worry about these details. Bear with me. I'll be saying more about quantum theories shortly, and you students will have a chance to ask questions.

Dean: So, based on what you are saying, and extrapolating for our purposes here, physics builds on previous discoveries one step at a time, as nature does, for example. Could you say that physics is evolving in a way similar to nature?

Prof. Watson: What do you mean?

Dean: Nature evolves one step at a time, creating hydrogen before it can make helium, a prokaryote before it can make a eukaryote. *(Professor Watson looks quizzical, surprised at the Dean's sudden leap in thought, having missed the group's connections in previous discussions*.) Do physicists like Maxwell and Lorentz create their formulas before Einstein can work through his own formulas on relativity? Is Einstein dependent upon them and their work?

Prof. **Watson:** *(gives a quick nod)* Yes, that's true. However, geniuses can make great leaps in thought that jump way ahead of everybody else. Einstein, for example, brought a 20th century revolution in physics. It combined classical mechanics with Maxwell's equations. The theory of special relativity unifies space and time into a single entity, called *spacetime*.[11] *(*"Aha!—a synthesis," *the Dean thinks to himself.)*

At the turn of the 20th century, Einstein's theory of relativity became the new playing field. Einstein discovered "the essential structure of the universe." He said: "When forced to summarize the general theory of relativity in one sentence: Time and space and gravitation have no separate existence from matter…Physical objects are not in space, but these objects are spatially extended. In this way the concept 'empty space' loses its meaning. ... The particle can only appear as a limited region in space in which the field strength or the energy density are particularly high."[12] This changed our whole conception of space and matter. Questions?

Alice: I'm majoring in philosophy. Plato wrote about a world beyond matter. Is the whole universe at the material level in physics?[13]

Prof.: Yes. And it was Plato who also said that the material and the immaterial are not on the same level. But physics is about matter and energy. In this field, nothing exists beyond the physical world. *(He pauses to make sure she understands and goes on.)*

In 1904, J. J. Thomson proposed the first *material* image of the atom, known as the "plum pudding" model.

In 1911, Ernest Rutherford deduced the existence of a compact atomic nucleus, with positively charged constituents called protons.

In 1913 Niels Bohr published the first quantum mechanical model of the atom. Sir W. H. Bragg in the same year began to unravel the arrangement of atoms in crystalline matter by the use of x-ray diffraction.

In 1915, Einstein extended *special relativity* to the *general* theory of *relativity*. Einstein's field equation described the curvature of *spacetime* as the basis of general relativity. This gave Robert Oppenheimer the chance to describe the gravitational collapse into black holes. In 1925 Wolfgang Pauli introduced the notion of quantized spin and fermions. Fermions are particles with a half-integer spin, such as protons and electrons, named after Enrico Fermi. By the 1940s, researchers like George Gamow proposed the Big Bang theory. Today, it is this theory that, in essence, is the foundation of cosmology. [14]

I'm giving highlights of the history, trying to make it brief, but I don't want to leave out questions that students may have for too long. How do you think I am doing?

Dean: *(Looks around.)* Alice is wondering where the "immaterial world" might come into your picture. But without having you go into more fully into explanatory details, I think students are getting the idea of how physics is developing, step-by-step *(several student heads bob)*—which is all we have time for. Please proceed.

Prof.: I believe you have talked in the class about Edwin Hubble publishing his discovery in 1929. Now we know that the universe is expanding at an exponential rate. Over the next several years after Hubble's publication, Werner Heisenberg, Erwin Schrödinger and Paul Dirac formulated a new field called quantum mechanics. In this field, the outcomes of physical measurements were found to be *inherently* probabilistic; I mean everything exists at the level of probability, even the pencil I hold in my hand. The theory describes the calculation of those probabilities at minute scales.

In 1925 Schrödinger formulated "wave mechanics." This offered a method for describing a wide variety of physical situations, such as the particle in a box and the quantum harmonic oscillator. Physics was bubbling with news, and there was public excitement over these discoveries. That same year Heisenberg described an alternative mathematical method, called matrix mechanics, which proved to be equivalent to wave mechanics. *(The Dean is sure students do not grasp terms like "matrix and wave mechanics" but decides not to interrupt.)*

In 1928 Paul Dirac predicted the existence of the positron and founded quantum electrodynamics. Quantum mechanics provided the theoretical tools for "condensed matter physics," whose largest branch is solid state physics, the physical behavior of solids and liquids, including crystal structures, semiconductivity, and superconductivity. The pioneers of condensed matter physics include Felix Bloch, who created a quantum mechanical description of the behavior of electrons in crystal structures in 1928.

I'm sure these terms are too technical. . . .

Dean: Keep going. Hearing about the development of quantum mechanics will fascinate quite a few members of this class.

Prof.: I am approaching the end. In 1928, George Gamow used the concept of "quantum tunneling" to explain alpha decay. Quantum tunneling says that there is a process by which particles can penetrate a potential barrier that has a higher kinetic energy than the particle itself. The principle of quantum tunneling would have important implications for all of particle physics, and as time passed, it developed practical technological applications.

In 1934, Enrico Fermi was bombarding uranium with neutrons and got odd results. At first, nobody could understand what was happening, but Otto Hahn and Lise Meitner figured it out in 1939. It was a process of nuclear fission. The nucleus of uranium was actually being split into two pieces, releasing a big amount of energy in the process. At this point it was clear that this process could produce a massive amount of energy, either for civilian use or as a weapon. *(Pause; Barbara raises her hand.)*

Barbara: Hello, Prof. Watson. I'm in political science, and I was wondering, were patents being filed at the time of these discoveries?

Prof.: The answer is "yes." Leó Szilárd filed a patent on the idea of a nuclear chain reaction. Then in the United States, a team led by Fermi and Szilárd created the first nuclear chain reaction in 1942 in the world's first nuclear reactor. And in 1945 the world's first nuclear explosive was detonated near Alamogordo, New Mexico.

Barbara: Are governments now the primary sponsors of physics? *(She has been concerned for some time about the possible use of nuclear bombs in a world of increasing political volatility.)*

Prof.: Yes, and Robert Oppenheimer, the leader of the Allied project, worried about the consequences of sponsorship by government. The whole world became concerned with those atomic explosions that took place at Hiroshima and Nagasaki during WWII.

Big governments began to fund physics as “basic” research because these findings could be useful to them. Toward the end of the twentieth century, a European collaboration of 20 nations, called CERN, located in Geneva, Switzerland, became the largest particle physics laboratory in the world.[15]

The findings of physics lead into vital civilian uses. For example, a team at Bell Labs -- William Shockley, Walter Brattain and John Bardeen – developed studies on metals, semiconductors and insulators. Out of their work in 1947 came the first transistor and its variations, like the bipolar junction transistor. This led to your computer. *(glances at laptops on desks across the room.)*

More developments took place in the miniaturization of integrated circuits, which produced all of our fast compact computers. These circuits revolutionized the way physics was done; simulations and complex mathematical calculations became possible.[16] *(Pause)*

That's all that I wanted to present as a background to our discussion. Now what about evolution?

Alice: Tell us about quantum mechanics. I've heard that this is the field of study where the material world is tough to defend.

Prof.: The word "quantum" came from a Latin word which means "unit of quantity." It refers to a unit assigned to certain physical quantities, such as the energy of an atom at rest. Physicists discovered that waves have discrete energy packets (called quanta) and that led to a special branch of physics. It deals with atomic and subatomic systems that we call quantum mechanics.

Dean: Does this field differ from regular physics?

Prof. The behavior of systems at atomic scales is different from solids or liquids. Let's see: How can I explain this?

If Newtonian mechanics governed the workings of an atom, electrons would collide with the nucleus, making stable atoms impossible. But the electrons remain in an orbital path around the nucleus. This defies properties of classical electromagnetism.

Some theorists wanted quantum mechanics to be consistent with Einstein's special relativity and began to focus on the problem. This took place in the late 1940s through the work of Richard Feynman, Julian Schwinger, Sin-Itiro Tomonaga, and Freeman Dyson. They formulated the theory of quantum electrodynamics that describes the electromagnetic interaction. This led to modern particle physics, which focuses on the fundamental forces of elementary particles. *(Prof. Watson pauses. He knows that Stewart Perry will be presenting the esoteric side of physics, but he wants the class to know the essential aspects of the "serious" side as well.)*

Dean: You can continue.

Prof.: In the 1950s, Chen Ning Yang and Tsung-Dao Lee discovered "asymmetry" in the decay of a subatomic particle. They showed that parity—that's the symmetry between physical phenomena occurring in right-handed and left-handed coordinate systems -- is violated when certain elementary particles decay. Until their discovery, it had been assumed by physicists that parity symmetry was as universal a law as the conservation of energy or electric charge. Their studies in particle physics earned Yang and Lee the Nobel Prize for Physics.[17]

Dean: I don't really understand these coordinate systems, but keep going. *(smiles, wanting to assure students that he too is lost in many of these details.)* Bring us up to date. Where is physics today?
Prof. Okay. Today, advanced physics demands very expensive equipment. Physicists are creating new systems of classification making this subject more difficult and, I would say, "mysterious." Quantum physics is at the top of the list.
Alice: What are those "bubble chambers"?
Prof. The invention of "bubble chambers" and "spark chambers" in the 1950s made it possible for physicists to discover particles called *hadrons*. Physicists needed some way to classify sub-atomic particles and determine how they interact as fundamental forces in nature. This led physicists to develop *quantum chromodynamics*. This describes the interaction between *quarks* and *gluons*… Well, what can I say?

Everything from galaxies to mountains to molecules is made from quarks and leptons. Quarks behave differently than leptons, and for each kind of matter particle there is a corresponding antimatter particle.

This is more than you need to know for purposes of our discussion. What are your thoughts? *(Looking again at students.)*
Alice: So what about nanotechnology?

Prof.: We are now talking about the control of matter on the atomic and molecular scale, generally 100 nanometers or smaller. We create materials within that size range.
Alice: I heard somebody talking about the danger of fullerenes. What is that all about?
Prof. A Nobel Prize-winning physicist, Richard Smalley of Rice University, discovered carbon nanotubes and fullerenes (or "buckyballs"). They are nanoparticles of carbon, categorized as graphite, but they behave in ways not like graphite. This makes the classification a potentially dangerous one.
Alice: How do we know if it's dangerous?
Prof.: It is being tested...[18]
Dean: Alice is suggesting something important that connects physics to our study of evolution. *(He looks at Prof. Watson more closely.)*

You are now doing what nature does. *You are creating the fundamental structure of the universe*. You are "nature" creating the same things as nature. Nature invents things, such as molecules. Now you are inventing comparable things. I think Alice is saying that you have a lot of power here. What's the next stage of creation in your evolutionary process?

Prof. We now know that all atoms heavier than helium were created in the nuclear furnaces of stars. If the values of some of the fundamental parameters of our universe were a little larger or a little smaller, life could not have arisen. The field is moving fast. I can't predict where it will be going.

Barbara: What do you mean?

Prof. If there are countless different universes with different properties—for example, some with nuclear forces much stronger than in our universe and some with nuclear forces much weaker—then some of those universes will allow the emergence of life and some will not.

Barbara: Wow. Could nanotechnology change the structure of our bodies? What about Genetically Modified Organisms? Are they dangerous? (*Till now, Jane has found it hard to concentrate on the load of information Prof. Watson has been detailing. Now she turns to Barbara, as she shares her concern about the potential danger of GMOs and nuclear bombs.)*

Prof. Some physicists agree. They have organized the Union of Concerned Scientists. Members of this group feel just as you do about possible ramifications from these developments.[19]

Jane: Is physics based on a concern for human life? *(There is a fear in her voice, which adds energy to the current of thought.)*

Prof. Well, look. . . . I understand. *(And he does.)* Physicists are moving into unknown territories. Stay alert with us on these matters. We are indeed *evolving* in new directions. Dark energy constitutes three quarters of the total energy of the universe.

Dean: Let's go back to some points we made in previous classes. Do physicists use metaphors?

Prof.: Yes, they do. All the time. In 1974 Stephen Hawking discovered the spectrum of radiation emanating during the collapse of matter into "black holes." That's a metaphor, the phrase "black holes." These "holes" are still a mystery to us.

Alice: "Black holes." Are there also "white holes"?

Dean: Just to clarify, Professor Watson: the class has talked about "binaries" or "opposites" that keep appearing in this subject of evolution. At our level it is, as you say, particles and anti-particles. So do there white holes exist with black holes, as Alice's question implies?

Prof. Yes. A white hole is the time reversal of a black hole. A black hole acts as a vacuum, sucking up any matter that crosses the horizon of an event, while a white hole acts as a source that ejects matter from its event horizon.

Dean: Do you see other opposites?

Prof. Well. *(Thinking.)* I do see paradoxes. The two themes of the twentieth century, "general relativity" and "quantum mechanics" together constitute a big paradox. General relativity describes the universe on the scale of planets and solar systems; quantum mechanics works on sub-atomic scales. They are like micro- and macro-systems that should correspond with each other. But they do not.

Dean: Does "string theory" help bring them together?

Prof.: String theory is developing as a mathematical approach. Its subjects are one-dimensional extended objects called strings that are unlike the standard model of particle physics. Strings interact in a way that is specified by mathematical self-consistency. It is an attempt to create a verifiable quantum theory of gravity but too complex to discuss for our purposes. Yet one shared property of all these theories is the holographic principle and that's where my assistant, Mr. Perry became interested.

Dean: What's so special about it.

Prof. : String theory would include all older theories of physics. It is the first candidate for the theory of everything. It's a way to describe all the known forces (gravitational, electromagnetic, weak and strong) and matter (quarks and leptons) in a mathematically complete system.

Barbara: Whoa!

Perry: String theory postulates that the smallest constituents of matter are not subatomic particles like the electron but extremely tiny one-dimensional "strings" of energy. These elemental strings can vibrate at different frequencies, like the strings of a violin, and the different modes of vibration correspond to different fundamental particles and forces

Prof: But it has not yet provided experimentally testable predictions.

Dean: If it cannot be tested, it should not be called science.

Prof. Watson: It is theory. It is exotic. String theory suggests that space-time has eleven dimensions as opposed to our three spaces and one time, but the theory can also describe universes with four space-time dimensions as well. All string theories predict the existence of *degrees of freedom* that are usually described as extra dimensions.

Dean: Degrees of freedom! We need to come back to that point.

Prof. Watson: The insight behind string theory is the holographic principle. Holography demands that a low-dimensional theory describing the fluctuations of a horizon will end up describing everything that can fall through, which can be anything at all. So a theory of a black hole horizon is a theory of everything.

Dean: This makes no sense to me. But I hear there are many different string theories.

Prof. Yes. Each describes fluctuations of horizons with different charges and dimensions. So any elementary particle should be thought of as a tiny

vibrating line, rather than as a point. The string can vibrate in different modes just as a guitar string can produce different notes, and every mode appears as a different particle: electron, photon, gluon, etc.
Dean: This is amazing. Can you come back when we talk about music theory?
Prof. We would like to join that discussion..[20]
Dean: Let's get to the nuts and bolts. Do you believe that the humanities and the arts have some connection with physics? If so, how?
Prof. I have asked my assistant Stewart Perry to talk with you about this. He has a double major in physics and art. He will speak to Alice's interest in Plato, the Greek philosopher who divided the world into the material and the immaterial.

Stewart Perry stands up and writes on the board:

The Interplay of Mirrors

Stewart Perry: *(Mr. Perry's right hand trembles as he turns to the class, and his voice is tight as he starts to speak. However, Prof. Watson has great confidence in him. He outperforms all other graduate students in this professor's courses, and if Stewart Perry has any problem speaking, the professor will back him up.)*

Thank you. Well. I'll begin by saying that physicists cannot avoid being the subject of their own inquiry; they look out into the universe and record what they see with a mind and body that was created there. They are involved in their own subject every step of the way; the components of their brain were shaped in the stars they observe; so they are like mirrors of what they see outside.

Dean: *(Interrupts)* You are "tracking us."

Perry: I *have* been following your work. I get reports from students who are in this class.

Dean: So you agree? We are products of a majestic energy that has some profound power in it?

Perry: Yes. The energies of the universe are intricately set in our bodies. Artists and scientists are very much alike in their effort to portray it.

Dean: Really? The inventions of artists and scientists seem so different. What do they have in common?

Perry: First, let's see how physics is linked to your study of evolution. *(He writes on the board:)*

Creativity

(Mr. Perry continues, more confidently.) In his book *The Act of Creation* published in 1964, the novelist-philosopher Arthur Koestler compares art with science. He asks: How are these areas of study alike?

Artists and scientists, he says, are creators who follow the same rules of work *(looking at the blackboard)*. Creativity. Creativity involves bringing different phenomena together into a "new whole," something that is greater than the sum of its parts. *(Members of the class perk up.)*

Koestler coined the term *bisociation* to mean the conjunction of conflicting information. He says it is the capacity for being "double-minded" or to be able to think on more than one plane simultaneously. Every creative act involves *bisociation* – the combination of previously unrelated ideas.[21]

Dean: Bisociation! It sounds like a term that fits what we have been talking about.

Perry: Koestler distinguishes “bisociation” from “association.” “Association” refers to previous connections that the mind makes among ideas in the past. It does not refer to the creation of entirely new connections. “Bisociation,” on the other hand, does make new connections. It combines separate ideas and situations and becomes an act of creation. It is an invention, comparable to the metaphor.[22]

Dean: That’s it! *(Prof. Watson nods his head as though to say, “Of course, we already understand what you are doing.”)*

Perry: Yes. Bisociation requires perceiving a situation or idea in two self-consistent but “mutually incompatible frames of reference.” Koestler argues that creative scientists such as Darwin, Einstein, and Poincaré -- along with the great novelists and poets -- do not *produce* without following this rule of creativity.

Dean: I will put Koestler's book into my reading assignment for this class.
Perry: Koestler says geniuses can hold one problem persistently in mind-- for weeks, months or years. And during this time it becomes associated with thousands of other ideas and impressions. Sooner or later, one of those ideas "clicks" with the residing problem and *Boom,* a solution emerges.

Koestler goes on to say that 'wholes' and 'parts' do not exist in an absolute sense; what is a whole on one level of a hierarchy, is part of a larger whole on another level of hierarchy. So he proposed the word *holon* to describe the relationship existing between parts and wholes. Think about the letters in a word -- and the word as a whole. (*He looks around at students and waits for someone to speak.)*

Jerry: The *letters* in a word are parts of the whole *word*. Then the word is part of a whole *sentence*. Then sentences are parts of whole *paragraphs,* and so on...*Uh*… Each *letter* is a *holon* in the larger scheme of a word, and so on. Eventually we get to a whole language.

Perry: Ah! Great! Now we are thinking together. Listen:

If you want to have a language, you need an alphabet, and if you want to build proteins, you need amino acids. If you want to build a molecule, you

need atomic elements. “Elements” are the letters in the formation of molecules. Is that clear?
Jerry: Yes, I get it.
Perry: In physics, there are around 106 elements. About 92 are made by nature and humans make the rest. The natural elements include oxygen, sulfur, carbon, copper, etc. Physicists are now adding new ingredients to the alphabet soup.
Jerry: So, physicists are doing what nature does, making the molecule soup bigger.
Perry: Yes. And they are all chains of holons. You can see this holon relationship in mathematics as fractals, like the Mandelbrot set. Koestler said these chains of *holons* develop as *holarchies*.[23]
Jerry: Holarchies? *(Fractals are also not in Jerry's vocabulary, but he lets them go.)*
Perry: Each opposing field of energy is like opposing fields of ideas. These fields are in conflict, synthesize, and transform. The material and the immaterial worlds -- as Alice said, agreeing with Plato – is part of this picture of “fields” we hold today. Or, as the physicist Steven Weinberg has said: “The essential reality is a set of fields.”

Each field of energy bears the same principles, such as “synthesis.” Ideas at this later stage of evolution are mirrors of the material world early on after the Big Bang. Would you agree, Alice?

Alice: In his most famous image – it's a fable really, with a message – Plato describes a cave where people are chained to the floor facing a blank wall. They know nothing more than the shadows they see on the wall, which are cast by people moving past the mouth of the cave. Most of them are content to sit staring at the shadows, but one individual escapes and climbs out to face the sunlight and is overwhelmed. He wanders around in wonder at the bright sunlight and then realizes that the shadows were a poor picture of reality. Now he returns to the cave to help people break their chains and escape, but people in the cave believe their world is real and his ideas threaten their reality. So they sentence him to death.
Perry: So the ideas we talk about everyday are only reflected images of really big ideas beyond our ordinary thought and vision. *(Jane feels shadows of energy, not just of ideas, in this conversation. She is still living with the tragedy of her father's unexpected passing.)*
Alice: Plato thought the real world *was* the world of ideas, was composed of ideas. He turned earlier Greek thinking directly on its head, you could say.
Perry: Right. But there is more. Who knows about Sigmund Freud and Carl Jung and could tell us about the shadow. This is part of a hidden world active all of the time.

Derek: I'm in psychology. Carl Jung introduced the idea of the Shadow. The Shadow is everything in us that is unconscious and repressed. Unconscious energies show up in nightmares and obsessions of behavior. If left unconscious and unacknowledged, the energies of the Shadow could be destructive. But, if brought to the surface, these energies could be better understood, developed, and integrated with our conscious lives.
Perry: And both Jung and Freud were worried about the future – just like Alice was worried when she asked about nanotechnology. Right?
Derek: They worried about what could happen with these conflicting fields of energy. If we do not learn how to integrate these different energy fields in a positive way, we are – civilization is – in trouble.
Perry: Freud and Jung were pessimistic about the future. But Koestler argued that - in the long run – civilization has a self-transcending drive.
Dean: So Koestler sees more reason to hope? All inventions and discoveries are based on a synthesis of differences -- and in the long run things should work out?
Perry: Koestler sees a reason to hope, but that's all, just hope. It is a constant struggle to evolve in the right way. It requires artistry.
Dean: Artistry?

Perry: There is artistry everywhere, in the effort to create syntheses, for example. A dramatist, writing a play works to join the *tragic* with the *comic*. A political scientist tries to bring together the politics of *freedom* and *order*. A physicist like Einstein tries to bring together the *relative* and the *universal*. It has not worked, so far.[24]
Derek *(interjects)***:** The psychiatrist Albert Rothenberg found that scientists were solving problems through the "unconscious" becoming "conscious." And that was creative in the best way.
Perry: There you have it. That's my thesis. And it is also consistent, by the way, with Jung's views on integrating the Shadow.
Dean: How does this happen? How does the unconscious become conscious?
Perry: Remember how Prof. Watson spoke of discoveries by the mathematician, Poincaré? (*The Dean nods.)*

Poincaré discovered the velocity transformations. He recorded what happened in a letter to Lorentz in 1905, that he had obtained "perfect invariance" of all of Maxwell's equations. It was the final step in the formulation of the theory of special relativity. So how, would you say, he did it?
Dean: I have no idea.
Perry: Half asleep, not entirely conscious. Poincaré wrote about "flashes of intuition" that led to his

finding the "Fuschian functions." One night, unable to sleep, he writes:

> A host of ideas kept surging in my head; I could almost feel them jostling one another, until two of them coalesced, so to speak, to form a stable combination. When morning came, I had established one class of Fuschian geometric series. I had only to verify the results, which only took a few hours. [25]

Dean: Interesting… and odd. Do you know of other cases of this sort of thing?
Perry: Other scientists have had the same experience. They get solutions straight from their unconscious. *(The Dean looks puzzled.)*

Jacques Hadamard received the Prix Poncelet in 1898 for his research in mathematical physics. He worked on the partial differential equations of mathematical physics. (He is famous for his 1898 work on geodesics on surfaces of negative curvature; he laid the basis for symbolic dynamics.) Hadamard reported, like Poincaré, that his *unconscious* was revealing answers to *conscious* problems he had been working on in physics.
Dean: What is going on here?
Perry: Call it creativity. It is in our nature.
Dean: This is new to me. Can you give us more examples?

Perry: A lot of scientists speak of having discoveries come to them in a dream state. Pasteur reported that his discovery of immunology took place in a sudden flash of intuition, without his thinking through the problem.

W. B. Cannon's theory of the "fight-flight syndrome" occurred to him in a sleepless night.

The physicist Friedrich Gauss said he discovered the law of induction at 7:00 A.M., half-asleep "before rising."

Enrico Fermi said he arrived at the method for producing thermal neutrons -- "without any advance warning or prior reasoning."

August Kekule formulated the ring structure of the benzene molecule in a "sudden visual imaging of a snake grasping its tail." He was half sleep at the time.[26] And there are many more!

Dean: Are these cases documented?

Perry: Yes. Rothenberg has done it. He interprets these events as part of a process of creativity. It is common to artists and scientists. He calls the phenomenon "Janusian." Do students know about Janus?

Mary: I do. Janus was the Roman god who had two faces looking in opposite directions.

Perry: "Janusian thinking" involves holding opposite images (or antithetical ideas) in your head together at the same time. Rothenberg says that these scientists

consider these opposites to be equally true. The tension of differences between them cannot be tolerated by the mind. So, after a while, a synthesis happens, as the unconscious is working hard on what cannot be solved by the conscious mind. *(Mr. Perry had begun looking into this matter when he was mentally dissociating. His thesis is part of his recovery from those dissociated episodes of schizophrenia.)*
Dean: *(The Dean looks calm but he is excited. He has been advocating equivalences in binaries/ polarities/opposites since the first day but he is finding confirmation)* Well. We have been talking about how both Mind and Matter are equally true.
Perry: Yes. Hold them both together as true.
Dean: That can be hard to do. So I have another question to you: Is the mind evolving simultaneously with matter?
Perry: Yes. And a neurologist or an anthropologist would agree.
Dean: Here's another question. Are metaphors inherent in physical nature?
Perry: *(A slight unease furrows his brow a little at this point. He looks to his professor.)* This is a question for Prof. Watson.
Prof. Watson: Yes, I agreed to follow up on Mr. Perry's talk on creativity. Thank you, Stewart. You

can take over again later. *(Prof. Watson gets up and writes on the blackboard):*

Theoretical Physics

Prof. Watson: Einstein spoke highly of his colleague David Bohm, whom he thought would be his successor. He liked what he saw in Bohm, who was thinking broadly, contributing to fields like philosophy and neuropsychology as well as to physics.

I mention this because Bohm's theory about the construction of matter connects with Koestler and Rothenberg. Bohm was on the cutting edge of physics.

Dean: On the cutting edge?

Prof.: He said that matter in the typical sense --he meant "physical reality" -- is composed of solid, well-defined bodies with definite positions in space and a specific duration in time. He called this the *Explicate Order*. However, this physical world does not end there.

By contrast, the quantum world is the *Implicate Order*. He found it to be a world of "super-positions, enfoldings, interpenetrations" with a space that is non-local. These orders are virtual opposites. This would interest Alice. Have you heard of this?

Alice: No. Was Bohm studying the mind? Does he mean a spiritual world?

Prof.: Well, no, but it is a hidden world. You cannot see the Implicate Order in a precise way. So Bohm offers metaphors to describe it. One of them is an image of *a drop of dye being twisted into a fluid* until it becomes totally enfolded. He says that any "images" of this Order would be limited because they could not reveal the full implications of it. But he wants *us* to see how physical processes are *unfolding* and *enfolding* in the universe.[27]

Dean: Was Bohm creating a new paradigm for physics?

Prof.: He says that physics needs a new paradigm. Within the profession, the universe is still pictured as a Cartesian Order, but that's the *explicate* notion of space and time, only part of the picture as David Bohm has perceived it. In the Cartesian Order, every point in space must be well defined, corresponding to a set of numbers. The success of working in this Order is built on the way in which the motion of objects in space should be described by differential equations.

But an Implicate Order is different.

Derek, could the Implicate Order help us to better understand the processes of consciousness. What do you think?

Derek: I dunno. Could studies of "consciousness" connect with studies of the brain?

Prof.: Karl Pribram is a neuroscientist who used the hologram as a model to explain how memory is distributed across the brain. Bohm, in turn, said that the Implicate Order provides insights into ways that we perceive the world. The hologram model worked for both of them.

Do students know what a hologram is? *(looks out over the class.)*

Derek: I think it's a three-dimensional image of some object. It's based on a photograph. Patterns of light are focused on it with a laser.[28]

Prof.: That's right. Pribram argues that the memory process in the brain is the same as a hologram. Alice and Jerry -- here is a thought *(The students look pleased that he has remembered their names.)* The model of a "neural hologram" was at first a metaphor for Pribram.

That's how his research began.

Alice: The metaphor started off his thinking?

Prof. That's how scientists work -- from *metaphors to models*. But here comes the surprise.

This metaphor is now a reality. Pribram believes there is enough laboratory evidence to demonstrate a physiological basis for the hologram model. He has accumulated evidence to show how many "brain functions" are analogous to holograms. So he has come to an empirical conclusion that this model, once a metaphor, is true.

Dean: Did Pribam and Bohm work together in the biophysical sciences?

Prof. Yes. The holonomic brain theory is a model for human cognition. Pribram and Bohm propose a model of thinking as guided by a matrix of neurological wave interference patterns. Pribram is proposing his paradigm for studying mental-and-physical processes as *simultaneous* so to speak. He views the brain as operating according to the same mathematical principles as a hologram.

He claims that *memory* is a result of biochemical changes in the brain that are stored in individual cells. A memory is brought back when cells are electrochemically activated. Pribram's hologram model explains why traces of the same memory have proven to exist *in more than one area* of the brain, that is, how memory comes to be distributed unevenly through our brain.

Dean: Bohm and Pribram have been in very different fields.

Prof. Right. Although at Princeton for a time with Einstein, David Bohm was a University of London physicist, and Karl Pribram is a neurophysiologist at Stanford University. They speculate that the universe could be a giant hologram, a construct reflected in part by the human mind.[29]

Mary: Wow!

Prof.: For Bohm, *space* and *time* are not the main factors that determine the nature of this implicate order. There is an entirely different connection between things. The connection may not be cause and effect in the ordinary sense. It may be by *association*. Your dreams will tell you something about this: Association and Metaphor. Can you follow that? *(Heads shake No.)*

What about you, Derek? You are majoring in psychology.

Derek: I'm amazed: metaphors and dreams are being linked with physics?

Prof.: Yes, Bohm offers another metaphor: that of a "flowing stream." It expands into an analogy; *(looking at his notes)* I quote.

> On this stream, one may see an ever-changing pattern of vortices, ripples, waves, splashes, etc., which evidently have no independent existence as such. Rather, they are abstracted from the flowing movement, arising and vanishing in the total process of the flow. Such transitory subsistence as may be possessed by these abstracted forms implies only a relative independence or autonomy of behaviour, rather than absolutely independent existence as ultimate substances.[30]

Bohm sounds like he's dreaming, but in a hologram it should become real and testable.

He says this implicate order is not to be understood as a regular arrangement of objects (e.g., in rows or in a series); rather, an order contained in each region of space and time. In some way each region contains a total structure "enfolded" within it.

Derek: Is this real? A total structure?

Prof.: If a holographic film is cut into pieces, each piece produces an image of the whole object, though the *smaller* the piece, the *hazier* the image. Clearly the form and structure of the entire object are encoded within each region of the photographic record.

(to Jerry) Jerry. Now I have something *you* especially may want to think about.

Bohm showed how language causes us to see the world as fragmented and static. Thought – through language -- creates fixed structures. Words can make dynamic entities seem static. But all manifest objects are in a state of constant flux and change.

Jerry: I don't get it.

Prof.: There is no such thing *as a thing (smiles placidly, looking at Jerry)*. All objects are in "motion" rather than in static form; only *verbs* exist. A noun is a verb in slow motion; sometimes the movement is slower than at others. Nature is moving so slowly that it appears to be static. This pencil, for example, is always changing. Your body appears to have a stable existence, but we know that you are evolving, however gradually and—from day to day—imperceptibly, toward dirt and dust.

Jerry: Thanks a lot. *(He pretends to be rueful, and the class laughs, including Jane for whom these matters are a source of worriment.)* What about a poem rather than a sentence? *(But his question is half-drowned out by the laughter.)*

Prof.: Do you follow me on what I was saying about the implicate order? Bohm says that physicists isolate these two realities in an attempt to get a unified field theory.[31]

Alice: So, Plato's division between the *seen* and the *unseen* is true?

Prof.: Well, no, or not quite. Yes, the visible-and-invisible division is true for Bohm, but matter and space are each part of his sense of wholeness.

Bohm calls this flow of energy the *holomovement*. This *holomovement* refers to a reality that is in a constant state of change, and the term *holo-* signifies that reality is structured like a hologram. Every *part* of the universe "contains" the entire universe.[32]

Jerry: *(sticking close to the argument)* Is evolution a giant holomovement? Could the total universe be contained in each region of time and space—past, present, and future? *(His face is squinching up; and putting his hands on his head, he confesses:)* I'm not sure what I'm saying, exactly. *(The class roars.)*

Prof.: For Bohm, the explicate order is *a projection from higher dimensional levels of reality*. A ceaseless enfoldment and unfoldment generates the look of solidity among the entities composing it. Subatomic particles are constantly dissolving into the implicate order and then re-crystallizing. Bohm sees life enfolded deep in this generative order.[33]

Dean: What do other physicists say?

Prof.: I don't know how many physicists would accept this view. I mention Bohm because he is so close to your thinking. Bohm wonders whether a "protointelligence" is operating in matter. He thinks that evolutionary changes do not emerge in a random fashion but *creatively* -- as relatively integrated wholes -- from implicate levels of reality. The separation of matter and energy, body and spirit, is an abstraction. [34]

Dean: Well. His ideas are different than any we have encountered so far, but I see how they mesh with our fundamental hypothesis.

Prof.: And there's more. Bohm uses the analogy of the seed being "informed" to produce a living plant. Life is enfolded in this organic totality.

Dean: *(looking toward the class)***:** Like Aristotle's acorn becoming an oak tree.

Prof.: Bohm believes that this invisible "in-forming" may be reflective of a deeper dimension of reality, that is, space and time could be derived from a deeper *objective* reality. He does not mean subjective reality, you understand. It is a physical frontier to be tested by physicists.

Dean: I think Bohm was breaking the mold like Galileo and Newton were in their day. How could his theory connect with the arts and the humanities?

Prof.: Higher education is part of this natural drive to create variety (specializations) and at the same time to search for wholeness.

Dean: So our class is on track with our study of Nature.

Prof.: I think so. Aristotle's study of the material world and the Plato's of the immaterial world could *both* be true. And yet Bohm is different than either of them.

Alice: How?

Prof.: In the material world there are two atoms (energy systems) that separate and then conflict. The physical components synthesize and transform into a new order. Sodium and Chloride, for example, combine to create table salt, written as:

$2Na + Cl2 \rightarrow 2\ NaCl$ *(writing on the blackboard)*. And in the world of ideas you find the same principle on a different level:

Bio (life, living organism) + *Logy* (knowledge) → *Biology* or the science of all forms of life *(again on the blackboard)*.

We think of the former (salt) as the objective order and the latter (knowledge) as leaning into the subjective order of ideas. Plato imagines a still higher order where even greater ideas may exist. But Bohm is talking about an implicate order that is different. For him, it is at the objective level. It is material.

Dean: But it looks like evolution for humans is moving toward a greater sense of interiority. I bet the Jesuit Bernard Lonergan, if alive today, would agree. Atoms fuse, molecules combine, cells join, symbols appear, and metaphors are created. A new consciousness of an interior wholeness deepens in humans in this phase of evolution.[35]

Prof.: Let me emphasize physics again before you go off into the stratosphere. Physicists want to arrive at a deeper level of understanding at the material level.

Dean: Okay. But you haven't answered my question yet: How does physics link with the humanities and the arts?[36]

Prof.: We are getting there. This is the focus of Stewart Perry's dissertation. So I am going to ask him to return to the podium. Mr. Perry. (*Mr. Perry stands up and writes on the Blackboard*.

The Poetry of Physics

Mr. Perry: Could there be any poetry in physics? *(Looks around the class by way of invitation, but no one answers)* Terms like *opposition, synthesis,* and *transformation* can be defined either with precision or ambiguity. Precision is important to physics; ambiguity is important to poetry.
Dean: What is poetry? *(He knows how important definitions are in this course.)*
Perry: In his famous poem "Ars Poetica," Archibald MacLeish says that a "poem" is a string of metaphors that has sensuous images. A poet *evokes* rather than *prescribes* what a subject is. So when MacLeish defines a poem, he uses a figure of speech: *"A poem should be wordless as the flight of birds*." What do you think of that?[37]

Mary: That's neat. He defines a poem by comparing it to a sequence of other things, so creates a series of similes and metaphors. Metaphors are the foundation of poetry. So, he is defining what a poem is by its own nature.
Perry: Right. Tom Briggs, an English professor, sees MacLeish's metaphor as composed of two terms: a poem— X— and a flight of birds—Y. They are identical so to speak. This points directly to your study of evolution. *(Students perk up.)*

With this definition, your mind pauses. At the "pause," you feel a tension between X and Y. X and

Y are compared *unconsciously,* and then *consciously,* in a fraction of a second. With no reflection, no reasoning -- an instantaneous action takes place, quick and natural. It is bisociation, your word for "compare, contrast, and synthesize."

Now notice.

You think it is a process of the *mind,* but it is equally a process in *nature*. Rothenberg shows how this sort of instantaneous action takes place for great scientists, in their dreams and half-sleep or in meditation, and Arthur Koestler shows how the same thing happens with poets.

Dean: It appears to be a process of the mind, but you say, we should also claim this as a process going on in the external world?

Perry: Yes. Consider: *This is what nature does outside the mind*. And this understanding changes the whole concept of evolution. It is no longer in the framework of science alone; it is in the framework of any type of knowing. It is also in the arts and the humanities.

The evolution of nature and the mind is based in bisociation. Nature cannot be understood as based on cause and effect alone, but on the principle of bisociation – the process of creation itself.

Dean: Bisociation was taking place in the stars long before animals and birds appeared in nature.

This complex process of "comparison, opposition, synthesis" is built into the nature of things.
Perry: Yes, and it is as much behind the evolution of atoms and molecules as it is of bacteria and bats.
Alice: Wow!
Perry: This principle of bisociation applies to the science of evolution. It could help explain what cannot be explained by natural selection. It is the way nature transforms and transcends the past. The physicist and the poet are working with the same processes of nature *(grinning now)*. Questions?
Jerry: Amazing. A poem is X and the "wordless flight" is Y? *(Jerry has not yet caught onto the key point, which Perry has just stated: that internal nature simulates external nature. He's got to return to the basic fact of the metaphor.)*
Perry: Yes. On the contrast side, we see X + Y, as separate entities. You know consciously that a poem is *not* the motion of a bird with flesh, blood, and feathers. But applying "wordless" to the equation heightens the contrast . . .. So then, in one fraction of a second, a new thought flashes in the middle of this ambiguity. It is suddenly a paradox, unsettling to the mind: the mind does not like to live in so much tension without resolution. You separate the two realities in your mind before you synthesize them.

Compare and contrast. On the comparison side, the claim that X = Y compels the mind to connect the different terms. In the mind's fraction-of-a-second stretch to connect the opposites, *it goes unconscious*. Then, *Voila!* Something new is realized.

We search for "similarity" between each different image for this new image-discovery to happen. Do you follow?

Jerry: So ambiguity has a role in science!

Perry: Yes. In *ambiguity,* many different meanings arise. In visualizing a flight of birds, say, we see and feel many different things. What do you see and feel? *(Jerry's eyebrows knit; he's thinking too hard to answer.)*

When I ask you to imagine – to see with your mind's eye – a flight of birds. What happens?

(Pause.) You might have a feeling of beautiful rhythmic figures. Or, you may suddenly feel happy because it seems a lyrical movement, maybe, like a dance. Or, you might feel a sense of excitement. Or, it is a forgotten pleasure of moving back and forth in a playground swing. Or, you may sense freedom.

The connection is not precise. It is not like a scientific concept or like seeing a pencil. It is a metaphor. It evokes all kinds of sensuous feelings depending on the individual doing the imagining.

Dean: So, the mind of the scientist works like the mind of a poet. But how does this apply to physics?

Perry: Bohm says matter and energy continually unfold and enfold; in a metaphor, an analogous sort of thing happens with meaning.[38]
Dean: Analogous?
Perry: The fact that the "flight of birds" is not a "poem" keeps you creating more meanings that are not all based on reason. And here is where we connect with Bohm's implicate order.
Dean: What?
Perry: MacLeish's metaphor could run into a thousand shades of meaning, of difference and similarity, between the *wordless flight of birds* and *a poem*. MacLeish's point at the end of *Ars Poetica* is that in the final count: "A poem/ should not *mean*/ But *be*."
Dean: Interesting. This "be" will lead us onto a new track, but for now let's stay with the metaphor.
Perry: The metaphor moves the mind beyond the confines of the X and Y terms. It goes from meaning that can be described or analyzed to a back and forth movement—implicate-explicate-implicate—, and finally, to a feeling of *being*. Are you with me? *(looks back at Jerry.)*
Jerry: I hate to think about it.
Perry: In this instance, what does it mean to *be*? Could it mean that ideas move into an unconscious state of being where they mix and slosh around?
Dean: Yes. Remember Poincare!

Perry: Poincare said:

"I could almost feel them jostling one another, until two of them coalesced, so to speak, to form a stable combination. When morning came, I had established one class of Fuschian geometric series."

So the process of contrast-compare-synthesize took place unconsciously. It was not "thinkable" for Poincare, at least not cognitively. The answer came to him unconsciously.

Dean: His was an example of nature doing its work. The process happens *through us* -- just as it has happened in external nature since the Big Bang.

Jerry: I am still trying to figure it out, wrap *my* brain around it. How does this happen physically *inside* the brain?

Perry: Neuroscience is working on this question. Scientists think that a great deal of processing -- including layers of conscious and unconscious perception -- takes place on the principles of comparison-and-contrast. Briggs says *(reading from his notes)*:

> Memory lies at the root of the brain movement in which the complex mix of reason, emotion, brain states, perceptual regimes and immediate environmental influences unfold in conscious (explicate level) awareness as a stream of comparing and contrasting. These comparing and contrasting activities then refold into the background (implicate)

levels of the brain to set the stage for further comparisons and contrasts.[39]

So there you are. In thinking about these things -- you are not alone.

Dean: Thank you!

Derek: Do those implicate-explicate orders of Bohm run parallel to the conscious-unconscious orders of Freud and Jung?

Perry: Well. Imagine walking along a road in the obscure light of the moon. We see an unknown shape in the distance. What is it? We notice the *contrast:* the figure against its background. At first we think we are seeing a person. We make a *comparison:* that shape of a person is compared to our memories of human shapes (arms and legs) in various positions. But as we draw closer we notice features unlike human ones. (The *comparison* has disclosed elements in *contrast*.) And so we then formulate a new image of what we see as an animal (*comparison*) until this association too reveals a greater difference (*contrast)*. *(Jane perks up, alert at these images.)* We keep making comparisons until finally, we walk far enough ahead to recognize the shape as a *bush*!

Jane *(suddenly chortles)***:** Oh, that happened to me!

Perry: This back and forth sequence of comparison -contrast- comparison -- takes place with "neuronal rapidity." The connections flow indistinguishably into one another. The dynamic of the metaphor engenders ambiguity, which means *all similarities* between terms are possible. It *evokes* rather than *prescribes*.

Dean: Evokes! Poets do what nature does: "They evoke possibilities." And what about physicists?

Perry: For physicists, there is also this tension of differences between parts that will make a whole. The mind wants to find consonance in the dissonance, and so it goes into a bisociative mode. If we think of this as a process common in the whole universe, it brings invention into a scale that is unimaginable.

Dean: So! We can make no single image of the universe and say, "This is it!"

Perry: That's right.

Dean: Evolutionists say: "Nature is a "mechanism." "Nature is an organism." But they all fall short.

Perry: Nature *invents* mechanisms and organisms. The universe cannot be explained by a root metaphor. *Root metaphors* do not work here.[40]

Dean: So, the ancient prophets were right. The universe is a constant search for a "union of opposites". Indeed, Jung referred to as *enantiodromia*. That's the superabundance of any force that inevitably produces its opposite.

Perry: Yes, . . . sort of. "Physicists," said Bohm, "cannot make final statements about nature. Scientific theories should be evocative. Theories should be like poems – consisting of insights, acts of perception. I like to think that the universe is a "poem," but that image also falls short.

Dean: So Bohm spells out the *suggestive* use of his own metaphors.

Perry: Yes. His theory shades into more subtle reaches and regions of higher-dimensional realities, as in an "infinite chaos" with "infinite degrees of order."

Mary: But! Is the mind then a mirror of the universe?

Perry: No. Bohm wants us to avoid any *root* metaphor. We should work with the X/Y dynamics of metaphors, as poets do. The richness of the root is tempting, he says, but it tries to catch, and fix, "the whole" too soon. The poetic metaphor avoids the exhaustion of a single metaphor because of its X/Y dynamics.

Dean: What is a *root metaphor*? Jerry, since you are in linguistics, can you tell us anything about it.
Jerry: A root metaphor is an image deeply embedded within a culture and in our mind. It is so totally embedded that people do not realize it as a metaphor.

Perry: *Mind* is a root metaphor.

Jerry: *Matter* is also a root metaphor.

Dean: Oh, Oh. I think we are at the root of our problem.

Perry: Right again. I would hold Mind and Matter in tension during your whole inquiry. Bohm would say that the metaphor builds a subtle structure of continuous change and innovation. Metaphors combine with others to produce new “orders” of understanding, and the combinations continue, with new types of sense and feeling.

Dean: So the X/Y dynamic stands for a constant process of comparison, synthesis, and innovation.

Alice: Tell me again. How does all this change happen?

Perry: Professor Tom Briggs proposes “an echo” in this principle of metaphor and coins the term *reflectaphor*. He puts together this word and word-part (*reflect* –and *-phor*) to propose an evocative series of ongoing changes, a constant bending back, a kind of spiral dynamics if you will.[41]

Dean: Spiral dynamics. That fits our way of thinking.

Perry: Good. Briggs introduces something like an artistic structure. *(Jane focuses on him, intent again. Her major is painting.)*

In poems, a central X-term may be linked serially to a number of different Ys to produce a branching-term metaphor.

Dean: What do you mean?

Perry: Listen to this poem by Emily Dickinson. *(He hands out a copy, then reads aloud)*:

There's a certain Slant of light,
Winter Afternoons –
That oppresses, like the Heft
Of Cathedral Tunes –

Heavenly Hurt, it gives us –
We can find no scar,
But internal difference,
Where the Meanings are –

None may teach it – Any –
'Tis the Seal Despair –
An imperial affliction
Sent us of the Air –

When it comes, the Landscape listens –
Shadows – hold their breath –
When it goes, 'tis like the Distance
On the look of Death –

Jane *(almost a whisper)***:** Oh my! *As she hears the poem read, she does not understand why it speaks so strongly to her.)*

Jane: How do you explain it?

Perry: The narrator in the poem compares “a certain Slant of light” on ”Winter Afternoons” to different images, such as “the Heft/ Of Cathedral tunes,” “an imperial affliction,” and “a Heavenly Hurt.” These are images visible externally— sunlight coming through the window–used to introduce images of internal seeing-and-feeling. It carries great emotion for me, and richness.

Dean: Mmm. She writes in the spirit of proverbs, riddles, and hymns. She uses evocative powers to elicit our intuition.

“Winter” light, with its oblique “Slant” is made to be a metaphor for – or at least it corresponds to – a wound that is inflicted both outside and inside. The wound and the meaning are in the same place.

Perry: Look at the rhyme of “scar” with “are,” a single comma in front of it isolates the word “are” at the end of the last line of the second stanza. You must gulp, even if slightly, before reading that word and gasp afterward…the breath then replicates both motion and isolation.[42]

Jane: Oh! *(The poem is about despair and death. These ever-present aspects of nature are still very close to Jane’s feeling.)*[43]

Dean: Well. Emily advances what we call *interiority*. Do you know what I mean by that? She brings the reader into a greater inner depth of knowing.

Perry: Dickinson’s poetry is about how nature is in, and part of, human nature. She moves from an outer (explicit) image to an inner (implicit) feeling.

Dean: Well! Is physics an artistic structure?

Perry: That question is at the heart of my doctoral dissertation. This is not "ordinary physics" *(smiles at Prof. Watson)*. I think physicists will keep discovering new things but will never end up with a final general law about "everything."

Dean: Why?

Perry: The implicate universe is a work of art. Briggs says reflectaphors emerge in the interactions of artistic "elements," like *shape, line, color and negative space*. In literature they appear in such techniques as *irony, pun, motif, and symbol*. Reflectaphors show an artwork's subtlety and its ability to astonish. They are seedbeds of its "truth" you might say. It is the way the mind gives meaning to things; their hidden order is a work of art.

Dean: So we can never explain the universe?

Perry: Look at what you said: can we "never *explain*." The very word "explain" is meant to place you outside the universe, but you are already in the universe and can never step outside of it completely. Thought and subjectivity are no more outside the universe than matter is. But the reflectaphoric process undercuts every machination of thought and of physical sensation. It keeps building and deconstructing and building something new.[44]

Dean: That's depressing. That's like waiting for Godot. *(Pause)* Does Briggs have anything more to say?[45]

Perry: It's complicated but let me simplify. One side of the reflectaphor is carried over to the other, and then is reflected or carried back again and again, goes beyond the first and—the comparison/contrast "dynamic" propelling this movement—bends the mind back again; and then beyond once again, giving no rest in some final stage. Between the elements of a reflectaphor (comparison/-contrast), there is no meaning.

Dean: No meaning!

Perry: There is meaning in the continual revelation of unfoldment and enfoldment. It is like the creation of a hologram, a process like light reflecting back and forth on objects – like the silver edges of those chairs.[46]

Dean: No meaning!

Perry: No fixed or finite meaning. Last night I listened to a violin concerto by Jean Sibelius performed by Gil Shaham. In each movement, I had different visions that kept coming fresh to me without my thinking. I listened to it again, and once again, new visions and images came to me.

Dean: I'm not sure that I follow you. …

Perry: In the first movement, *Allegro moderato,* I saw dragon flies making love on a moonlit river, rising and falling as they flew toward each other and then above and below in the night sky. Next I heard a glacial stillness in the sound of orchestral violins, rhapsodic solo lines. There was "eruptiveness" and then dark stirrings in the sound of cellos. It was a movement, a process evolving naturally, with nature. I listened again, and I saw fresh images, moving back and forth. This is evocation at its best.

Dean: But this type of imaging is normal for those who listen to classical music. What is so different in your case?

Perry: I was just *being* with the music; there was no particular meaning.

But then, I had the sense that there was actual music in nature, as constellations and caverns were being shaped, the iron fire in the earth forming, rivers flowing, as well as dragonflies dancing.

I *saw* music actually playing in the creation of those marvelous forces. New rhythms were evolving and shaping evolution. Behind those physical forces was this music, a reality like what we see outside—in flocks of birds flying in unison, in whales diving, in billowing formations of cumulus clouds.

The physicist cannot see it or measure it, but I tell you, music is there. I feel it… *(Stewart Perry suddenly stops speaking. He coughs to disguise a choke in his throat... He is still trying to separate the hallucinatory visions he has had from his physics. He remains silent, and Prof. Watson intervenes, glancing quickly at his clock.)*

Prof: Ah! I see our time is running out.

Dean: You are right; I hadn't noticed. *(Looks to see that Mr. Perry is all right.)*

This has been fascinating. I would like to invite the two of you to the session on Poetry. Could you join us for that? Would you be willing? *(Both heads nod with interest.)*

Prof.: We have 30 seconds. What could you possibly say to conclude?

Dean: Not easy. *(Looks at his notes and then at the class.)* According to physics, we are in a universe of vibrating fields, in a vibrating body with a vibrating mind and spirit. We work in vibrating fields, which are evolving . . . well, perhaps with music. And poetry tells us how we can feel beyond our straight talk. *(Jane is tuned in. She will go home and read Dickinson's poetry.)*

Quantum physics has led us into a multi-dimensional reality; perhaps a paradigm shift is in the making. We are all participant observers, in the universe and part of it. For some time now, physicists have been suggesting that the very *act of observing changes reality*. Are we participating in *the reality we perceive?*

Stewart Perry coughs, loudly, like an "Ahem."

Perry: Sorry. *Prof. Watson and the Dean look at him quickly; and then they look once more at the clock.*

Dean: My, what a class! More on all this next time. Have a wonderful day.

Stewart Perry has come through his lecture with flying colors. This occasion of his "coming out" to speak to a class was one more step toward overcoming his condition.

Professor Watson supports him fully. He is aware of how John Forbes Nash, Jr. was finally victorious in his efforts to overcome schizophrenia and went on to win a Nobel Prize. Nash's specialty was differential geometry and partial differential equations. At two different periods of his life, he worked at Princeton University and lived to write about his struggle. Professor Watson hopes that Stewart Perry may find his way to eminence in his study of physics and artistic structures.

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[1] What is schizophrenia? Nobody has the full answer. Psychiatric research in neurobiology shows no single organic cause. There is debate about whether the diagnosis represents a single disorder or not, since it has many discrete syndromes. Despite its etymology, schizophrenia is not synonymous with dissociative identity disorder, previously known as multiple personality disorder or split personality; in popular culture the two can be confused.

[2] Who are we? Physics is part of the answer. The *Scientific American* says: "At the end of this journey to the terascale and beyond we will know for the first time what we are made of and where the place we briefly live operates at bottom." February 2008, p. 38. A *terascale* is the realm of physics that comes into view when two elementary particles smash together with the combined energy of about a trillion electron volts, or one tera-electron volt.

[3] Thales posed the problem of change by asserting that there exists some first principle that continues, similar to the way that immortal gods persist through time. Aristotle says, "And Thales, according to what is related of him, seems to have regarded the soul as something endowed with the power of motion, if indeed he said that the lodestone has a soul because it moves iron.... Some say that the soul is diffused throughout the whole universe; and it may have been this which led Thales to think that all things are full of gods." Aristotle. *On the Soul*, i. 2; 405 a 19. and i. 5 ; 411.

[4] The term "physics" has changed in meaning over time. From encompassing the whole world (Locke also included God, angels, etc.), the term has come to be restricted to inorganic bodies, and finally restricted further to sense and reason. In the thirteenth

and fourteenth centuries, it meant the "art of healing, medical science" and "natural science." According to the *Oxford English Dictionary* the word was first used in 1487 by “J. Skelton in a translation of Diodorus Siculus, Bibliotheca Historica III. 174 .” The specific sense of physics as a "science treating of properties of matter and energy" originates in 1715.

[5] Much of early physics began with Arab and Persian scholars building on previous work in astronomy and mathematics. They developed new fields that would become modern optics, experimental physics, and hydrodynamics. During the Middle Ages, much work took place through the experimental method of Ibn al-Haytham (ca. 965–1040). He built a *camera obscura* and discussed the theory of attraction between masses and the magnitude of acceleration due to gravity. In 1121, al-Khazini, in his treatise *The Book of the Balance of Wisdom,* developed the concept of gravitational potential energy. Then Avempace (d. 1138) argued that there is always a reaction force for every force exerted but not conceived as equal. And so the history has much detail within the Islamic tradition.

See James Evans, *The History and Practice of Ancient Astronomy* (Oxford University Press, 1998) Lloyd Motz and Jefferson Hane, *The Story of Physics*

(NY: Plenum, 1989); Joseph Needham, *Science & Civilization in China,* (Cambridge University Press, 1986). Roger Newton, *From Clockwork to Crapshoot: A History of Physics* (Harvard University Press, 2007). David Pingree, "Legacies in Astronomy and Celestial Omens," in *The Legacy of Mesopotamia,* ed. Stephanie Dalley (Oxford University Press, 1998)

[6] Prof. Watson is skipping much of this history. Galileo Galilei is a key figure in Western history, often considered the "father of modern physics," since so many advances were made after his work. In his wake we see Christiaan Huygens, Johannes Kepler, and Blaise Pascal. Sir Isaac Newton startled the world with his *Philosophiae Naturalis Principia Mathematica* in 1687. From the late seventeenth century onward, Boyle, Young, and others developed the field of thermodynamics. In 1733, Bernoulli initiated the concept of statistical mechanics. Also in 1733, C. F. du Fay discovered the existence of two types of electricity and named them "vitreous" and "resinous" (later known as a positive and a negative charge respectively). William Watson discovered in 1747 that a discharge of static electricity was equivalent to an electric current. Charles Augustin de Coulomb formulated Coulomb's law, which gives the

definition of the electrostatic force of attraction and repulsion. In 1798, Thompson demonstrated the conversion of mechanical work into heat. André-Marie Ampère discovered the relationship that relates the circulating magnetic field in a closed loop to the electric current passing through the loop. For more, see Isaac Asimov, *Biographical Encyclopedia of Science and Technology: The Lives & Achievements of 1510 Great Scientists from Ancient Times to the Present* Revised second edition, Doubleday (1982); and James Burke, *Connections,* (NY: Simon & Schuster 2007).

[7] In the early 1800s much more was happening. In 1804 Young founded the theory of capillary phenomena on the principle of surface tension. In 1824 Carnot published the *Reflections on the Motive Power of Fire,* which is considered the founding paper in thermodynamics. Carnot established a general theory of heat engines and outlined the principles of what would later become known as the Carnot cycle, the Carnot heat engine, Carnot theorem, and thermodynamic efficiency, to name a few. This work laid the foundations for the first and second law of thermodynamics.

[8] Classical mechanics was given a new formulation by William Rowan Hamilton in 1833, which a century later gave an entry to the wave formulation of quantum mechanics. In 1847, James Prescott Joule stated the law of conservation of energy, in the form of heat as well as mechanical energy. About the same time, entropy and the second law of thermodynamics were first described in the work of Rudolf Clausius. In 1875, Ludwig Boltzmann made the important connection between the number of possible states that a system could occupy and its entropy. With two installments in 1876 and 1878, Josiah Willard Gibbs developed much of the theoretical formalism for thermodynamics, and a decade later firmly laid the foundation for statistical mechanics — much of which Ludwig Boltzmann had invented independently. In 1859 Kirchoff explained what became known as Kirchoff's law of thermal radiation, which provided a general statement about emission and absorption in heated objects. Later on in his career, Kirchoff worked with Robert Bunsen to establish the field of spectroscopy, specifically through their formulation of Kirchoff's three laws of spectroscopy. In 1881 Gibbs also was very influential in moving much of the notation of physics from Hamilton's quaternions to vectors. From 1873-76 Gibbs would help to apply thermodynamics to

chemical processes, laying the foundations of chemical thermodynamics. Gibbs published three papers, the most famous being *On the Equilibrium of Heterogeneous Substances,* in which he demonstrated that thermodynamic processes could be analyzed graphically by studying the energy, entropy, volume, temperature and pressure of the thermodynamic system, in such a manner as to determine if a process would occur spontaneously. The first and second laws of thermodynamics emerged in the 1850s, primarily out of the works of William Rankine, Rudolf Clausius, and William Thomson. The third law of thermodynamics, which was established by Ludwig Boltzmann, states that the entropy of a pure substance approaches zero as the absolute temperature approaches zero. In 1879, Sir William Crookes discovered a new form of matter, which he called "radiant matter." Crookes was able to make his discovery of plasma by inventing the Crookes tube. The discovery of plasma constitutes the first time a new state of matter had been discovered, aside from the common knowledge of solids, liquids, and gases.

[9] James Clerk Maxwell built upon Michael Faraday's physical conception of electromagnetic fields with an interlinked set of twenty equations that explained the interactions between electric and magnetic fields and

unified the two phenomena into a single theory of electromagnetism. Maxwell's equations were presented to the Royal Society in 1864. These twenty equations were later reduced, using vector calculus, to a set of four equations by Oliver Heaviside. A prediction of Maxwell's equations was that light is an electromagnetic wave. Confirmation of Maxwell's insight into electromagnetism was made in 1888 with the discovery of radio waves by Heinrich Hertz and in 1895 when Wilhelm Roentgen detected X-rays.

[10] In his paper of 1894, Poincaré distinguished different categories of 2-dimensional surfaces. He showed that any 2-dimensional surface having the same fundamental group as the 2-dimensional surface of a sphere is topologically equivalent to a sphere. He conjectured that this result held for 3-dimensional manifolds, and this was later extended to higher dimensions. Poincaré also originated the theory of analytic functions of several complex variables. He began his contributions to this topic in 1883 with a paper in which he used the Dirichlet principle to prove that a meromorphic function of two complex variables is a quotient of two entire functions.

[11] Relativity prescribes a different transformation between reference frames than does *classical* mechanics; this required the development of *relativistic* mechanics as a replacement for classical mechanics. Karl Schwarzschild found exact solutions to Einstein's field equation in 1915.

[12] For more, see Alan Macdonald, "Einstein's hole argument," *American Journal of Physics* -- February 2001, Volume 69, Issue 2, pp. 223-225.

[13] Giovanni Reale, John R. Catan, *From the Origins to Socrates,* (SUNY Press, 1987), 121.

[14] James Chadwick discovered neutrons in 1932. Research was soon conducted into nuclear physics, for the purpose of creating a nuclear bomb. The German effort to do this, led by Werner Heisenberg, did not succeed, but the Allied Manhattan Project reached that goal.

[15] Another "big" moment of science was the discovery of ionized gases, or plasma, which had begun with Crookes' tubes late in the 19th century. Large international collaborations over the last half of

the twentieth century embarked on a long-range effort to produce commercial amounts of electricity through fusion power, which remains a distant goal.

[16] The discovery of nuclear magnetic resonance in 1946 led to new methods for studying the structure of molecules. This became a widely used tool in analytical chemistry, which gave rise to an important medical imaging technique, *magnetic resonance imaging* (MRI).

[17] In 1954, a class of "gauge theories" developed to provide a framework for understanding nuclear forces and Murray Gell-Mann proposed a theory for the strong nuclear force. An "electroweak force," the unification of the weak nuclear force with electromagnetism, was proposed by Sheldon Lee Glashow, Abdus Salam, and Steven Weinberg and confirmed in 1964 by James Watson Cronin and Val Fitch. This led to the Standard Model of particle physics in the 1970s, which describes all of the elementary particles observed to date.

[18] In 2004 an environmental toxicologist, Eva Oberdörster, with Southern Methodist University in Dallas, Texas, conducted tests. She found extensive brain damage to fish exposed to fullerenes for a

period of just 48 hours at a relatively moderate dose of 0.5 parts per million (commiserate with levels of other kinds of pollution found in bays in the United States). The fish also exhibited changed gene markers in their livers, indicating that their entire physiology had been affected. In a concurrent test, the fullerenes killed water fleas, an important link in the marine food chain. No one can say whether fullerenes would also cause brain damage in humans but it has been cautioned that more studies are necessary and that the accumulation E. Oberdörster (2004) "Manufactured nanomaterials (Fullerenes, C60) induce oxidative stress in brain of juvenile largemouth bass". *Environmental Health Perspectives*. (available on-line).

[19] The Union of Concerned Scientists is the leading science-based nonprofit working for a healthy environment and a safer world. UCS combines independent scientific research and citizen action to develop innovative, practical solutions and to secure responsible changes in government policy, corporate practices, and consumer choices.

[20] Attempts to unify quantum mechanics and general relativity made progress during the 1990s. At the close of the century, a Theory of Everything was

still not in hand, but some of its characteristics were taking shape. String theory, loop quantum gravity and black hole thermodynamics all predicted quantized *spacetime* on the Planck scale.

[21] Arthur Koestler, *The Act of Creation* (NY: Penguin, 1990, o.d. 1968.) Koestler believes that a principle involving all creative action could be called "bisociation." This principle “uncovers, selects, re-shuffles, combines, and synthesizes” already existing facts, ideas, faculties, skills. The more familiar the parts are, the more striking the new whole. Take a joke, for example, where we see there is a simultaneous awareness of two conventionally unrelated "operational fields," drawn from Koestler.

A pompous dignitary slipping on a banana peel brings to consciousness an awareness of the field of dignity, honor and respectability on the one hand, and the field of human frailty, weakness and triviality on the other hand. The incongruity of this action is at the essence of humor. The trick is to connect the two separate fields.

[22] David J. Sill, “Integrative Thinking, Synthesis, and Creativity in Interdisciplinary Studies” *The Journal of General Education* - Volume 50, Number 4, 2001, pp. 288-311

[23] Koestler gives many examples of high creativity but common to them all is this: The creative geniuses of this world – such as Darwin, Einstein, Poincaré, great novelists, poets, etc. -- don't produce ideas without “bisociation.” Inventions only emerge after long periods of intensive thought. What happens is that one thought or problem is held persistently in the mind—it could be for weeks, months or years--during which time it becomes associated with thousands of other ideas and impressions. Sooner or later, one of them "clicks" with the resident problem, and the solution then rapidly emerges. Alfred Koestler, *The Ghost in the Machine* (Hutchinson & Co, 1967). Koestler coined the term *holarchy* in *The Ghost and the Machine* and wrote about Janus in conjunction with a continued exploration of this idea. Every holon is two-faced like Janus, the Roman god Each whole is a part of something greater, and each part is in turn an organizing whole to the elements that constitute it.

[24] Sander Bais helps readers through the quandaries of fundamental concepts, such as simultaneity, causality, and time dilation. His diagrams illustrate the difference between the Newtonian view, in which time was universal, and the Einsteinian, in which the speed of light is universal. Sander Bais, *Very Special Relativity: An Illustrated Guide*, (Harvard University

Press: 2007). When space shrivels and time slows, the world according to Einstein's special theory of relativity can be a confusing place. Sander Bais's book helps, with pages of diagrams and concise explanations for all the oddities of relativity.

[25] Anna Sierpinska *Understanding in Mathematics* (Routledge, 1992).
[26] Albert Rothenberg, *The Emerging Goddess* (Chicago: University of Chicago Press, 1979) 15-105.

[27] Bohm is saying that if we learn to perceive the cosmos as one type of order transforming into another, new doors of comprehension will open. My own study of two orders in the economy can be seen in *A Future of the American Economy* (Stanford: Stanford University Press, 1990). I talk about the latent and the manifest forms that are transforming in the economic order.

[28] To make a hologram, a laser light is split into two beams, one of which is reflected off an object onto a photographic plate where it interferes with the second beam. The complex swirls of the interference pattern recorded on the photographic plate appear meaningless to the naked eye, but the pattern has a hidden order. When illuminated with laser light, it

produces a three-dimensional image of the original object, which can be viewed from any angle.

[29] There is much more to this story of David Bohm that includes his fleeing the United States to avoid testifying before the McCarthy Hearings and becoming seriously depressed at times. His professional work remains respected by the best physicists while others are doubtful about his politics and outlook on an implicit order. Stewart Perry believes that Bohm's way of looking at the universe could help explain some of the unsolved puzzles of physics.

[30] David Bohm, *Wholeness and the Implicate Order,* Routledge & Kegan Paul, (London, Boston: 1980) 11.

[31] David Bohm, op. cit. 62.
[32] For more on this, see Stanlislav Grof, *The Adventure of Self-Discovery: Dimensions of Consciousness and New Perspectives in Psychotherapy and Inner Exploration* (State University of New York Press, 1988). Stanislav Grof, *Beyond the Brain-Birth: Birth, Death, and Transcendence in Psychotherapy* (State University of New York Press (August 1985).

[33] Bohm suggests that the quantum potential is guided by a superquantum potential, representing a second implicate order, or superimplicate order. He proposes that there may be an infinite series and, perhaps, hierarchies of "generative" orders, some of which form relatively closed loops and some of which do not. Higher implicate orders organize the lower ones, which in turn influence the higher.

[34] Michael Talbot, *The Holographic Universe* (HarperCollins, New York: 1991) 271. Also see *Quantum Implications: Essays in Honour of David Bohm*, B. Hiley & F. David Peat, eds. (Routledge & Kegan Paul, London: 1987) 48.

[35] In all fields of inquiry, however, the drive toward "the whole" is not just linear. The thousands of branches of evolution among plants and animals with so many extinctions show the lack of progression and linearity in biology. In psychology, we see how the progression of an infant growing up into adulthood can go in many perverse and problematic directions, even into regression. Sigmund Freud wrote of how people can regress and stay in some stasis, even curled immobile for a lifetime on the floor of a hospital ward, never progressing into adulthood. In the field of history, we

see nations with budding democracies suddenly become dictatorships due to outside threats. At all levels of evolution, there are cycles, regressions, and stagnation.

[36] In the arts and humanities, human choice is not always an either/or proposition. It is not just Evil versus Good, Black versus White. It is not just Order versus Disorder. All great binaries are not just in opposition to one another; they are co-present in the moment. So we must combine them to produce an adequate level of wholeness by invention.

[37] Here is Archibald MacLeish's "Ars Poetica" (1926):

A poem should be palpable and mute
As a globed fruit,
Dumb
As old medallions to the thumb,
Silent as the sleeve-worn stone
Of casement ledges where the moss has grown --
A poem should be wordless
As the flight of birds.
A poem should be motionless in time
As the moon climbs,
Leaving, as the moon releases
Twig by twig the night-entangled trees,
Leaving, as the moon behind the winter leaves,
Memory by memory the mind --

A poem should be motionless in time
As the moon climbs.
A poem should be equal to
Not true.
For all the history of grief
An empty doorway and a maple leaf.
For love
The leaning grasses and two lights above the sea --
A poem should not mean
But be.

[38] John Briggs, “The (implicate) Universe as a Work of Art,” *Essays in Honor of David Bohm,* Routledge & Kegan Paul, Ltd. 1987.

[39] *Sunrise Magazine*, Theosophical University Press, February/March 1993.

[40] An example of a *root metaphor* is Newton’s notion that the universe is a machine, or Whitehead’s notion of the universe as an organism. Any root metaphor has some advantages for the explication of a theory, but it cannot tell the whole story.

[41] The word metaphor comes from the Greek *meta,* which means “in the midst of, in company with,” or simply “with”; and Aryan *medhi* which means “middle”; also from the Greek *phoros* derived from *pherein,* “to carry or to bear.” The word ‘reflect’ comes from the Latin *re-* and *flexes* which together

mean “bending back or bending again.” Briggs puts these together to coin the word *reflectaphor*.

[42] At this point Perry is paraphrasing Brenda Hillman in her Preface to Emily Dickinson, *Poems* (Boston: Shambala, 1995) xii.

[43] Dickinson’s poetry depends on “evocation.” This is exactly the point these physicists are making. Emily alters the metrical beat to fit her feeling: *slow,* then *quick,* and then *hesitant,* unpredictable to a reader. She uses “off rhymes” to convey the tension in these images. She keeps everything vivid and exact, but does not use “straight talk.” She places a common word in an extra-common context, shocking the reader into attention. This poem, “A certain Slant of light” exposes her truth about nature. It is different from Christian symbolism where “light” stands for grace and the kingdom of God. When viewed in its “Slant,” or indirect aspect, light is a state of “affliction.” Dickinson uses the metaphor of “slantness” to convey the conviction that both nature and the God of nature are flawed, since death, loneliness, and isolation are active within the natural world and afflict the human soul. See Michael Lake in an essay on “Poetry for Students” (The Gale Group, 1999).

[44] Briggs emphasizes that the *reflectaphor* does not work like a machine. He says that, to achieve the proper X/ Y tension, the terms have to be close enough together for an observer to perceive their similarities yet far enough apart to create an enduring contrast. How could one determine mechanically what the proper distance is to achieve that "spark"? About metaphor, Aristotle said that it is "the one thing that cannot be learned."

[45] *Waiting for Godot* is a play by Samuel Beckett. The characters wait for someone named Godot, who never arrives. They claim that Godot is an acquaintance, but in fact they hardly know him: they wouldn't recognize him if they saw him. To occupy themselves, they eat, sleep, talk, argue, sing, play games, exercise, swap hats, and contemplate suicide—anything "to hold the terrible silence at bay."

[46] Tom Briggs says that a "reflectaphor mirrors the apprehender of the reflectaphor." Bohm would say the observer becomes revealed as the observed. He says that, in the context of a particular artwork, a reflectaphor mirrors other reflectaphors within that same context and, in fact, is a reflection of the whole of that context.