THE UNITY OF THE SCIENCES IN UNIFICATION THOUGHT

VOLUME THREE

LIFE, MIND AND SPIRIT

by

Richard L. Lewis, PhD

UNIFICATION THOUHT INSTITUTE
SEOUL • TOKYO • NEW YORK

To my
True Parents

With Thanks.

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The Unity of the Sciences in Unification Thought

Volume One:	Quantum Foundations of Biology
Volume Two:	Mathematics, Physics and Chemistry
Volume Three:	Life, Mind and Spirit

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FORWARD

Unification Thought[1] is the worldview founded on the teachings of Reverend Sun Myung Moon. His view of God, mankind and the universe is explained in the *Divine Principle.*[2]

This worldview has profound implications for all the sciences and, in this *The Unity of the Sciences in Unification Thought*, I explore them in detail.

The first volume in the trilogy, *The Quantum Foundations of Biology,* was written 10 years ago, and is based on my Ph.D. Thesis. In this, I apply the concepts established in quantum physics to the sciences of biochemistry and genetics. This volume was previously published as *Do Proteins Teleport in an RNA World?*

The second volume in the trilogy, *Mathematics, Physics and Chemistry,* was written 5 years ago. I this I expanded the earlier ideas in the fundamental sciences. This volume was previously published as *Unified Science, Book One.*

The third volume in the trilogy, *Life, Mind and Spirit,* was completed in 2013. In this, the principles derived in the second volume are applied to the life sciences and the human mind and spirit.

I hope this trilogy will inspire intellectual development of a science that embraces the whole of the Cosmos; God, mankind, mind and spirit. There is much work to be done by the generations to come. I wish them well.

Richard L. Lewis
Manchester, NH
November 2013

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SYSTEMATIC HIERARCHIES

In *The Unity of the Sciences, Volume One,* we discussed how modern physics has replaced concepts at the foundations of all sciences, and speculated on how this change in their foundations would alter the biological sciences. The second and third volumes in the trilogy develop these ideas in detail.

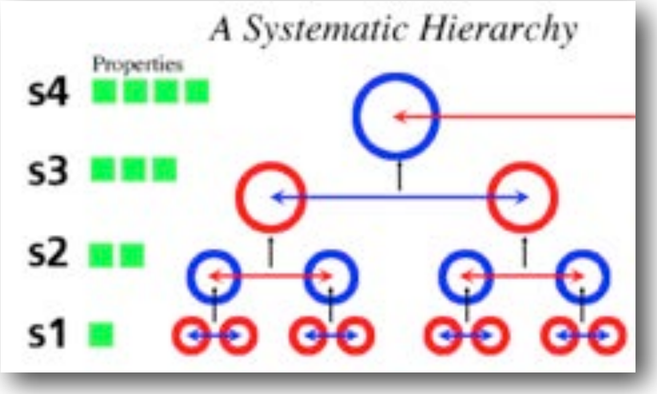
In *The Unity of the Sciences, Volume Two,* we dealt with the three realms that make up the cosmos, the entirety of everything. We called these the Abstract Realm, the Physical Realm and the Spiritual Realm. In *Volume Two*, we dealt mainly with aspects of the cosmos that are considered to be firmly established and well understood; mainly mathematics in the Abstract Realm, and physics, chemistry and cosmological history in the Physical Realm.

In this *The Unity of the Sciences*, *Volume Three,* we will apply these concepts to the structure, function and origins of living systems*;* the nature of the mind and the realm of the spirit.

A Systematic Hierarchy

Both the physical and abstract realms have the structure of a systematic hierarchy whose levels are distinguished by the sophistication of their emergent properties. The systems are composed of interacting subsystems coupling with sub-subsystems. We will review 'interaction' in a later section.

At the lowest level of the hierarchy are the simplest of systems, s1. The s1 systems interact to create more sophisticated systems, s2, with a set of emergent properties that are not possessed by the isolated s1 systems. We will discuss the source of these emergent properties when we discuss the *Logos*, a sophisticated, systematically structured type of Natural Law.



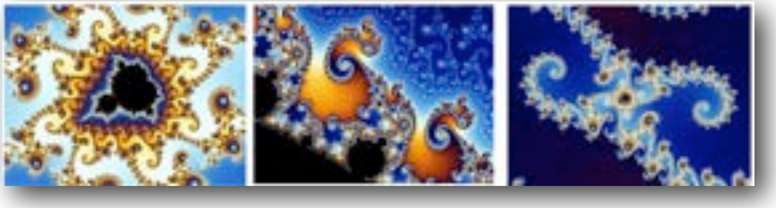
The s2 systems interact to create even the more sophisticated systems, s3, with a set of emergent properties which, in turn, interact yielding even more sophisticated s4 systems and on up, generating a hierarchy of emergent properties.

We will refer to this ubiquitous type of structure as a 'systematic hierarchy' of entities—the term *entity* simply meaning anything deemed worthy of being assigned its own name. A large part of *Volume Two, Mathematics, Physics and Chemistry,* was taken up with examining the entities at the lowest levels of the systematic hierarchy that comprise both the Abstract Realm and the Physical Realm.

ABSTRACT REALM

There are only two entities at the very foundation of the abstract realm, linear extension and circular rotation. In *Volume Two* we discussed both in detail and how they are seamlessly combined in the entity called a *complex number*. Unlike almost all types of numbers, complex numbers are technically *complete* in that whatever you do to a complex number, you always end up with another complex number. The set of complex numbers are a closed and complete system. The integers, on the other hand, are an example of a set of *incomplete* numbers since doing things to integers, such as making fractions out of them or taking the square-root of minus-one, does not result in another integer.

The study of the lowest levels of the abstract realm is mathematics. We discussed how the concept of *Absolutely Nothing* is inconceivable inasmuch as it implies, by Set Theory, the concept of One, and this in turn implies the counting integers, the simplest of all numbers. These are at the foundations of math and have emergent properties such as addition and multiplication. We discussed the systematic hierarchy of the integers, the rational, the irrational and the transcendental numbers—all of which are purely linear extension—and their combination with angular rotation to create the complex numbers. The highly sophisticated properties of these complex numbers were illustrated by the forms created by simply adding and multiplying them together to generated the intricate forms expressed in the Mandelbrot Set.

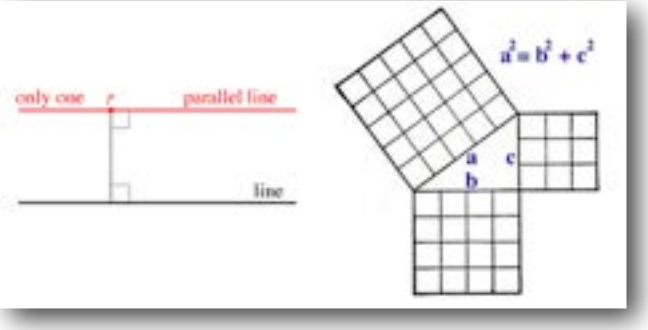


The connection of this abstract level with modern physics was noted in that spacetime, in special relativity, is described by complex numbers, and the behavior of fundamental particles is accurately predicted, in quantum mechanics, by repetitively adding and multiplying complex numbers.

Cause and Effect

The lower and the higher levels of the abstract realms are inextricably intertwined so that it is impossible to say which level is the cause and which level is the effect. Put another way, it is impossible to say which came first.

An example is the simple Euclidean concept of singular parallel lines on an infinite flat plane. Euclid started his systematic hierarchy with a set of axioms, all of which were simple and obvious except for this “parallel axiom.” Unlike the other axioms, his statement about this one was quite convoluted and, when simplified, amounted to the assertion that, given a line and a point *not* on that line, there is one, and *only* one, parallel line passing through that point.



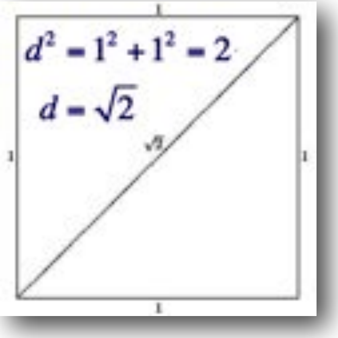
Later, a sophisticated manipulation of theses Euclidean axioms proved the sophisticated Pythagorean relation between the areas of squares sitting on the sides of a finite triangle.

It is impossible to say which is cause (came first) and which is effect (came after). Either can be taken as fundamental, i.e., as an axiom. It is impossible to prove the parallel postulate from any simple concepts—many have tried; all have failed—and there are no flat infinite planes available on which to test the assumption. So you have to take it as an axiom, a given about the way the cosmos works. But it is equally possible to take the Pythagorean theorem as the given axiom and easily prove the parallel postulate using it. Cause and effect are not aspects of the Abstract Realm. In the systematic hierarchy of the Abstract Realm, the simple levels are cause-and-effect and the sophisticated levels are also cause-and-effect.

↕	s4	Transcendental numbers	π e e^{π}
	s3	Irrational numbers	√2 √3 √5
	s2	Rational numbers	½ ⅔ ¾
	s1	Positive integers	1 2 3

Note that a systematic hierarchy cannot be changed at any level or the whole structure collapses. As it was assumed that space was flat, it was thought that Euclid's Parallel Postulate was an example of an unshakeable and absolute truth about the universe; once the concept of *curved space* was included, the axiom of a single parallel held true only in a flat space but was untrue in a curved space. A convex space has an infinite number of parallels, while a concave space has zero parallels. Euclid's problematic axiom has a limited *domain* of flat space, it does not have a universal domain.

Universal Truths



Some truths, however, do have a universal domain, they apply everywhere. An example is the *existence proof* of numbers that are not the ratio of two integer. Pythagorus was a great believer in ratios, but he was confounded in attempting to find the ratio that measured the diagonal of a perfect unit (flat) square. His own Pythagorean Theorem stated that the square of the length of this diagonal equalled the sum of the squares of the other two unit sides, equalled 2. So the diagonal was the number, that when squared, resulted in exactly 2. So the Pythagoreans then searched for the ratio of integers that, when squared, resulted in exactly 2. $\left(\frac{n}{m}\right)^2 = 2$

They failed in their search. As it is an instructive example of the abstract systematic hierarchy at work, we will pause to see one of the ways of proving that the square-root of two, √2, cannot conceivably be the ratio of two integers:

First, a few simple foundations:

1. An *even* integer leaves a remainder of 0 when divided by 2. Examples are 0, 2, 4, 6….
2. An *odd* integer leaves a remainder of 1 when divided by 2. Examples are 1, 3, 5, 7….
3. Both even and odd integers when multiplied by 2 become even integers.
4. Any integer has one, and only one unique factorization, the set of prime number factors ≠1 that, when multiplied together, result in that integer, n={p^n,q^n, r^n…} where n is the count of each prime in the factorization. As this is not obvious, this is simple subproof of prime-factors uniqueness.
    - a. One of Euclid's proofs is that if an integer, N, is the product of two or more integers, {a, b, c…}, and N is divisible by a prime number, p, then p must also divide at least one of the integers {a, b, c…}
    - b. Assume that there is an integer, N, that has two different prime factorizations,

      $N = \{p_1 p_2 p_3 \ldots p_n\} = \{q_1 q_2 q_3 \ldots q_n\}$
    - c. Prime p_1 divides N which is obtained by multiply all the qs together, so p_1 must divide one of the qs. But all the qs are primes, and only have the factors {1,q,} so p_1 must be identical to one of the qs. Renumbering the qs so that $p_1 = q_1$, and then dividing N by $p_1 = q_1$, and repeating it for all the ps. If all the ps and qs are identical, and all cancel out, then the result is 1. If all the ps and qs did *not* cancel we get the absurbd situation where a prime number not equal to 1 is equal to 1. The ps and qs must be identical. The factorization of every integer, note the domain, is unique.

      $\frac{N}{p_1 p_2 \cdots p_n} = 1 = q_?$
5. This unique prime factorization, P.f, of any integer has a count, n, for each prime in the factorization that can be:
    - f. An all-odd count of prime factors. Examples are all the prime numbers, with just 1 factor, e.g., {2}, {3}, {5}…, or 27 with a P.f of three 3s, {3x3x3}, or 54 with one 2 and three 3s {2,3,3,3}
    - g. An all-even count of factors present, e.g., 4={2,2}, along with the even number, 0, of prime factors that are all absent, 4={2^2,3^0,5^0…}
    - h. A mixture of even count factors and odd count factors, e.g., 18={2,3,3} with a count of 1 and a count of 2.

5. When any integer is squared to create another integer, the number of its prime factors is doubled. An integer that is a perfect square has an all-even count of prime factors.

$$\begin{aligned} N &= \{p^n, q^n, r^n\} \\ N^2 &= \{p^n, q^n, r^n, p^n, q^n, r^n\} \\ &= \{p^{2n}, q^{2n}, r^{2n}\} \end{aligned}$$

6. When a single prime is added to the prime factors of an all-even square integer, the count of that prime factor in the result becomes odd.

$$N^2 \times p = \{p^{2n+1}, q^{2n}, r^{2n}\}$$

On these simple foundations, it proves inconceivable that the number that measures the length of the diagonal in a unit square, the square-root of 2, is the ratio of two integers is quite elementary:

If √2 equals the ratio of two integers, squaring both sides of the equation gives 2 as the ratio of two square integers, both with an all-even prime factorization. In particular, both square integers will have an even number of 2s in the count of their prime factors.

Multiplying both sides of the equation by the integer m^2 results in an integer, N, that has two prime factorizations, one with an even count of 2s, the other with an odd count of 2s.

$$\begin{aligned} \frac{n}{m} &= \sqrt{2} \\ \frac{n^2}{m^2} &= 2 \\ n^2 &= 2 \times m^2 \\ N &= N \\ even &= odd \end{aligned}$$

As it is impossible that an integer not have a unique prime factorization—the *Fundamental Theorem of Arithmetic*—it is also impossible for √2 to be the ratio of two integers, a *rational* number. Rather, √2 is an example of an *irrational* number, and the diagonal of the unit square cannot be measured by the ratio of two integers to the chagrin of the Pythagoreans.

Measuring rotation

Moving on from linear extension in *Volume Two*, we then discussed circular motion and angular rotation, in terms of *i*, the rotation operator and the *imaginary* square-root of minus-1, $i^2 = -1$. Then we dealt with the sine and, cosine entities as open or closed, bound or unbounded waves.

Next, we combined linear extension and angular rotation into a discussion of the entity known as a *complex number*. In complex numbers, both size and rotation are seamlessly combined into one number. As complex numbers might seem to be exotic to some readers, we went into the many sophisticated emergent properties of the complex numbers, starting with an explanation of the various ways of expressing the same complex number, z, each with its particular usefulness.

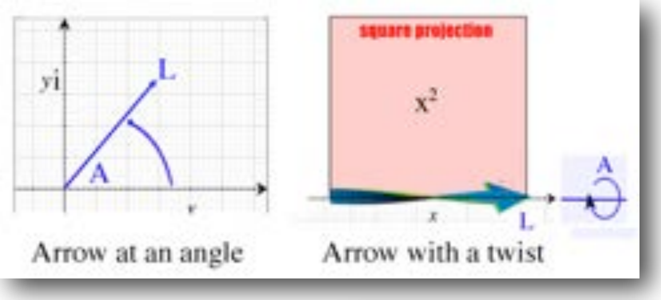
Finally, we looked at more examples of inextricably intertwined simple-sophisticated levels such as: the counting numbers and the irrational transcendental numbers; the distribution of the prime integers and the infinite sum of the zeros of the Zeta Function.

$$\begin{aligned} z &= (x + yi) \\ &= me^{ia} \\ &= m(\cos\alpha + i\sin\alpha) \\ &= m@\alpha \\ &= \nearrow \end{aligned}$$

s4	Bound waveform	ψ^2
s3	Sine wave	ωt
s2	Sine function	sin(a)
s1	Rotation operator	*i*

We then discussed how the Abstract Realm could give rise to the other two realms by creating two complementary structures at the initiation of the Big Bang (a topic that will be revisited in this volume).

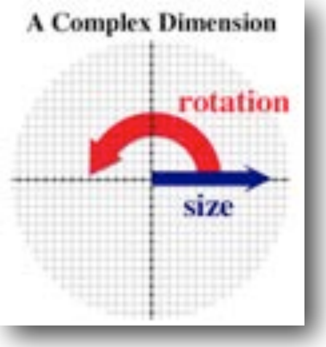
A complex number is usually illustrated as an arrow on a plane of two dimensions. While this is extremely useful—the popular book by Richard Feynman on quantum mechanics is full of little such arrows—it is misleading because it suggests an external rotation in two dimensions, x and y. A more realistic illustration of a complex is an arrow with a length and a twist along a single axis.



Arrow at an angle

Arrow with a twist

This twisted arrow represents a single, complex dimension. Much of the common perception of quantum science as being “strange” and “weird” is based on the common assumption that reality can be explained with simple dimensions, when in reality the universe can only be described by complex dimensions, and components of complex dimensions. This will become clear as this discussion progresses.



A very important property is the square projection (technically, the absolute square) of a complex number which, as the name suggests, is not a length but an area. In this case, the twisted arrow is a better illustration as the square projection is simply the square sitting on the arrow. If along the x-axis, the square projection is simply, x^2.

The relation between internal and external is as the relation of a complex number to its square projection, which is why so many important equations in physics involve the square of a parameter. The equation that gives the external probability of an event in quantum mechanics, for example, gives the square projection of an internal probability amplitude that is the result of adding and multiplying complex numbers. Squaring a line alters dimensions and it becomes an area. The absolute squaring a complex number alters dimensions, and internal becomes external.

THE PHYSICAL REALM

The Physical Realm, like the Abstract Realm, is also systematically hierarchical in structure with simple systems at the lower levels (e.g., electrons, quarks, photons, etc.) which are interacting subsystems of sophisticated systems at a higher level (e.g., water, aminoacids, nucleotides).

Unlike the two-way Abstract Realm, the relation of “which came first” is strictly one-way in the physical realm where the systematic hierarchy is built over time from simple levels to sophisticated levels.

In the physical realm, simple systems come together to create more sophisticated systems with emergent properties, and these systems, in turn, come together to create even more sophisticated systems. (It is this decidedly one-way nature of our physical experience that probably accounts for our tendency to assume that the counting integers came first and that the Mandelbrot Set came after when, in fact, they are inextricably both cause and effect.)

COMPLEX DIMENSIONS

At the very foundations of the physical hierarchy are time and space. In classical physics, this pair was taken at face value, and their external differences made them as different as chalk-and-cheese. They were obviously very different aspects of the experience of the physical realm.

Physics found things to be more sophisticated when it started exploring regions beyond everyday experience. The real numbers of classical science had to be replaced by the sophisticated concepts of Special Relativity, which unite time and space dimensions into a subset of a construct in four complex dimensions, four orthogonal complex planes. A complex dimension embraces both linear extension and angular rotation in a unity that can only be described by complex numbers.

While the mathematical entities on the complex plane—a single complex dimension—have been explored, witness the Mandelbrot Set and the Zeta Function, the mathematical structures in four complex dimensions have hardly been examined. A start has been made in the exploration of the octonions, one of the few algebras that allow for division. The octonions involve sets of eight numbers and have the unusual property of being *nonassociative* along with exhibiting the the more common *noncommutative* behavior. So, when performing the basic operations on octonions, shifting brackets or altering the order can produce quite a different result:

$$(x \circ y) \circ z \neq x \circ (y \circ z) \quad \text{nonassociative}$$

$$x \circ y \neq y \circ x \quad \text{noncommunative}$$

It is the mathematical exploration of such spaces, as well as the two subsets we will be assigning to the physical and spiritual metrics, that will broaden our understanding of spacetime.

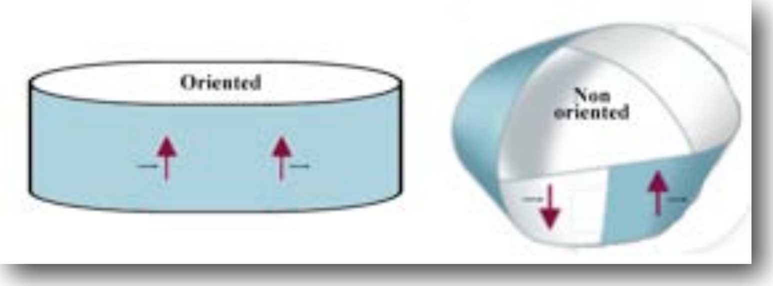
TWISTED SPACETIME

While not yet a mainstream concept, much about the nature of the fundamental particles that make up the physical realm can be explained by considering them as twists in spacetime that mix one dimension with another. Such twists have been suggested relatively recently:

> In the 1970s and 1980s, [Dr. John Moffat] further explored modifications to general relativity, including a 'non-symmetric gravitational theory,' in which extra terms are added to Einstein's equations (think of it as giving space a 'twist' in addition to being curved).[3]

General Relativity established that this complex spacetime could be curved on a large scale. The bosons and fermions uncovered by high-energy physics, out of which matter is constructed, all behave as topological twists in this complex spacetime on a the truly-minuscule scale of ten -trillion-trillion-trillionths of a meter. The tiny atom is a trillion-trillion times larger than this fundamental pixelation of spacetime.

These tiny twists can be 'oriented' twists (*or-twists*—in which no dimensions get mixed up—or 'nonoriented' twists (*nor-twists*) that do mix up dimensions. A transparent Moebius strip is a simple space with a nor-twist in which the two sides get mixed up. The nor-twist changes the two-sided space into a space with only one side. Traveling once around a Moebius strip turns you upside down, and you have to make another full circuit to get right-side up again. This defining characteristic of an nor-twist is called a spin of ½ as it takes two circuits to get back to the starting state. (The spin of a no-twist is 0, while a single 360°-twist has a spin of 1).



Transfer through, or by, a nor-twist always flips a spin into its opposite spin.

The fundamental systems at the foundation of the physical systematic hierarchy are twists in the physical metric. The oriented twists in spacetime are called the *bosons*, and the non-oriented twists in spacetime are called the *fermions*.

The spatial dimensions are twisted along the complex time axis and, as we shall see, can twist in either direction. As there are only three orthogonal space dimensions, the tiny twists that are the boson and fermion fundamental particles both come in sets of three.

BOSONS

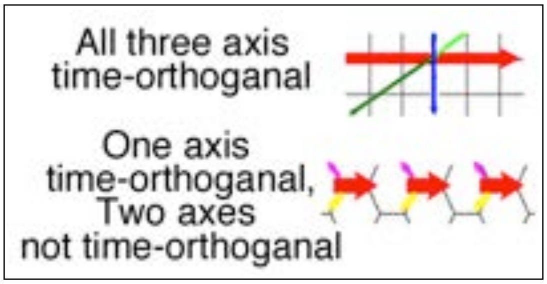
The bosons are simple or-twists in external spacetime. They are symmetrical open 'cosine' waves with a spin of 1 that does not mix dimensions. Bosons can have a single twist, or two orthogonal twists, or three orthogonal twists.

0 or-twist: The hypothetical Higgs Boson is expected to have zero twists.

1 or-twist: The simplest boson has a single or-twist, and is called a Z-boson. Being an open wave, all its energy is at the boundary which then abruptly falls to zero. This abrupt energy change at the boundary stresses the spacetime and this gives the Z-boson an enormous mass-energy of ~90 GeV. This energy can twist a second dimension, and there are two resonances, the W^+ and the W^-, that also have electric charge and a lesser mass-energy of 85 GeV.

2 or-twists: A boson with two or-twists at right angles is called a photon. It escapes the obeseness of the Z because the two twists resonate together out of phase, as a sine wave driving a cosine wave, and as a cosine wave driving a sine wave. The energy of one open boundary is constantly being transformed into the other open boundary. The energy in either boundary does not last long enough to amount to a Planck's Constant of *the action.* So the double-wave energy is virtual, not real, and there is no open real wave and no real boundary energy. The two aspects are called the electric and the magnetic, respectively, and a photon is an electromagnetic wave. The only energy is inherent in how tightly wound up is the double-helix in spacetime. Each photon has just one quantum of the action—a measure of energy-in-time—distributed between energy and time period. Existence, like space, time, and energy is also pixelated. For example, a radio photon is loosely wound; it is low in energy and long in time. A gamma photon is tightly wound; it is high in energy and short in time. But both have exactly one quantum of action.

3 or-twists: A boson with three oriented twists, all at right angles, in space along time is called a gluon. The three directions are differentiated by the three quantum colors—Red, Blue and Green—and the three quantum anticolors—Cyan, Yellow and Magenta—or antired, antiblue and antigreen. A gluon has one twist along positive complex time, a quantum color, and two pointing along negative complex time, as quantum anticolors. Using color terminology, the pairs are as in the chart. As discussed in *Volume Two,* the energy in these open waves twists the local spacetime out of its usual relectilinear configuration into a hexagonal configuration where only one direction remains as before—the positive color—while the other two shift by 30° or 60° as negative anticolors. In the illustration is a red quark as it is unchanged and orthogonal to the time axis, the other two axes are at only 60° or 30° in a hexagonal relation to the time axis.



So gluons come in different varieties, such as red-antired (cyan), red-antigreen (magenta), red-antiblue (yellow), red-antired (which is indistinguishable from blue-antiblue or green-antigreen). Having an odd number of twists, a resonance is not possible and a single gluon has a tremendous boundary energy. This is reduced when a large number of resonating gluons in a sphere—called a glueball—creates a surface in which the colored ends are crowded together with ends of other colors and anticolors. Each pixel of surface is constantly changing in colors and anticolors, it never remains the same for more than an instant. The color at a location never stays around long enough to amount to a pixel of the action, so the energy of the bit of colored surface is virtual. The surface of the glueball sphere is still where all the energy resides but, by this rapid flickering of color and anticolor, is now *virtually* colorless and the interior of the sphere is colorless and has zero energy.

	COLOR	ANTICOLOR
x	Red	Cyan
y	Green	Magenta
z	Blue	Yellow
x, y or z	color	anticolor

It is not considered unusual for the mathematics developed in one field is successfully applied to another, quite different field. This is an example. In *Volume Two* we explored the mathematics of color technology—the positive RGB colors of TVs and computers, and contrasted them with the negative CMY colors of printing [4]—and applied its insights to the open cosine waves of gluons.

Gravity's Boson

These are the three simple bosons with, with oriented twists of spin 1, that mediate the three fundamental interactions, the Weak, Electromagnetic and Strong, that are the foundations of quantum physics. In *Volume Two*, we also discussed the boson with integer spin-2, called the graviton, that is the *local* description of that faint universal tendency of all energy to clump together. This is best described as a *global* entanglement on the complex level, and the curvature of spacetime fabric quantified by the equations of General Relativity. Gravitons are so low energy as to be undetectable, although the death throes of massive stars are expected to generate gravity waves of synchronized gravitons that should be detectable.

There is also the putative Higgs Boson with integer spin-0 that would be involved in giving the fermions their (naked) mass-energy. If found, this boson will be an excited, but untwisted, pixel of spacetime.

FERMIONS

Fermions are composite, not singular entities like the bosons. At the core is a non-oriented twist, and this jitters about, shedding a halo of *virtual* bosons. It is as if the nor-twist is constantly trying to flip off its nor-twist but only sheds or-twists as a nor-twist is permanent (unless it meets an ant-fermion with exactly the opposite twist). The shed virtual bosons do not have pixel of energy-in-time action, the Planck's Constant necessary for real existence in spacetime, so they do not have a *real* existence—hence the name—and exist solely in complex spacetime. This halo of not-real, virtual or-twist bosons in which the nor-twist fermion is enshrouded is called the *charge* of the fermion.

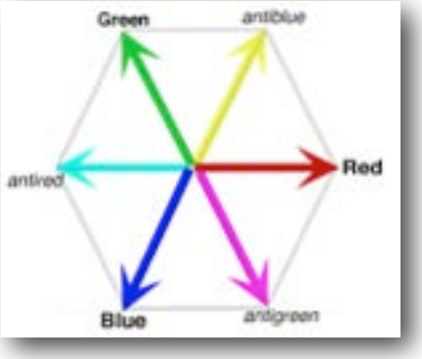
This halo can be directly experienced by attempting to force together the N-poles of two strong magnet. The cushion of virtual bosons is quite tangible, if invisible and insubstantial.

1 nor-twist: The simplest fermion is a single nor-twist in spacetime and is called a neutrino. It is surrounded by a halo of virtual 1-bosons which gives the neutrino a *weak* charge. If the twist is to the *left* along the time axis, it is a *matter neutrino*, if the twist is to the *right*, it is an antineutrino, an example of antimatter.

2 nor-twists: A fermion with two orthogonal nor-twists is called an electron. The electron is surrounded by a halo of virtual 1-bosons, which gives it a weak charge, and a halo of polarized 2-bosons, which gives it an *electromagnetic* charge. The polarization gives the electron a *negative electric* charge, a *down magnetic* charge, and a left spin. If it has a right spin, it is an antimatter *positron* with a positive electric charge and an up magnetic charge

3 nor-twists: A fermion with three nor-twists puts so much stress on spacetime that it collapses from its regular square-symmetry into the hexagonal symmetry that characterizes quantum color.

The three hexagonal nor-twists are called quarks that, depending on the pattern of collapse of 30° or 60°, can be either a D-quark or a U-quark alters the electromagnetic nor-twist. The shift gives the U-quark ⅔ the positive electric charge of the positron, and the D-quark ⅓ the negative electric charge of the electron. The U-quark is a variant built on a positron, so it could actually be considered to be ⅔rd antimatter.



The quarks are surrounded by a halo of virtual 1-bosons, which gives a quark a weak charge, plus a halo of polarized virtual 2-bosons—negative charge and down magnetism for the D, positive charge and up polarization for the U—and a halo of 3-bosons which, while individually flickering in and out of existence too rapidly to ever amount to a pixel of action, collectively have a real, and high energy, the energy that gives matter almost all its mass.

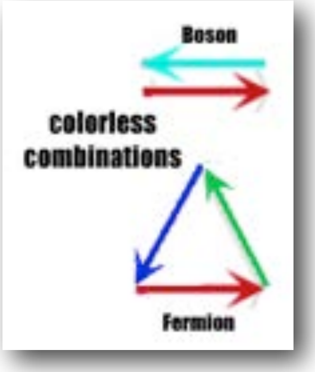
Depending on its hexagonal structure and which of the three spatial dimensions remains orthogonal to the time axis, a quark can have a red, blue or green *color*. Inasmuch as the energy of an isolated quark is unboundedly enormous, the existence of an isolated quark is impossible since it would have an infinite energy. This accounts for what physics calls the *confinemen*t of quarks; a free quark is impossible. Quarks can only exist in two types of virtually colorless confinements where all the energy is in a glueball surface pixelated with virtual colors and anticolors:

(1) **Mesons**. These are composed of a color quark and an anticolor antiquark, and are surrounded by a halo of gluons. They are bosons as they have an integer spin. The simplest are the pions.

(2) **Baryons**. These are composed of three quarks of each of the three colors and surrounded by a halo of gluons. They are fermions as they have a half-integer spin. The simplest are the nucleons, the proton of two U-quarks and one D-quark, and the neutron of two D-quarks and one U-

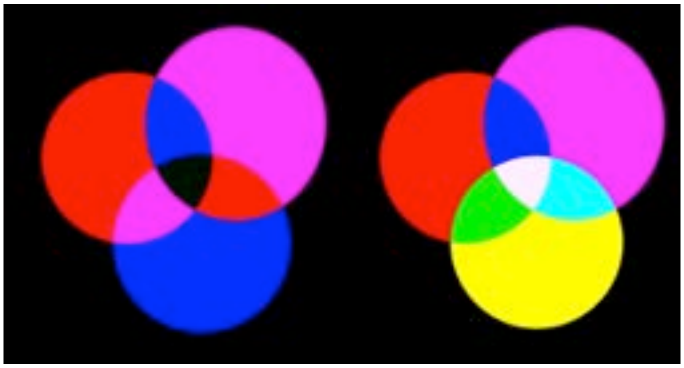
quark. Combinations of three U-quarks or D-quarks have been observed in high-energy physics.

SURFACE-NEUTRAL GLUEBALLS



In either case, all types of quarks throw off the now-finite color energy into gluons so rapidly that they are essentially colorless and behave as if a colorless 2-fermion. In this color-free state they are confined to the colorless center of the glueball of real gluons they generate about them. Over 99% of the mass-energy of pions or protons is in the pixelated surface of the glueball, a hollow center in which the now-colorless quarks jitter about.

As an aside, note that if the U-quarks have an anticolor, a colorless black in a neutron is attained with two colors and a third anticolor, while in the proton, a colorless white is attained with one color and two anticolors. The neutron has ~1% more mass-energy in its gluon halo than the proton, and it has a small probability of decaying into a proton, an electron and an antineutrino, with a half-life of about eleven minutes.



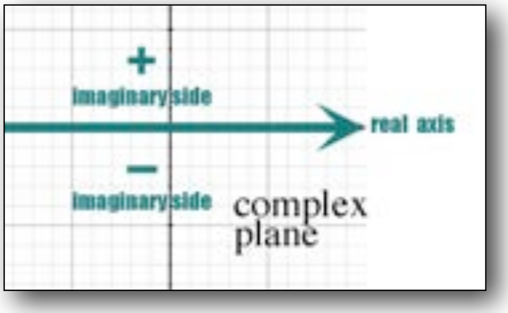
The bosons are symmetrical ‘cosine’ wave-twists in the space dimensions along the complex time dimension, and going backwards or forwards in along the complex time axis, they look the same.

This is not true of the fermions which are asymmetrical ‘sine’ wave-twists in space along the complex time dimension. A fermion going in the positive direction in complex time is called a ‘matter’ particle; a fermion going in the negative direction in complex time is called an ‘antimatter’ particle. So there is an anti-neutrino, an anti-electron (positron) with an opposite polarization, and antiquarks with anticolor that congregate into anti-protons and anti-neutrons. The pions are a quark and an anti-quark in temporary alliance so look the same both ways.

THREE GENERATIONS

There is yet another layer of complexity to the composite fermions: they come in three generations.

The first generation is based on the neutrino that has a nor-twist that mixes up a single complex dimension which, unlike a simple dimension, has a sidedness to it. The line of real numbers has a plus-imaginary side and a negative-imaginary side to it. It is these two sides that get mixed up in the nor-twist of a neutrino. As might be expected, this is not a high energy state and, for a time, the neutrino was considered as massless as a photon.



Adding a second nor-twist to this ‘electron-neutrino’ creates an electron, and adding a third creates a D or U quark. The foundation neutrino of this first generation , the *electron neutrino,* has a nor-twist in a single complex spatial dimension.

If the nor-twist of the foundation neutrino rotates two complex spatial dimensions as a unit, it is a *muon neutrino.* Adding a second nor-twist generates a *muon,* and adding the third generates an C or S quark.

If the nor-twist of the neutrino rotates all three complex spatial dimensions as a unit, it is a *tauon neutrino.* Adding a second nor-twist generates a *tauon,* and adding the third generates an B or T quark.

GENERATION # NOR-TWISTS	1	2	3
THREE	U quark D quark	C quark S quark	B quark T quark
TWO	Electron	Muon	Tauon
ONE	**x** e-neutrino	**xy** μ-neutrino	**xyz** τ-neutrino

The nor-twist of the foundation neutrino of each generation mixes the sides, by half-twisting one, two or all three complex spatial dimensions *left* along the time axis.

The rest energy mass of the neutrinos is small and difficult to measure. The muon is just like an electron except that it has ~200 times the mass-energy of an electron—105 MeV vs. 0.5 MeV. The second generation of quarks are like the first generation quarks but have a greater rest mass-energy. The C-quark is a very overweight D quark, while the S is an overweight U. While the collapse into the hexagonal form makes the U less massive than the D—of great importance for proton and nuclear structure—the collapse makes the C more massive than the S.

The tauon is an obese electron, while adding the third nor-twist results in the third generation of quarks, the B-quark that is an obese D-quark and the T-quark which is a morbidly obese U-quark.

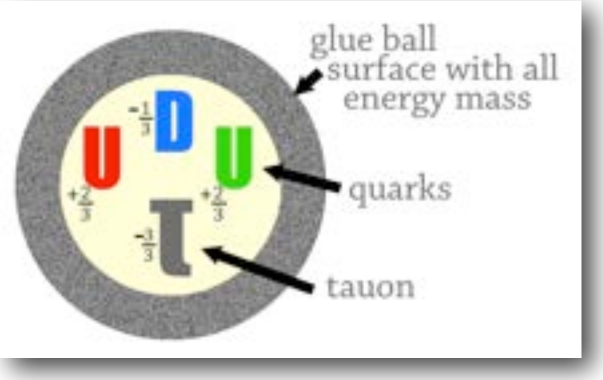
The quarks are not symmetric. In the first generation, it is the positive baryon, the proton, that has less mass-energy than the neutral baryon. This is usually said to result because the D-quark is more massive than the U-quark (even though examination of neutral first-generation mesons, the pion, finds them to be 50% a +U–U pair and 50% a +D–D pair). The other possibility is the difference between the black and a white colorless canceling in the neutron and proton. Whatever the reason, it is swamped by other concerns, since in the second and third generations it is the neutral baryon that has less, and the positive baryons the greater, mass-energy, and usually exponentially so.

All the fermions in the three generations have their anti-matter counterparts. The second and third generations played a role in the Big Bang, but everyday life involves only the first generation.

	QUARKS		
	1st	2nd	3rd
Charge + ⅔ Spin ½	**U** 0.002 GeV	**C** 1.270 GeV	**T** 171.2 GeV
Charge – ⅓ Spin ½	**D** 0.005 GeV	**S** 0.104 GeV	**B** 4.2
Mass ratio	*0.4*	*12.2*	*40.8*

Room temperature fusion

The tauon has interesting possibilities for technology as it is quite capable of taking the place of the electron in the hydrogen atom. The rest mass of the tauon at 1,776 MeV is almost twice that of the proton at 938 MeV, so the 1s-orbital of the tauon is confined deep inside the proton, far below the massive surface, jittering with the UDU color-free quarks almost as an equal. The isolated tauon is unstable, and falls apart in 30 trillionths of a second into a tau-neutrino and a W^- boson. The W then decays into leptons 35% of the time, and 65% into a neutron, an electron and a neutrino. Inside a proton, it is probable that these pathways are inhibited and the confined tauon stabilized by its environment.



This is a novel nucleon with zero electric charge as all the virtual photons of the electromagnetic interaction are as confined as the gluons are. But the system still has the chemical imbalance of a hydrogen atom and has the usual valence and reactivity of a hydrogen atom. Two tau-hydrogen atoms will chemically unite into a tau-hydrogen molecule.

In this tau-hydrogen molecule the two nuclei are touching. This two-proton combination is unstable as it has excess nuclear energy over the more stable one-proton, one-neutron *deuteron* combination. A D quark beta-decays, liberating a couple of 2 MeV energetic gamma photons, while the two protons have united to become a single deuteron. This concludes our brief foray into the possibilities of room temperature, hydrogen fusion.

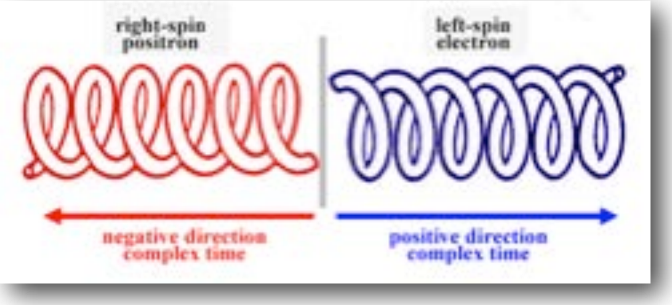
ANTIMATTER

As mentioned, the twists in spacetime are in the three spatial dimensions along the time axis. An oriented boson has an identical projection from the internal to the external going in either direction along the time axis. A photon, for instance, is externally identical going forwards or backwards in complex time.

This does not hold for the nonoriented fermions. Twists along the positive time axis are matter fermions, while twists along the negative time axis are antimatter fermions. An electron's two nortwists are both along the positive complex time axis, while a positron has the same twists but along the negative complex time axis.

This is not really time travel because the external, observable movement through time is the square projection of complex time, and this is always positive.

$$+t^2 = (+t^2) = (-t^2)$$



Even though the electron and positron are traveling in opposite directions through complex time they both travel in the same direction in observable time.

If a left-spinning electron were reflected in a (hypothetical) time mirror, it would be observed as a right-spinning positron.

A Chiral universe

There was an assumption shared by both classical science and early quantum mechanics, an assumption that was so commonsensical that no one even realized it was an assumption. It was one of the "unknown unknowns" and not one of the "known unknowns" in our theories of how the universe functioned. I am sure the reader will agree that it is a most reasonable assumption. The universe has no preference for rotating in one direction as opposed to rotating in the opposite direction. In more technical terms: the universe shows no *chiral* preference for rotating clockwise or counterclockwise, for spinning up or spinning down, or for twisting to the right or twisting to the left. All else being equal, the universe is not inherently chiral.

Angular rotation, unlike linear size, can appear to be different depending on how you look at it. From the front, for example, the hands of a clock appear to be going clockwise, but if you walk past the clock and look back at it, you will see that the hands are moving in an counterclockwise direction. Its chirality is dependent on your point of view. The only situation in which the clock has an absolute chirality is if it is moving away from you at the speed of light so there is no possibility of overtaking it and viewing it from the other side. This is true for subatomic particles: only those traveling at light speed have an *absolute* chirality. Fundamental particles moving at sub-light speeds have a *relative* chirality as you can always move and view them from the back side.

The non-oriented twists of the sub-light fermions do come in two relatively opposite chiral forms, and they like to pair up as chiral pairs they have no overall chirality. For electrons and protons with an appreciable rest-mass, it is only with difficulty that they ever get close to light speed, so their chirality is always relative.

The only exception to this is the neutrino, which has, at most, only 1eV of rest mass-energy. If it created with a lot of kinetic energy, say 1 MeV, it will shoot away at light speed to an accuracy of a dozen decimal places. In such a situation, the neutrino will have an absolute chirality. Neutrinos that are generated in the decay of radioactive nuclei have kinetic energies in this range, and it was expected that such neutrinos would be found to have an absolute chirality that was either right-handed or left-handed in equal numbers.

Some odd aspects of the weak force that was responsible for the decay could be explained by a chiral preference, but it took the genius of Madame Wu, a Chinese-American *grande dame*, to come up with an experiment, and then perform the difficult experiment (involving a magnetic radioactive isomer of cobalt in an ultra-cold high-vacuum), to put the assumption of chiral equality to the test.

It would be an understatement to say that the results of this investigation into absolute chirality shook the scientific edifice—all the neutrinos were spinning to the left; the physical universe was fundamentally left-handed. Furthermore, as theory digested this fact about absolute chirality, it turned out that while a left-neutrino had a minuscule rest mass-energy, a right-neutrino would have a truly enormous mass-energy far beyond that yet reached in any experimental apparatus. To this day, no one has yet detected a right-neutrino.

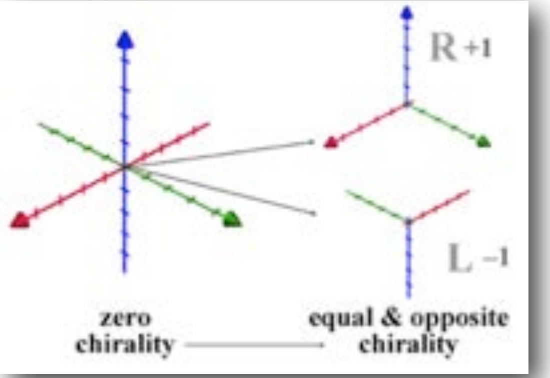
The implication was that the electrons and quarks also had an absolute left chirality, a chirality that was lost in their normal state of sub-light speed.

The tiny fraction of quarks and electrons that emerged unscathed, after all the electrons and anti-electrons (positrons), quarks and anti-quarks created in the maelstrom of the Hot Big Bang had annihilated with each other into gamma rays, were of high-energy, and all the fermions in the universe had an absolute left-spin. As the universe cooled and expanded, the fermions interacted with each other, shedding their kinetic energy as extra photons, and the sub-light speed world of atoms appeared on the stage of history. The absolute chirality was lost in the familiar universe that has no preference for left over right angular rotation.

The absolute ‘left-handedness’ of the early universe that distinguishes ever-present matter from extremely rare antimatter (that spins in a right-handed direction along negative, complex time) must either have been established at the singularity of the Big Bang or it was established in the first few ticks of quantum time. It could not have been later since all that followed was symmetrical and could not alter a chirality in any way.

While current theory looks for a ‘just after’ scenario to explain the asymmetry, it will be simpler in the approach we are developing if we consider the ‘right from the very start’ scenario. The structure of the complex physical metric is left-handed, although this is lost in the square projection of observable space and time.

Chiral relations are not possible in one dimension or two dimensions, but they are possible in three dimensions. Consider the three orthogonal axes, colored red, green and blue in the 2-D illustration, each axis extending out in either direction If the construct is separated at the zero point into two separate spaces as shown, then the two spaces are chiral complements, that are equal and opposite, as +1 and –1, or R and L.



No matter how you rotate the spaces, it is impossible to superimpose all three colors—when two of them are aligned, the third is always pointing in the wrong direction.

Modern science is quite comfortable with zero decaying into equal and opposite parameters. The virtual foam that is the vacuum is an example of the decay, where the parameters can be a unit of ±spin, ±electric charge ±magnetic moment, or ±strong-force color, ±momentum, etc. It is really a generalization of Newton’s ‘action and reaction are equal and opposite’ to the realm of quantum physics and the vacuum.

$$\boxed{\begin{array}{l} 0 \rightarrow +1 \;\&\; -1 \\ \quad \rightarrow +i \;\&\; -1 \end{array}}$$

CHIRAL WORLD

Because the Logos involves complete, not component, complex dimensions, it is not chiral. Its effect in the left-handed complex spacetime of the physical realm is decidedly chiral. The sequential establishment of the physical systematic hierarchy involves many situations in which the chiral foundations reveal themselves.

For instance, the complex structures on the midlevel of the Logos, which resulted in the subsystems uniting in the form we call life, differentiate between left and right.

1. Carbohydrate is a fundamental subsystem of all living systems and it plays a vital role in life’s functioning. Every single one of these molecules—from the ribose-sugars in virus DNA, to the glucose-cellulose in trees, to the glucose-sugar for tea and coffee—is a specific chiral form; they are all D-sugars—the reference compound rotates the polarization of light to the right.
2. Protein is also a fundamental subsystem of all living systems and it plays a vital role in life’s functioning. Every single one of these molecules—from the aminoacids in the yeast enzymes that turn sugar into alcohol, to the muscle fibers in a tender salmon steak, to the proteins that are pumping ions around in your eye and brain as you read—is a specific chiral form; they are all L-aminoacids (the reference compound rotates the polarization of light to the left).

The natural law, the abstract structure in complex space, that makes life probable is decidedly chiral. Only the D/L carbohydrate/protein combination is present at this level in the Logos; it does not have a D/D, an L/L or an L/D combination.

This suggests that all the living systems we eventually come across as we explore the universe will have the D/L structure; all things considered, they will be fundamentally fine to eat (the L sugars and the D aminoacids are poisonous.)

QUANTUM PROBABILITY

To summarize, observable reality involves a subset of four complex dimensions and its twists that are the fundamental bosons and fermions. The square projection of these four complex space-time dimensions is the observable location of a fundamental particle in real space and real time. As it is the square that is observed, even though they are moving through complex time in opposite directions, the square is the same for both and they travel together through observed time.

Quantum physics adds more complex dimensions to the picture. The square projection of these ‘higher’ complex dimensions is the observable probability of a fundamental particle being at that location. These higher complex dimensions are what scientists call natural law, a topic we will later discuss in more detail.

The probability is determined precisely by natural law, but quantum probability is not at all like the classical probability that is exhibited by the tossing of coins. At the foundations of classical probability is the concept of ‘independent assortment.’ For coins, this means that the result of the first coin toss has no influence on the result of the second coin toss, i.e., the probability of the second is independent of the result of the first.

A coin is composed of zillions of bosons and fermions, so it is somewhat surprising that neither bosons nor fermions obey the rules of classical probability and independent assortment. They follow two opposite types of ‘probability statistics,’ and classical probability is just the average of the two.

The three probability statistics—classical, boson and fermion—can be illustrated with a thought experiment with three types of coins that can come up heads, H, or tails, T, when tossed.

The classical, boson and fermion coins all behave the same when dealt with singly, they each come up 50% H and 50% T.

The dramatic difference between the three types of coins only shows up when two or more coins are thrown together.

1. The classical-coin pair has four equally-possible combinations that can result—HH, TT, HT, or TH—when tossed together. Two of these are *even* combinations with both the same (HH or TT) and two are *odd* combinations, the mixed (HT or TH). The result of independent assortment when tossing a classical coin pair is 50% even and 50% odd combinations.
2. The boson-coin pair when tossed together behave quite differently. A toss always results in *even* combinations—HH or TT—100% of the time. There is no independent assortment; this is an example of *dependent* assortment.
3. The fermion-coin pair when tossed together also behave differently but in an opposite way to the bosons. The toss always results in *odd* combinations—HT or TH—100% of the

time. Again there is no independent assortment, but a dependent assortment known as the *Pauli Exclusion Rule*.

The departure from commonsense classical probability is even more marked when a third coin is thrown. The boson coins continue with even combinations—HHH or TTT—a behavior that continues even when zillions are tossed, always an even combination. This is the quantum probability that results in the zillions of identical photons that compose laser light and radio broadcasts.

The third fermion coin is even less commonsensical in its behavior. It comes up 50% H or T but it refuses to land on the table, instead floating above the other two coins, and it is impossible to force it down to mingle with the other two coins.

COINS	1	2	3	4
CLASSICAL	50% H, 50% T	50% even, 50% odd	25% even	12.5% even
BOSON	50% H, 50% T	100% even	100% even	100% even
FERMION	50% H, 50% T	100% odd	$50\%\frac{H}{HT}$, $50\%\frac{T}{HT}$	$50\%\frac{HT}{HT}$

Electrons behave like this, and Pauli's Exclusion Rule of a zero probability of two electrons ever being in the same state that results in the sequence of ever-larger quantum orbitals that, when electrons inhabit them, give rise to the systematic hierarchy that is the periodic table of the elements and much of chemical behavior. The various elements all have a different, if periodically varying, set of emergent properties because of Pauli's rule.

In classical science, probability was a human construct that had no real existence. In the new physics, probability has the iron rule of absolute law and has a very real existence. It is quantum probability, for example, that will maintain the extension of our sun at planetary-size when it runs out of fuel and cools down from a white dwarf star to a black dwarf star 20-odd billion years from now. It will be quantum probability alone that will prevent any further gravitational collapse as the star remnant cools towards zero, Quantum probability is mighty indeed, and very real.

All this is enough to cause classically-trained scientists to throw up their hands and mutter about the weirdness of the quantum realm, the 'strange theory' that precisely explains so much about the world. But there is more the science has discovered about this Physical realm that is even stranger to the classical mindset.

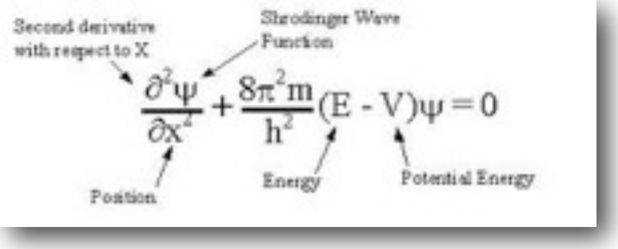
While spacetime and particles involve just a real and imaginary subset of four complex dimensions—we will discuss the complementary subset later in the discussion—quantum probability involves all of a complex dimension, the first level of natural law and the foundation of the systematic hierarchy that is the Logos.

We shall refer to the spacetime aspects of a system that are described by simple numbers as being 'external,' while the natural law aspects of a system described by complex numbers as being 'internal.' Quantum physics states succinctly that the fundamental entities of the physical realm are quanta of energy-twists in spacetime with an external particle aspect and an internal wave aspect, the projection of the internal determining the history of the external in spacetime.

Quantum waves

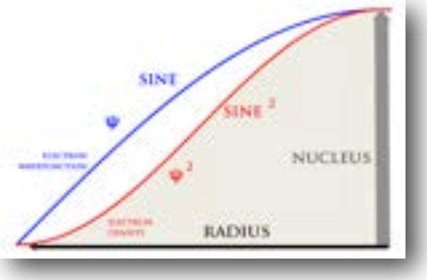
$z =$	$x + yi$	rectangular
	$me^{\alpha i}$	polar
	$m(\cos\alpha + i\sin\alpha)$	trigonometric

Both unbounded traveling waves and bounded standing waves are combinations of sine and cosine waves. The internal aspect of a physical system is a wave that is described by complex numbers. The trigonometric form of complex numbers explains why this internal aspect of fundamental physical systems is called its wavefunction, ψ (psi).



The wavefunction, of complex numbers *p@a*, is also called the *probability amplitude* because is absolute square, p^2, *is* the external probability of finding the electron density.

Over time, the electron has an overall average density around the nucleus that reflects the complex form of the wavefunction. When the wavefunction has the form a closed sine wave, the electron density around the nucleus—and the electron is rotating trillions of times a second—is exactly that of a closed, sine-squared wave.



It would be quite possible by adding up all the little arrows to come up with the shape of a helium atom. A shortcut called the Schrödinger Equation combines all the adding and multiplying of complex numbers, and condenses it all into a single, elegant equation. We explored in detail this equation in *Volume One*. While it looks formidable to the non-mathematician, the equation is actually stating something that is simple enough to be put into words for a helium atom.

First, because a helium atom is perfectly spherical, we can replace the position x with r, the distance from the nucleus.

Second, it states that the sum of adding the two main terms (involving the second derivative of the wavefunction, and the wavefunction) is always zero. These two terms are always equal and opposite.

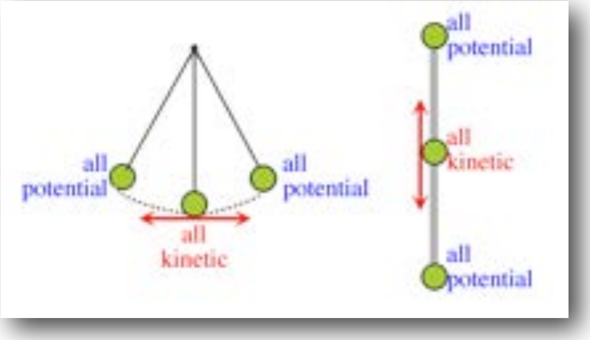
The first term is the second derivative of the wavefunction, which is very simple calculus. We are perfectly familiar with speed being the rate of distance travelled over time, and with acceleration/deceleration as the rate of change in speed with time. Acceleration is the rate of change in velocity, the change in the rate of distance travelled with time. A mathematician would say that velocity is the *first* derivative of distance with time, acceleration is the *second* derivative of *distance* with time (and the first derivative of *velocity* with time).

So, given that the wavefunction is the overall shape, the first term is a measure of the rate of change in the shape, how the curvature changes with distance from the nucleus. This term can be thought of as the acceleration of change in the overall form.

The first third of the second term is a constant that includes a multiple of π-squared, the rest mass/energy of the electron, and the square of Planck's Constant, the pixel of action and existence.

The terms within the brackets are E, the energy of interaction, and V, the potential energy at point r from the nucleus, the center of the interaction. Together they are a measure of how the interaction energy is distributed with distance along the radius from the center. This is akin to swinging pendulum bob with energy that is conserved but oscillates between two extremes, all as kinetic energy or all as potential energy in the gravitational field. At the center of the arc, the energy is all in the speed of the bob as it rapidly sweeps through the center. At the end of the arc, the bob is momentarily stationary before it swings back, and all the energy is in the gravitational field.

The electron in a helium atom is similar. When it is at the boundary, all the interaction energy, E, is in the electromagnetic field of the coupling virtual bosons, V. The velocity at the boundary is zero and the all the energy is potential, V=E. When the electron is streaking through the center, all the energy E is kinetic, and none of it is potential energy, V=0. The electron oscillates up and down the axis which is also rotating in all three spatial dimensions.



The two electrons move in phase to minimize their mutual repulsion: either both are at opposite ends and as far away as possible, or streaking past each other at the center so briefly that they hardly interact. The rotation rate is a trillion, trillion times a second.

The Schrödinger equation simplifies for the helium atom, and can be solved. The deceleration in the curvature of the form at distance r from the nucleus equals the enhanced mass times the form at distance r times the kinetic energy at distance r.

As the total energy always equals the sum of the kinetic and potential, the bracketed term is simply the energy in kinetic motion at a distance from the center.

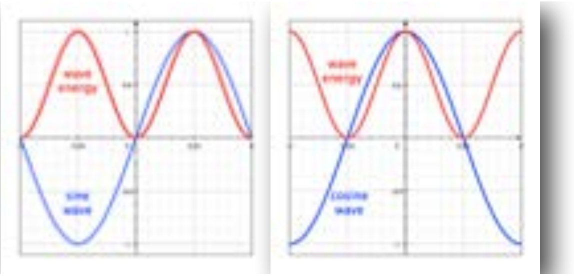
$$-\frac{d^2\Psi_r}{dr^2} = M(E - V_r)\Psi_r$$

The final term is simply the complex number that is the wavefunction at that distance. So Schrödinger's Equation can be simply expressed in words.

At every distance from the center, the rate of change in the form of the wavefunction, when added to the wavefunction mass times the kinetic energy, will always sum to zero.

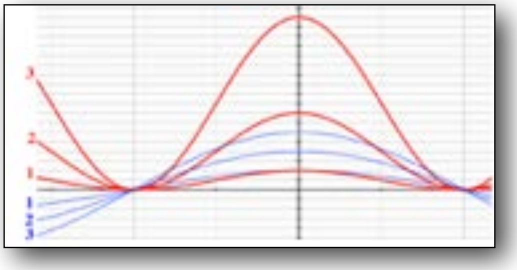
Like any equation, there are only a small set of solutions to this equation, and these solutions are precisely the orbitals of the elements. Each of the odd-looking 4f orbitals—uranium and plutonium have electrons in them—is a ψ that is a solution to the equation.

For a traveling wave, the only difference between a sine and a cosine wave is phase; otherwise they look the same. There is a significant difference between *closed* standing waves—exemplified by asymmetric sine waves with zero energy at the boundaries—and *open* standing waves—exemplified by symmetric cosine waves with all their energy at the boundaries. We saw a consequence of this in the massiveness of the Z boson and the hollow colorless centers of nucleons.



The wavefunction, the internal aspect of fundamental particles, is a waveform that can be either an unbounded traveling wave or a bounded standing wave. Most of the standing waves we will be dealing with in sophisticated systems will be closed, asymmetrical sine waves.

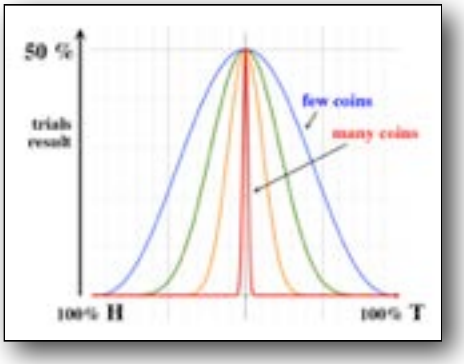
As we saw with the boson coins, bosons get together in even combinations where they are all in the same state. Their individual waves unite together with the amplitudes adding together arithmetically as 2, 3, 4, 5 … N, while the intensity of the wave—being the square of the amplitude—exponentially increases as 4, 9, 16, 25 … N^2. The intensity of the final wave can be enormous, as is exemplified by laser beams that slice through steel. The photons are all in the same state.



Both classical probability and both kinds of quantum probability are alike in one respect—they all obey the Law of Large Numbers. A classical coin toss illustrates the basic principle, i.e., the greater the number of tosses, the more accurately the actual result will precisely reflect the abstract probability.

Just throwing one coin results in either 1H or 1T, which does not reflect the 50% probability at all. Throwing ten coins you sometimes get 5H+5T, but often the result is 6H+4T or 4H+6T, or even 7H+3T or 3H+7T. Occasionally the even 10H or 10T will appear. But, if you throw a trillion fair coins at a time, however you will find that the result is 50±0.000,001%.

The Law of Large Numbers (LoLN) states that the probable deviation of the observed result from the true probability will be proportional to the square root of the number of trials. So a fair coin thrown a million times can be expected to result in 500,000±1,000 H and T. So a result of 450,000H and 550,000T would be highly unlikely if the coin was fair.



For classical science, this is somewhat a circular argument since the only way to test the fairness of a coin is to toss it repeatedly, the more tosses, the more accurate the measure. In quantum science, the probabilities can be calculated directly by squaring the complex probability. At present, this can only be done precisely for simple systems, such as the electrons of hydrogen and helium in their standing waves, the orbitals, about the nucleus.

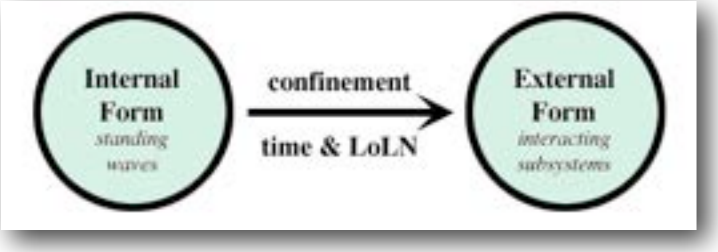
The electron wave sweeps around about a trillion trillion times a second, each second there are 10^{24} trials. The electron appears over even brief periods of time to be smeared out around the nucleus in an electron-density that has a boundary where it falls to zero—an orbital is a closed sine wave. The calculated density is exactly that of the observed density.

Confinement and form

We have already encountered confinement in the quarks and gluons of protons, neutrons and composites as nuclei. The internal wavefunction is a standing wave such that the probability of a quark or gluon leaving the nucleus is exactly zero. As described in the mention of white dwarf stars, the power of quantum zero is not to be trifled with.

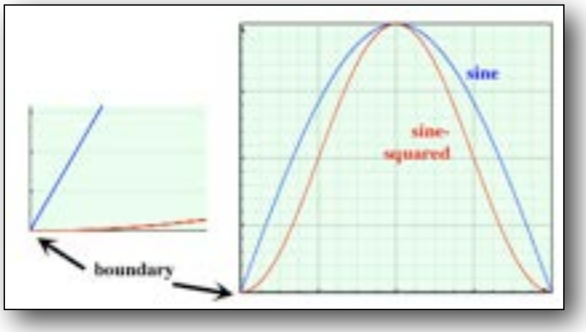
A better-understood example is the confinement of electrons by the internal wavefunction of atoms. For example, the probability of an electron, proton or neutron leaving a helium atom is essentially zero. The internal aspect of the helium system, a set of resonating standing waves, confines all the subsystems as the external aspect of the system. The form of the internal aspect, by the LoLN, is expressed as its square in the external probability density of the electrons.

The electrons are subsystems of the helium system, and it is the internal aspect of the helium atom that determines the external density of its subsystems. This principle holds for all systems: The form of the internal aspect determines the external form of the interacting subsystems over time.



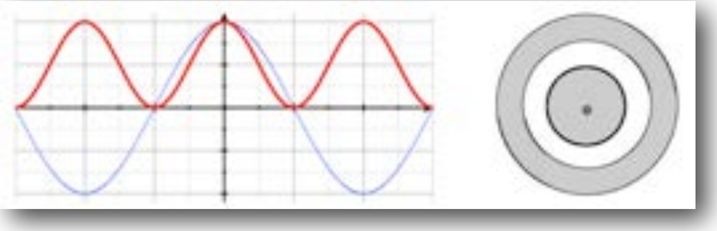
In bounded waves, the LoLN has a direct relation with time. In a wave, the same state occurs with each cycle, so the number of trials in a second will depend on the frequency. We can define the characteristic period of any system to be the time in which sufficient trials occur for the LoLN to express the internal form. The internal wave confines the subsystems of the helium atom into a perfect sphere, just as the wave of the atomic nucleus confines the quarks and gluons.

While the wave of the helium is a three-dimensional sine wave, it will suffice for our purposes to illustrate it with a simple sine wave. While the internal sine wave is rapidly changing at the boundary, the external sine-squared wave of the electron density has a zero rate of change there (more technically, while the sine wave has a derivative of 1 at the boundary, the sine-squared wave has a zero derivative there). While the internal form of the wavefunction is that of a sine, the external form of the electron density is that of a sine-squared wave.



This perfectly spherical density of electrons is greatest at the center and zero at the boundary—it is as close as modern physics gets to the “massy spheres” of solid matter at the foundations of classical physics. The helium atoms in thermal motion behave just like billiard balls; they bounce off each other in 3-D just as solid balls do on a pool table. This is why helium is as close as reality gets to being a perfect gas.

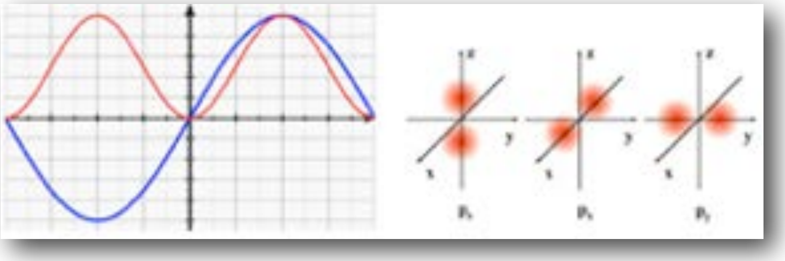
The helium’s electrons are in a standing spherical wave called the s-orbital with a zero electron density at the boundary and the maximum density around the center. A simple sphere, however, is not the only form that the standing waves can take up. While the standing wave of the 1s-orbital involves only 1 ½-sine wave, the 2s-orbital involves 3 ½-sine waves. The density of the electron is zero at the boundary, but there is now a second node of zero density between the boundary and the center. The electron density is now in both the center and a shell about the center.



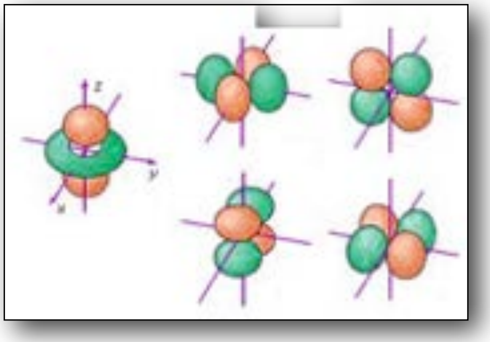
2s orbital

The 3s-orbital has five ½-sines, the 4s has seven, etc. It is these s-orbitals, with only a singlet electron in the neutral atom, that give hydrogen, lithium, sodium, potassium their chemical properties that make them essential in living systems. The illustration is that of a single electron in the 2s orbital state with a lobe at the center and one on either side.

The s-orbitals involve a standing wave with an odd number of ½-wavelengths. There is also a family of orbitals involving an even number of ½-wavelengths called the p-orbitals. When the simple s- and p-orbitals are filled with electrons, the result is a very low-energy, and chemically inert. The simplest p-orbital is the 2p which, along with a boundary node, has a single inner node at the very center where the probability density of a 2p-orbital electron is exactly zero.



The probability density is in two lobes on either side of the center, and a 2p electron is 50% of the time in one lobe and 50% in the other. There are three p-orbitals that can fit at right angles about the central nucleus, when they are full of electrons the density is almost as perfectly spherical as that in helium. The neon atom has its s- and p-orbitals filled, and the electron density is almost as perfect a sphere as that in helium. Helium is the first, and neon is the second, of the ‘noble’ gases that form one column in the periodic table of the elements. The p-orbitals play a significant in the chemistry of the elements that are the main subsystems of living systems, such as carbon, nitrogen, oxygen, sulphur, phosphorus and chlorine.



In 3-D, standing waves can take on some unusual forms, such as seen in the d-orbitals that have two nodes at the center. Four of the forms are variations on the p-orbital theme but one of them has a most unusual donut form.

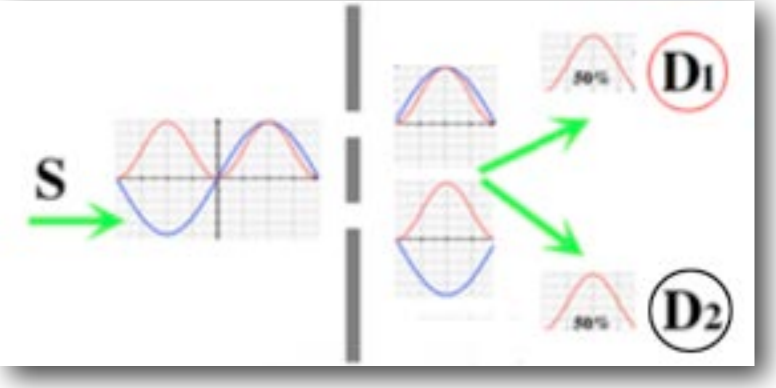
Entanglement

We have already seen that when scientists started to probe into a detailed understanding of nature they found that the ‘nuts and bolts’ running beneath everyday reality were a lot more sophisticated than any simple classical concepts could handle. The orbitals introduce what is probably the least commonsensible, most classically impossible way the very simplest, fundamental systems in the physical hierarchy behave.

An single electron in a p-orbital has a 50% probability of being in either lobe and a zero probability of being at the center. A single electron in a d-orbital, as illustrated, is 50% of the time in the red lobe and 50% in the green lobe, and 25% of the time in each of four-lobed forms. It does not travel between the lobes; it is sometimes in one lobe and sometimes in another, but it is never in the space between them. Some would call this jittering back and forth while ignoring the space in between—a simple form of teleportation.

While classically strange, this is the way things are, and a simple experiment suffices to illustrate such nonclassical behavior. When a wave passes through two slits that are close together, the wave splits into two waves that move apart in space. The external separation, however, does not change the internal wave and its associated probability density. A single electron goes 50% through one slit and 50% through the other one.

If an electron is sent one-by-one from a source, S, through the slits to detectors D1and D2, the wave splits in two and the electron density is now in two lobes that are substantially separated. The electron is 50% in one lobe and 50% in the other lobe with a zero probability of being in-between the two lobes. It does not travel between lobes, it is either in one or the other.



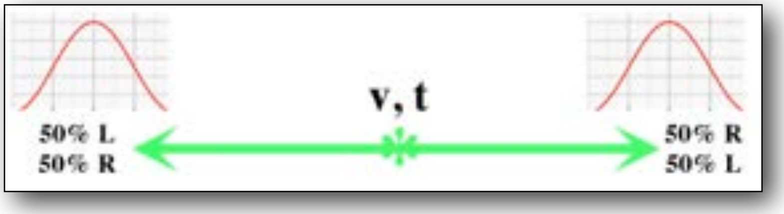
It is just a matter of chance which

lobe it is in when the wavefront intersects the detectors and the electron interacts with it. The interaction instantaneously alters the wavefunction of the electron. The distant lobe disappears—called *the collapse of the wavefunction*—and the wave changes to form localized in the firing detector. D1 will fire 50% of the time, and D2 will also fire 50% of the time. Like a coin, it takes the LoLN to express this probability, so many electrons need to be sent one by one through the apparatus to show this "interference" effect.

Such *slit experiments* in which the classically-impossible feat of passing through both slits at the same time are not confined to simple electrons and photons, decidedly 'bits of matter' molecules of 90 atoms have been successfully passed through two slits at the same time. All 90 atoms being 50% of the time in one lobe, and 50% of the time in the other lobe that is centimeters distant. Teleportation indeed.

It should be clear by now why scientists speak of reality as being permeated with "quantum weirdness" and abandon it for the comfortable, if only approximate, concepts of classical physics. By any common application of the word "weird," the implications are "not normal', "not natural," "not what one would expect." But the fabulously-successful concepts and equations of quantum physics apply throughout the known universe, and as such are the very paragon of what is normal, natural and what one *should* expect. Hopefully, the next generation of physicists will expect the universe as it is and not think anything weird is going on at all.

This phenomenon of being in two places at the same time because of the internal wave is called 'entanglement,' and is particularly fascinating and nonclassical when pairs of particles are involved. If two entangled particles, one spinning left and the other spinning right, move apart at velocity v, for a time period t, they will both be in the same wave but constantly switch locations. The L will be in one lobe 50% of the time while the R is in the other, and vice versa.



The most astonishing thing about such entanglement is that it is independent of both v and t. Theory suggests that even if the velocity of separation is close to light speed and the time since separation is billions of years, the same phenomena holds—L or R will be found in one lobe and R or L will be in the other lobe. That the node externally separating the two lobes of the wave stretches across giga-light-years to the edge of the visible universe is irrelevant to their internal wavefunction. The particles are quite oblivious to their external separation in space.

As many natural processes in outer space eject such entangled particles, and many reach us here on earth as cosmic rays moving at essentially light speed. If the separation of the entangled particles occurred ten million years ago then its entangled partner is 20 million light-years away.

The technological implications for interstellar travel of being able to exploit this natural and abundant web of internal connections across the vastness of space are clearly considerable.

PHYSICAL INTERACTION

Helium is an example of a system whose internal wave firmly confines all of its interacting subsystems; in most systems, the confinement of at least some of the subsystems is only partial.

We have already seen such an example in the electron whose internal wave does not locally confine the virtual photons and they fade off to infinity as the electric field created by the electric charge, although it does keep the weak bosons firmly confined.

In a systematic hierarchy, the stability of a system is dependent on the stability of its subsystems. While the internal wave of a neutron confines its subsystems as firmly as a proton does, if one of the quarks decays into another quark, the neutron is also altered. The quarks in the colorless center have a halo of virtual photons and weak *virtual* bosons and, if one of its D-quarks ejects a weak *real* boson—which, before it amounts to a quantum of action, decays into an electron and antineutrino. The result is the the D-quark becomes a less-massive U-quark, the *beta decay* converts the neutron into a proton. The half-time for this ‘beta decay’ is when the LoLN states that 50% of a large number of neutrons will have become protons. This is ~11 minutes, an age in nuclear time, and the reason why the weak boson was given such a moniker.

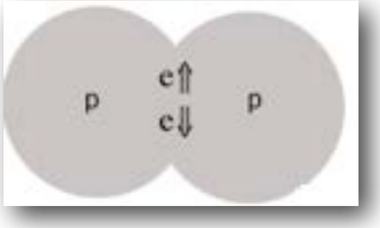
An atomic orbital is filled when it contains two electrons spinning in opposite directions. If two fermions with the same spin attempt to get together, their internal waves merge and cancel out by destructive interference; the probability of them getting together is zero. If the fermions have opposite spins, however, the nor-oriented ½-spin flips the sine wave so that the two waves combine, just as the boson waves do. The internal probability becomes a 2sine wave while the external probability becomes a 4sine-squared wave. This high probability gives such a matched electron-pair a low energy and a high stability.

These electron-pairs are so stable that much of chemistry is contained in the admonition, “Thou shalt not break up an electron pair.” Much of chemical change is driven by an electron moving to create a stable pair with another.

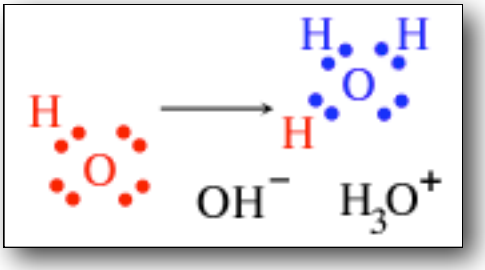
A hydrogen atom has a single electron in the s-orbital. This is an unbalanced, high-energy and unstable state that gives the atom its a ‘chemical valence,’ determining how it interacts with other atoms to make a stable electron-pair. The hydrogen with this singlet electron is called a free radical, and it highly reactive chemically.

In the systematic view, the subsystems of any system can be divided into two classes, the ‘core’ subsystems that are firmly and stably confined by the internal wave, and the ‘peripheral’ subsystems that are not. For the hydrogen atom, the quarks and gluons are core subsystems, while the single unbalanced electron and halo of virtual photons are peripheral subsystems. The electron is called the ‘valence’ electron of the hydrogen atom, and the unbalanced virtual photons are its electric dipole.

The hydrogen atom can make a pair by sharing, gaining or losing its electron. A H-atom can share its electron, for example, with another H-atom. Their two atomic waves merge into a single football-shaped molecular wave that firmly confines both paired electrons, all the virtual photons and, of course, the quarks and gluons. This is a stable system at ordinary temperatures and a gas of hydrogen molecules will last indefinitely.



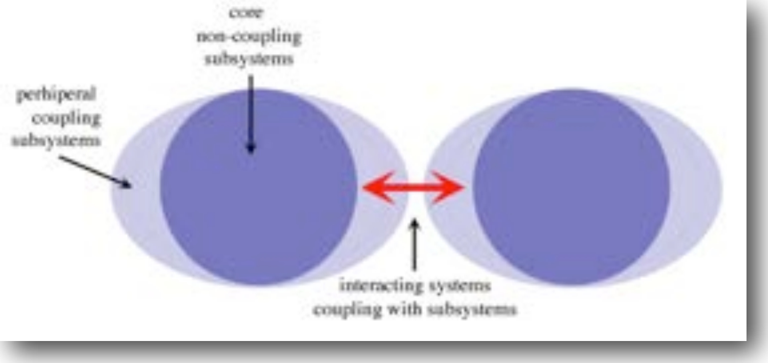
An H-atom can also abandon the single electron and share an electron-pair with another atom. A oxygen atom has two p-orbitals containing electron pairs that the H-atom can share. This is what happens in acids and, when a hydrogen atom leaves a molecule it is a part of, abandoning its electron, and shares an electron pair in the p-orbital of an oxygen atom in a water molecule. The acidity of acids is not free protons, as H^+ would suggest, but the H_3O^+ ion.



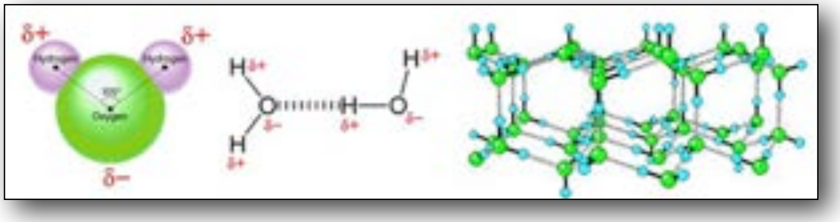
Occasionally, the hydrogen atom can be induced to take on an electron (by pushy atoms such as sodium) and become a hydride ion. This is not a particularly stable situation, and NaH reacts with water to release hydrogen gas.

Covering all these ways, hydrogen is said to interact by ‘coupling’ with its electron. This illustrates a general principle—systems interact by coupling with their peripheral subsystems. An electron and positron interact with each other by coupling with their peripheral virtual photons, forming a 1s ‘atom’ of positronium momentarily before they meet and annihilate into photons.

A system is capable of coupling in all the ways that its subsystems are capable of, and it is capable of coupling with the subsystems themselves. A hydrogen atom is capable of coupling with electrons and photons; a water molecule can also do this as well as couple with hydrogen atoms. Larger molecules are capable of coupling with fragments of molecules, called radicals, such as OH–, and so on.



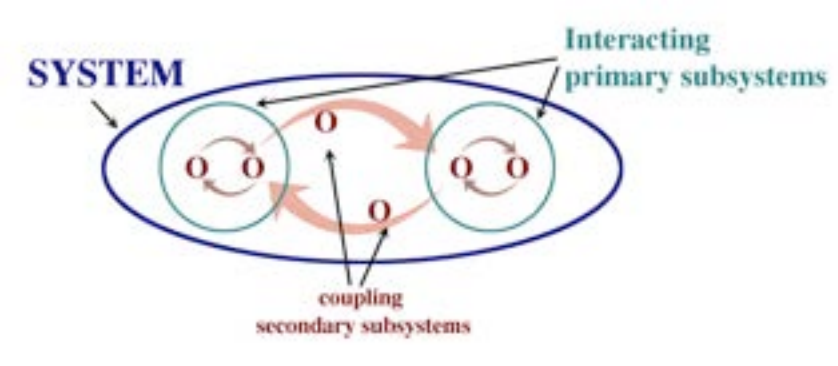
Unlike the symmetrical nonpolar bond in a hydrogen molecule, the bond between H and O atoms is asymmetrically polarized, and the electrons spend more time about the O nucleus than they do about the hydrogen. This allows water molecules to couple with each other by coupling with hydrogen atoms, the hydrogen bond that is responsible for all the anomalously-useful properties of bulk water and the hexagonal symmetry of ice crystals.



Interacting subsystems

This coupling with subsystems applies to the interacting subsystems that comprise a system in a systematic hierarchy. A system is a set of interacting primary subsystems that couple with sub-subsystems, the secondary subsystems of the primary subsystems.

A systematic hierarchy of systems composed of interacting subsystems coupling with sub-subsystems has a triple-level structure, illustrated by molecules and cells.



This coupling by a system using its subsystems is the external aspect of interaction, but there is also an internal aspect to take into account. For subsystems do what the wave tells them to do over time, and the external is a result of the internal resonance of waves. The Logos is the source of the set of emergent properties that appears at each level during the interaction of the subsystems to create the system.

System	molecule	cell
Subsystems Interacting	atoms	organelles
Sub-subsystems coupling	electrons	molecules

Confinement

In system building, when a system emerges from its disparate subsystems, the internal waves of the subsystems resonate together, as prescribed by the Logos, as the internal wave of the system. The form of the internal system wave is prescribed by the Logos, and it confines the subsystems into the externally observable form of the system.

This confinement of the subsystems by the system wave can range from totally confined to barely confined.

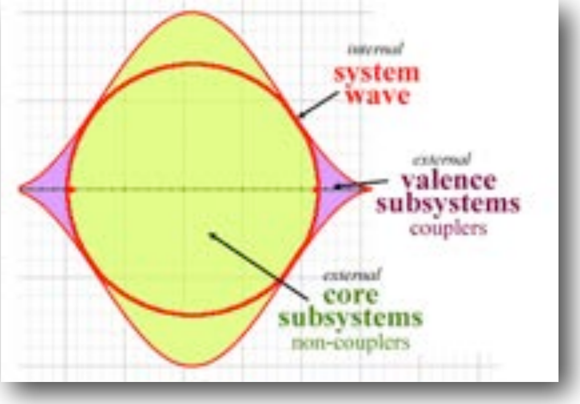
Total confinement

Simple examples of total confinement are provided by the helium nucleus and the helium atom. The subsystems of the nucleus are two protons and two neutrons coupling with quarks and gluons. At reasonable temperatures, there is zero probability of any of these subsystems leaving the system. The subsystems of the atom are the nucleus and the two electrons coupling with photons. There is also an almost zero probability of any of these subsystems leaving the system. Helium is physically and chemically inert.

Partial confinement

In most systems, the system wave only totally confines a subset of its subsystems, the remainder are only partially confined. The system wave of the helium nucleus, and of all nuclei, is like this, i.e., it confines all its subsystems except for virtual photons of a positive polarization. The helium atom, on the other hand, confines even its virtual photons.

Many more examples are provided by the atoms of the various elements. Each system wave totally confines a ‘core’ subset of subsystems while the ‘valence’ electrons are not in a stable state. The periodic table of the elements results from the sequential filling of the orbitals, resulting in atoms where attaining stability ranges from dumping a valence electron, to sharing a valence electron, to adopting a valence electron. These are the emergent chemical properties inherited from the Logos.

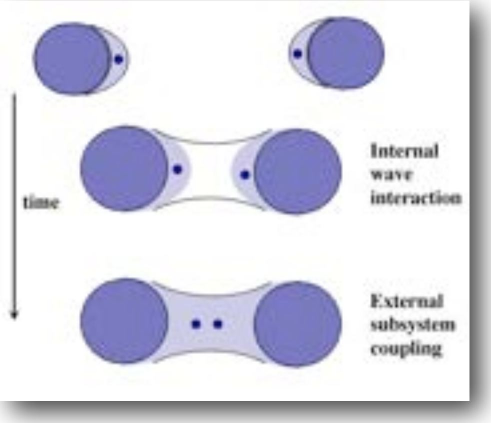


Any system that is not totally inert will have this set of partially-confined valence subsystems as well as its core subsystems.

Ordered interaction

There is a sequence to any interaction, first the internal and then the external. First, the internal waves overlap and interfere. The internal wavefunction, z, changes to z*. The external probability alters from $|z|^2$ to $|z^*|^2$. This is the internal aspect of interaction.

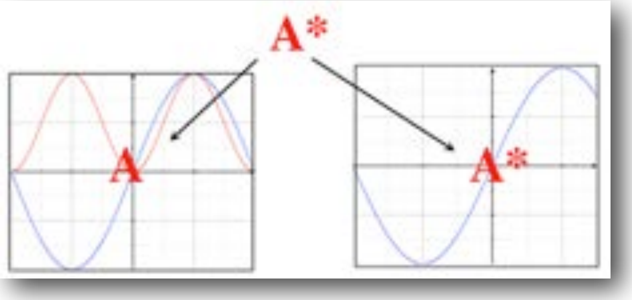
Second, over the characteristic time period the LoLN will alter the external density of the subsystem from $|z|^2$ to $|z^*|^2$, and the external coupling is completed.We can illustrate this with two hydrogen atoms, each with their single peripheral electron and constant core.



Some interactions—in the sense of influencing—between systems are wholly internal, and do not have an external aspect. We have already encountered this in the behavior of fermions and bosons in the way they do not obey independent assortment, on an internal level they are responding to each other. Nothing is exchanged externally, there is no energy involved.

Another example is the excited atoms we have already encountered. A helium atom, for instance, can absorb a specific size of photon and one of its electrons leaves the 1s orbital and enters into the 2s orbital. In a few billionths of a second, this excited atom spits out that specific photon and the helium returns back to its ground state.

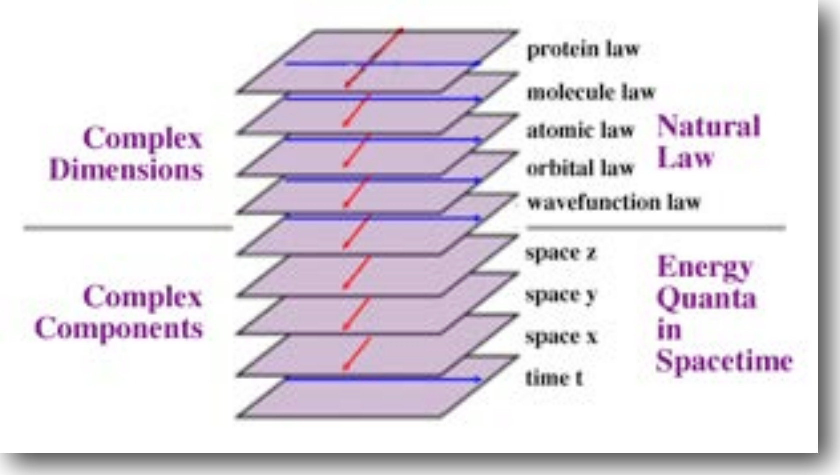
In order for a photon to exist between two mirrors, the separation has to be a whole number of ½-wavelengths, otherwise the photon wave experiences destructive interference and cannot exist there.



If an excited atom is placed in a box into which its specific photon does not fit, the excited atom is quite stable, the photon is not emitted. Its internal wave is zero in the box and it stays with the atom. There is nothing external happening, but internally the photon is suppressed.

LOGOS AND NATURAL LAW

It is the forms to this multidimensional abstract Logos that progressively guide the systematic confinement of the external particles into the forms we call atoms, the forms we call molecules, the forms we call cells, the forms we call human, etc.



So both matter and natural law are constructs in complex dimensions. Space and time, which is twisted in matter, take up the first four levels. Natural law starts at level five, with the constructs of the quantum wavefunction, the atomic nucleus and orbitals of the Periodic Table of the elements. Level six rules the chemical interactions as molecules, on so on up a hierarchy until we reach the level at which the human form resides, a finite number of levels from 5 to N.

It is this structure of natural law that makes each discipline in science somewhat self-contained, e.g., a chemist needs only a smattering of physics or biochemistry to be a brilliant chemist.

That natural law is a complex entity related to time and space, and that its structure rules the realm of quantum probability, explains one of the facts of life often mentioned by Christian de Duve:

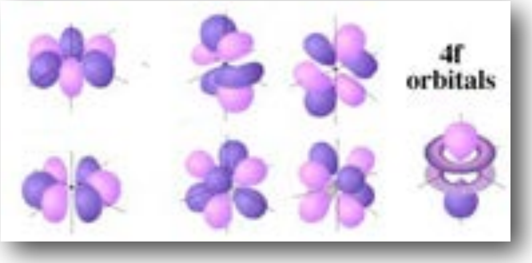
1. We know from our study of history that there are millions of discrete steps that had to have occurred in the 4 billion-year progression from simple chemicals on the abiotic earth to the emergence of human beings.
2. We know from probability theory that the probability of each step is unity or less, and that the overall probability of a sequence of steps occurring is equal to the product of the probability of each step occurring.
3. We know from basic arithmetic that multiplying a set of numbers all less than 1 together results in a number that is smaller than any of the members in the set. If one or more of the set is infinitesimal, the result will also be an infinitesimal.

$$\begin{aligned} 10^{-1}\times 10^{-3}\times 10^{-2} &= 10^{-6} \\ 10^{-1}\times 10^{-3}\times 10^{-900} &= 10^{-904} \\ 10^{-1}\times 10^{-900}\times 10^{-900} &= 10^{-1801} \end{aligned}$$

The implication of these points is that not a single one of the steps from atom to Man could have had an infinitesimal probability, let alone two of them; every single step from atom to Man must have had a significant probability.

While this is impossible to explain in classical science, it is to be expected if the internal space of quantum probability has a structure which, at its very highest levels has the structure of a human being. The Logos has a structure in multidimensional complex space that is expressed in the external form-over-time, the internal wave confining the host of fundamental particles that comprise the human body. Plants and animals do not reach into these upper levels and reflect the forms of abstract structures lower down.

The lowest levels of the Logos deal with the quantum waveforms that, when inhabited by electrons, are the orbitals that give the elements their emergent chemical properties. These forms in the lower levels of the Logos already have a precise and sophisticated form, as illustrated in the bizarre shapes of the higher orbitals. The seven 4f orbitals, with many entangled lobes are an example of structure at the lowest levels of the complex dimensions of the Logos. It is the filling of these 4f orbitals that give the increasingly valuable *rare earth* elements—the *lanthanides* such as cerium, europium and dysprosium—the properties that make them so essential in our technological world



When the external form reflects the internal form, we call this a state health and happiness, but when it does not, there is unnatural discomfort and disease. In this sense, the concept of the Logos is similar to that of the commonly used concept of “Mother Nature.”

Physical systematic hierarchy

The systematic hierarchy of the physical realm is founded on complex spacetime. On this foundation, a systematic physical hierarchy emerged over time—reflecting the abstract hierarchy in the Logos—of atomic nuclei, atoms, molecules and macromolecules, each with a set of emergent properties. In *Volume Two,* we examined the levels up to molecules, and the stepwise expression of the Logos over time from the Big Bang origin event.

While we have numbered the levels in the Logos, the math of multiple complex dimensions is in its infancy, so it is quite possible that, like the spacetime level, each of the indicated levels involves multiple complex dimensions. Just as in the Abstract Realm, it is impossible to change one level without altering all the other levels. The Logos of the Big Bang is the Logos of the present day; the laws of nature have not altered at all.

In our discussion, we next explore the levels above the molecular level—the key macromolecules of life, the proteins and the nuclei acids.

The proteins have a set of emergent properties that make them preeminent at manipulating analog forms, such as the ice structure of water or the chemical transformation of molecules.

The nucleic acids have this analog ability to a degree, but they have a higher set of emergent properties making them preeminent at the manipulation of digital information about the analog form of systems. Like the analog structure of living systems, this digital information about analog form is stored in a multilevel systematic hierarchy of sophistication.

	Logos Level	Systems	Interacting subsystems	Emergent properties
↑	**11**	Nucleic acids	Monomers & phosphate	Manipulate and transmit digital information
	10	Proteins	Monomers	Manipulate Analog form of water & other molecules
	9	Molecules	Atoms	Plethora of molecular properties
	8	Atoms	Electrons & nuclei	Periodic chemical properties
	7	Nuclei	Protons & neutrons	Stable isotopes
	6	Fermions	½ twist & halo of 1 twists	Weak, electric & strong charge
	5	Bosons	Twisted spacetime	Coupling of weak, electric & strong interaction
	1–4	Spacetime		

Resonance

The ‘two opposite sides’ of spacetime involve four of the five basic parameters of energy quanta. The fifth parameter, that of probability, is the same for both physical and spiritual realms in that it involves both components. If the spiritual and physical were identical, if the wave aspect of the basic spiritual atom was identical to the wave aspect of the basic physical atom, we would expect some sort of crossover. Modern experiments with atoms would surely have picked up any such crosstalk between the two realms.

As the complex components of the physical metric have a fundamental *left* configuration, we can expect that the complementary spiritual metric has a fundamental *right* configuration. This is imposed by the Logos at the moment of Creation.

We have already seen that the simplest physical quanta of positive energy, the *left* neutrino, has a very small mass-energy and moves at essentially light speed, the upper limit. The *left* neutrino is in resonance with the Logos-imposed chirality. On the other hand, a putative *right* neutrino is not in accord with the Logos, and it would have an enormous positive mass-energy, and lumber slowly along close to the zero-speed, the lower limit.

This suggests that the simplest spiritual quanta of negative energy spin *right,* and have a low negative energy and move close to the unbounded, upper speed limit. On the other hand, a spiritual quanta spinning *left* would have an enormous negative mass-energy, and lumber slowly along close to the light speed lower limit.

Thermodynamics tells us that the speed of quanta is reflected in the temperature of the surroundings. If actions that resonate with the Logos are *good,* and result in generating *right* quanta, while actions that do <u>not</u> resonate with the Logos are *evil and* result in generating *left* quanta, the result would be a blazingly hot heaven of good people and a bitterly cold hell of evil people. These are just suggestions to stimulate further thought about the harmony of religion and science.

The negative energy quanta of the complementary spiritual metric is a barely-understood topic, so we can only make suggestions. As we shall see in the following section, the difference in the physics of the two realms is often that of an inverse relationship: a parameter that is x in one realm is 1/x in the other.

In the systematic hierarchy of the physical realm the wave aspect has the effect that simple systems are condensed (atomic nuclei) while sophisticated systems (human body) are diffuse. If the wave aspect of the spiritual realm has the opposite effect—the simple atoms are diffuse while sophisticated humans are condensed—simple systems would be so different in the two realms that they would be far apart and not influence each other.

As systems become more sophisticated in the same way, another possibility of crossover between the two realms emerges, the phenomenon of resonance. Since we discussed this for waves in general in *Volume Two,* we will just mention an example here—the diamond allotrope of carbon. The adamantine quality of diamond is not because it is difficult to disturb the bond between just two carbon atoms on the surface. The carbon atoms in a diamond are almost identical, and they resonate together as a single entity. An attempt to disturb the surface is akin to disturbing all the bonds in the crystal. Natural carbon is almost entirely the isomer carbon-12, but there is a small fraction of it that is carbon-13. This ‘impurity’ does not resonate exactly with the others which reduces the overall unity and stability of the giant molecule. It is theorized that when the technology to create pure carbon-12 diamonds emerges, they will be harder and even able to scratch natural diamond.

Sequential expression of Logos

We discussed the Logos—the laws of physics, chemistry, biochemistry, etc.—a construct in the Abstract Realm. The natural law determines the internal aspect of systems—an aspect that can only be described by complex numbers (e.g., the wavefunction of a photon or the orbital of an atomic electron). This internal aspect is in the Abstract Realm, but it is amphibious in that it has a projection in the Physical Realm known as quantum probability. This quantum probability aspect of a system determines over time the probability density of the fundamental entities that are at the lowest level in the Physical Realm hierarchy—mainly electrons, quarks and photons. This is the external aspect of a system, its external form in the Physical Realm.

While the Logos, as a structure in the Abstract Realm, does not operate with a cause-and-effect relation between the lower and the higher levels in the hierarchy, the structure of the Logos is expressed first at the lowest levels and only later at the higher levels.

In *Volume Two,* we discussed the cosmological history of the Physical Realm and the stepwise expression of the Logos, starting with the nature and origin of the fundamental particles in the Big Bang, then moving on to the nature and origin of the elements in the first generation of stars, and concluding with a discussion of a third-generation star, our sun, and the earth, and the nature and origin of the pre-life molecules on the early, and abiotic, earth of four billion years ago.

LOGOS	SUBATOMICS	ATOMS	MOLECULES	POLYMERS
Systematic expression as history of Physical Realm				polymers
			molecules	molecules
		atoms	atoms	atoms
	subatomics	subatomics	subatomics	subatomics

THE SPIRITUAL REALM

Up to this point, we have discussed the systematic hierarchy of the abstract realm from mathematics to the Logos, and the systematic hierarchy of the physical realm that unfolds from simple to sophisticated under the guidance of the Logos. We turn now to the third realm about which very little is known to science, the realm of spirit.

First, we will discuss the theoretical possibility, given modern physics, that another realm coexists with the physical realm. Is this consistent, given what modern science understands about the nature of reality.

Second, we will discuss the experimental evidence already uncovered in modern cosmology that a second realm actually shares the cosmos alongside the physical universe of galaxies, stars, planets and humans.

THEORY

Modern physics has gone far beyond the classical concepts of time, space, energy and mass. While an invisible, intangible spiritual realm coexisting alongside the physical is inconceivable using classical concepts, as we shall see, the concepts established in modern science are remarkably amenable to its existence. We will start with the contemporary understanding of the spacetime metric.

Spacetime

It took the genius of Einstein to realize that space and time were so similar that in his Special Relativity they could be transformed into each other. In this experimentally-verified view, velocity through space and velocity through time are very similar when expressed in “natural units.”

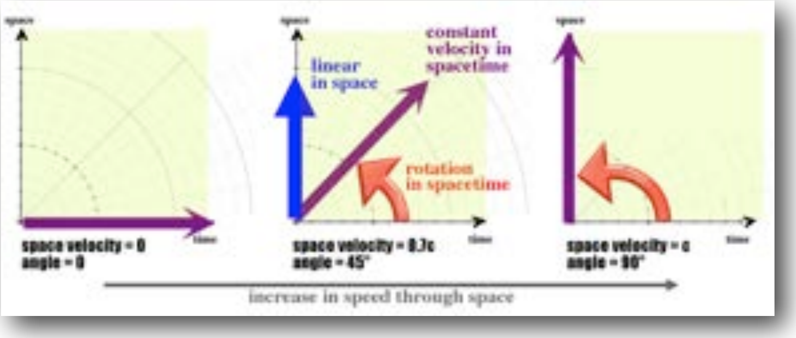
Velocity through space and through time, in natural units, ranges from zero to one, from absolute zero to the speed of light. In spacetime, the velocity is always 1, but this can be unequally distributed between space and time.

In our quotidian lives, our velocity through space is essentially zero in natural units, we rarely move at significant fractions of light speed in the absolute frame of reference proved by the cosmic microwave background radiation. We are moving through time at essentially light speed. While 1 centimeter and 1 second might both be considered equally small units of time and space in human units, they are vastly different in natural units, 1 second = 30,000,000,000 centimeters!

In high-energy physics, unstable subatomic particles can be accelerated to almost light speed—both absolute zero and light speed are asymptotes—and their prolonged lifespan observed. A particle that would normally decay in seconds at thermal speeds can have its half-life stretched into hours when traveling at essentially light speed. Traveling at high-speed through space involves traveling at slow speed through time, the relation being a simple Pythagorean one in natural units (and condensing the three space dimensions into one for simplicity).

$$1^2 = t^2 + x^2$$
$$1^2 = 1^2 + 0^2 \quad \text{zero in space}$$
$$1^2 = 0^2 + 1^2 \quad \text{lightspeed in space}$$

It can be seen that, at a velocity √½ light speed (~0.7c), the velocities through time and space are equal and the velocity through spacetime has been rotated by 45°. Increasing a linear velocity in space rotates the direction of the constant velocity through spacetime. Such a combination of linear and angular is the prime characteristic of complex numbers.



In this unified spacetime, the obvious difference between time and space showed up in the Pythagorean relation that measured the separation between events in spacetime. Two formulations of this worked equally well with a minus sign. This implied that either space or time had to be an *imaginary* number, i.e., a complex number with a zero *real* component. The other, time or space, being a *real* number, i.e., a complex number with a zero *imaginary* component.

$$d^2 = t^2 - x^2 \quad \{t,\ ix\}$$
$$d^2 = x^2 - t^2 \quad \{it,\ x\}$$

In the early days of the science, it seemed obvious to assign space the real number and time the imaginary number.

Later consideration made it clear that time behaved as the real numbers while space behaved as the imaginary numbers. For instance, the nonoriented twists of an electron can be along either direction of the complex time axis—it is matter going in one direction and antimatter going in the other. An electron going the opposite way in complex time is a positron. Very different. This is like the different behavior of the real numbers, plus-one and minus-one.

Electrons, on the other hand, traveling east or west in space are different, but not by much. This is like the behavior of the imaginary numbers where the only difference between +i and –i is that of clockwise and counterclockwise, so similar that a different point of view will convert one into the other.

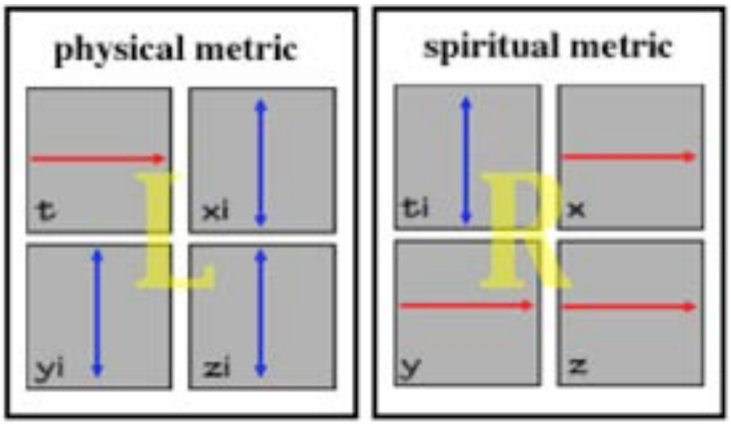
n	n^2	n^3	n^4
$+1$	$+1$	$+1$	$+1$
-1	$+1$	-1	$+1$
$+i$	-1	$-i$	$+1$
$-i$	-1	$+i$	$+1$

So, the currently accepted expression for the ‘metric’ in human units for measuring separation in physical spacetime is with time as the real complex component, and space as the imaginary complex component.

$$\begin{aligned} d^2 &= ct^2 + (xi)^2 + (yi)^2 + (zi)^2 \\ &= ct^2 - x^2 - y^2 - z^2 \end{aligned}$$

We earlier mentioned that spacetime embraced four complex dimensions. The caveat is that physical spacetime involves only an

asymmetrical subset of the components of four complex dimensions. The physical metric of space-time is an asymmetric set of the components. Applying the simple principle behind
0 = +1 & –1, the remaining subset of components can be postulated as the metric of the spiritual realm.



We have already seen that the physical metric is left-handed on the internal level, so we can expect that the spiritual metric is right-handed on the internal level.

It is the physical metric that is twisted up in the positive energy quanta of tardyon bosons and fermions. We can assume that it is the spiritual metric that is twisted up in the negative energy quanta of tachyon bosons and fermions.

Two solutions

The quantum theory that dealt with the internal wave aspect of matter was originally worked out for systems moving at everyday velocities, speeds that were a tiny fraction of the speed of light. It was Dirac who combined the wave aspect of quantum physics with the theory of special relativity for velocities approaching light speed and completed the description of relativistic quantum wave mechanics.

His equation for energy allowed for two solutions, in the same way that both +2 and –2 are both the square-roots of +4.

The positive solution to the Dirac equation corresponds to the physical world, which is all about the behavior of quanta of positive energy. When the quantity p (related to momentum) is zero, this positive solution to the Dirac equation collapses into Einstein’s well-known identity.

$$E^2 = c^2p^2 + m^2c^4$$

$$E^2 = m^2c^4$$

$$E = mc^2$$

$$-E = -mc^2$$

The negative solution to Dirac’s equation was an enigma. Investigation of the consequences of quanta of ‘negative energy’ revealed that such quanta, called tachyons, would have a very strange set of properties:

1. Tachyons would have an energy measured by imaginary numbers [but energy, surely, was always positive and real] whose square would be negative.
2. The velocity of tachyons would also have an asymptotic range from a *lower* limit of light speed to an unbounded upper limit. This was hard to comprehend inasmuch as the familiar limits to the velocity of quanta were the inverse, from zero to light speed. Tachyons with negative energy would have a negative mass and travel at light speed or faster. The familiar tardyons with real energy that compose the physical realm travel at light speed or slower.

3. As the kinetic energy of a tachyon increases, the slower it moves; as its kinetic energy decreases, it speeds. It made an Alice-in-Wonderland sense that adding negative energy would slow things down.
4. As a tachyon adds negative energy, it slows down asymptotically to light speed as its negative inertial and gravitational mass increases without limit. This is in contrast to tardyons that speed up asymptotically to light speed by adding positive energy as their positive inertial and gravitational mass increases without limit.
5. The gravitational interaction between quanta of negative energy is to expand and increase their spatial separation. The gravitational interaction between quanta of positive energy is to contract and reduce their spatial separation, an antigravity.
6. The gravitational effect of multiple tachyons of negative mass on each other would attempt to spread them out relatively uniformly in an open spacetime metric of negative curvature. The gravitational effect of multiple tardyons with positive mass on each other is to clump them together into a closed spacetime metric of positive curvature. This is an example of a 2-D ‘space’ with:
    - a) a closed, positive curvature is the surface of a ball
    - b) an open, negative curvature is the surface of a saddle.

Allow me to post an historical note here. For classical, commonsense reasons, the negative solution to Dirac’s equation obviously could not possibly be taken at face value. Negative energy made no sense, so it was a relief when antimatter was discovered. This, it was decided, must correspond to the negative solution to the Dirac equation. Negative energy must be positive energy but with all its properties reversed. With the discovery of the antielectron and the antiproton, this seemed a reasonable solution.

This perspective still holds even though later work in quantum mechanics revealed that antimatter actually involved the same quanta just going in the opposite direction through complex time, made this an unreasonable conclusion. Antimatter is just as much a quanta of positive energy as is matter: both an electron and a positron have a positive rest-mass energy of ½MeV and when they annihilate, they mutually untwist into gamma ray photons with 1MeV total energy.

$$+1-1\neq 2$$

$$+1-1=0$$

The problem with this is that it is akin to plus and minus one summing to two, instead of the expected zero.

REALM	PHYSICAL	SPIRITUAL
LOGOS	*natural law*	
SYSTEMS	bottom-up	top-down
METRIC	t, xi ***L***	ti, x ***R***
ENERGY	+E	–E
QUANTA	tardyons	tachyons
ADDING ENERGY	Speed up $1/v \rightarrow 1$	Slow down $v \rightarrow 1$
ASYMPTOTIC SPEED LIMITS	$0 \rightarrow c$	$c \rightarrow \infty$
GRAVITY	Collapse ⇓ ⇑	Expand ⇑ ⇓

Tardyons and tachyons

We shall take the two solutions to Dirac's equation at face value, and add it to our picture of the spiritual realm—tachyons interacting on the other side of spacetime, and the physical realm tardyons interacting on this side of spacetime. One interacts with gravity, the other with anti-gravity. So far, modern physics has been quite at home with the concept of a second, coexisting realm we are calling the spiritual.

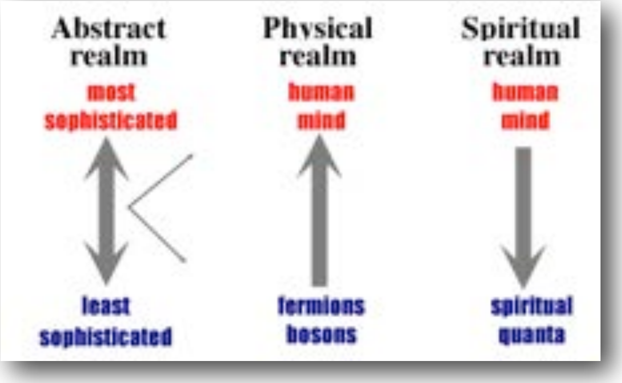
In the physical realm, quanta of energy move at fractions of light speed, while in the spiritual realm, quanta move at multiples of light speed. The relationship between velocity in the two realms is a reciprocal one. What is v in one realm is 1/v in the other.

The reciprocal function in math is a fascinating one in that it can take the infinity of integers and slot every single one of them into the space between zero and one. It does this remarkable feat not by packing them close together, as one might think—the integer 2 takes up fully half the available space—but by decreasing the distance at exactly the same rate as the integers are increasing.

A google at 10^{100} is an enormous integer, greater than the number of atoms in the visible universe, but the reciprocal function finds it a place close to zero, but still leaving room for the truly enormous integers, $\text{google}^{\text{google}}$ and $1+ \text{google}^{\text{google}}$ to have a place.

We discussed earlier the systematic hierarchy of complex dimensions that comprise matter and natural law. We have just discussed the lowest four of these levels in terms of their components. The laws at each level on up, however, are structures in the full hierarchy of complex dimensions, so we can expect the same natural laws to apply in the spiritual realm and the systematic hierarchy founded on the tachyon quanta. The math involves switching plus and minus signs, and multiply and divide signs, but the observed realm ends up looking the same.

Cause and effect



The physical and spiritual realms appear to an asymmetric distribution of properties, somewhat akin to 0 = +1 & –1. The abstract realm is bidirectional cause and effect, while the physical realm is one-way, bottom-up cause and effect. So, we will suppose that the spiritual realm is also one-way but in the top-down direction, from most sophisticated to least sophisticated. The most sophisticated entity in the physical realm is the human mind, which can impose its form on the less sophisticated levels. This would account for the religious teaching that our character is reflected in our eternal spiritual body. We will return to this much later on.

Missing Cosmological Constant

In *Volume Two,* we discussed *virtual particles,* ephemeral quanta that lack a pixel of existence. They can be experienced directly by attempting to squeeze the N-poles of two strong magnets together. The distinct cushion experienced that resists such efforts is composed of a host of virtual particles.

Just like its twisted cousin, undisturbed spacetime has an internal probability aspect. The probability that the ground state, empty vacuum, will do nothing is very, very high. But it not *exactly* 100%. A speck of utterly empty vacuum of undisturbed spacetime has a infinitesimal 'probability amplitude' to decay into an electron-positron pair, and an even infinitesimally smaller probability to decay into a proton-antiproton or neutron-antineutron pair, etc. The duration these matter-antimatter pairs exist for is also infinitesimal, so they never ever amount to a pixel of existence (more technically, a Planck's Constant of action or energy-in-time).

So the probability that a volume of space will contain a virtual particle pair such as electron-positron with a transitory positive energy of 1MeV is very, very small indeed.

The problem arises because the Law of Large Numbers insists that even a very, very small probability becomes a certainty if extraordinarily immense enough numbers are involved.

As an example, we can use some simple numbers. Let the the complex probability of a pixel of space spontaneously twisting into a virtual electron-positron pair be one billionth, with the observed external probability, as usual, being the square of this at one billion-billionth. The decay lasts only a billionth of a second before the particles recombine back into untwisted space without ever amounting to a pixel of existence. So, in a volume of space of a billion, billion, billion pixels—10^{18} pixels—the observed density of particle-pairs is, on average, one pair and the energy in that volume will be 1 MeV. This should show up as an observed energy density in empty space. This energy density is called the *cosmological constant.*

As discussed in *Volume Two*, space only seems continuous because it has a very high resolution. This is rather like the white screen of the computer I am writing on which is an illusion of the resolution of the tiny pixels. My eye is not able to resolve the tiny pixels present in equal amounts of bright red, green and blue, so I perceive a continuous white. While it is known from theory that space is not continuous but pixelated, the resolution is so high that our best instruments are incapable of resolving the separate pixels. While the resolution of my computer screen is ~10,000 pixels (10^4) / sq. inch, the resolution of space is ~a google (10^{100}) / cubic meter. So, even infinitesimal probabilities can become significant.

The actual numbers have been measured quite accurately and the expected energy density of virtual particles in empty space calculated. This is the expected cosmological constant, and it is ~10^{100} times greater that the observed energy density of empty space (which is essentially zero).

A solution to this glaring disparity between theory and reality was soon offered by an area of mathematics called ‘group theory’ that was very successful when organizing and predicting the host of ‘fundamental particles’ uncovered by modern experiment.

Group theory

A ‘group’ is a set of objects, e.g., numbers, that have the following properties:

1) They interact with each other—called an *operation*

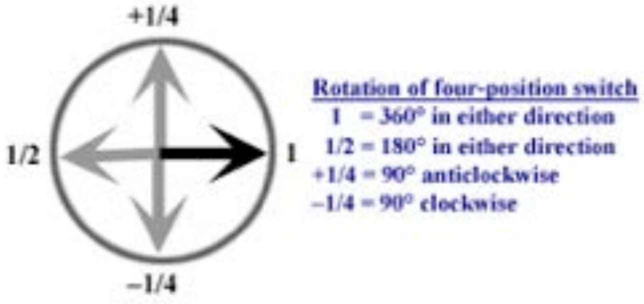
2) The interaction always results in another member of the set—the set is *closed* under multiplication

3) There is an identity interaction in which there is no change—the *identity* operation.

×	+1	–1	+*i*	–*i*
+1	***+1***	***–1***	***+i***	***–i***
–1	***–1***	***+1***	***–i***	***+i***
+*i*	***+i***	***–i***	***–1***	***+1***
–*i*	***–i***	***+i***	***+1***	***–1***

Based on these three simple foundations, the astonishingly-sophisticated edifice of group theory is constructed. A very simple example of a finite group is the set of four complex numbers, {+1, –1, +i, –i}, that interact by multiplication. The results of multiplying any combination of them always results in a member of the set, which is closed as illustrated in the multiplication table. The identity operation is multiplying by +1, as seen in the first row and column. This set of four numbers is a group, and everything that has been proved in group theory will hold for this group.

Another representation of the same abstract group is a switch with four settings, and the operation is turning the switch. Its behavior is identical to the set of four numbers.



Many of the subtle properties of groups are tied in with their subgroups, subsets of the set that are themselves groups under the same operation. Two subsets of any group are the ‘trivial’ subgroups: the identity element by itself—multiplying +1 an unlimited times is always +1 so it is closed and there is an identity element—and the subset that is the entire set which also obeys the rules. It is the nontrivial ‘proper’ subsets that have interesting properties.

In the above example, the two trivial subgroups are {+1} and {+1, –1, +i, –i}. Like the group itself, they have a period-four—multiply any element by itself four times and you get back to the starting number.

The only nontrivial subgroup is {+1, –1}—any other combination, say {+1, +i}—is not closed under multiplication, so cannot be a group. Even this simple example of subgroups illustrates the emergence of new properties—in this case, the emergence of period-two subgroups that was not a property of the period-four original group.

The rules connecting the properties of groups and the properties of subgroups are precise and well-understood. One of the basic rules governing groups and subgroups is obvious with a little reflection: The period of a proper subgroup is a factor of the period of the group. Perhaps less obvious is that this also implies that a group with a prime-number period cannot have any proper subgroups at all.

Supersymmetry

Without going into any further detail, we will just state that sophisticated group theory was applied to the plethora of things emerging from the smash-up of very high-energy particles colliding head-on.

All the menagerie of subatomic particles could be placed in a closed set because interactions between them always resulted in particles that were members of the set. The barrier to this set being a group was that a single nonoriented particle never turned into a single oriented particle, or vice versa. The two sets had all the appearance of being subgroups of a larger group in which they could interconvert. Adding to the known set of particles another set of theoretical particles, known as ‘supersymmetric’ particles, would complete this all-encompassing group. Each regular particle has its supersymmetric twin in this larger group. The table is a partial listing of the names they were given.

PARTICLE	SS TWIN
neutrino	***sneutrino***
W boson	***wino***
electron	***selectron***
quark	***squark***
photon	***photino***
gluon	***gluino***

This set of particles, it seemed, could resolve the glaring factor of 10^{100} in the disparity between the cosmological constant as predicted from the results of many precise experiments and the observed cosmological constant. All that was needed was that the contribution of the supersymmetric particles exactly cancel out the contribution expected from the regular particles.

The first, rather obvious, requirement for such a cancellation is that a pixel of spacetime has an equally small probability of decaying, for an equally brief moment, into a virtual supersymmetric pair as it does for decaying into a regular virtual pair.

The second requirement is also simple if we accept the imaginary complex energy of Dirac's equation at face value, i.e., that the positive rest-mass energy of a regular matter/antimatter pair is equal to the negative rest-mass energy of a supersymmetric matter/antimatter pair.

In this case, the massive, positive cosmological constant of the regular virtual particles in the vacuum is cancelled by the equally massive, negative cosmological constant of the virtual supersymmetric particles in the vacuum. The resultant cosmological constant would be zero by the simple math of $\left(+10^{100}\right)+\left(-10^{100}\right) = 0$. A similar situation applies to each of the protons in our bodies, they are repelled by all the protons in the earth with enormous force, and attracted with an equally enormous force by the equal number of electrons in the earth. When this balance of enormous forces is disturbed, as it is in a thunderstorm, the huge energies involved in this balance is revealed.

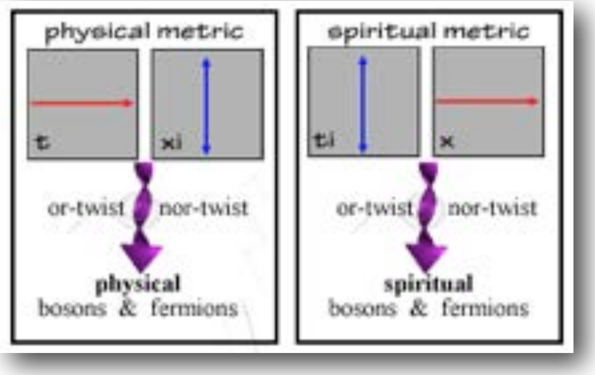
Unfortunately, the concept of tachyons with negative energy had fallen out of fashion and a more complex picture was adopted: The supersymmetric particles had real, positive energy and their cancellation somehow occurred because the supersymmetric twin of an oriented boson was a nonoriented fermion, and vice versa. The twin of the doubly nonoriented electron was the doubly oriented photino, and so on.

This theoretical consideration has given rise to the hopeful expectation that such supersymmetric particles will come flying out of the ultra-energetic collisions created in the CERN synchrotron, the LHC, on the border between France and Switzerland. There has been no sign of them yet at energies of tens of billions eV.

Energy quanta		Physical	Spiritual
Nonoriented: *spin*	½	neutrino	sneutrino
+ *EM charge*	½ ½	electron	selectron
+ *color*	½ ½ ½	quark	squark
Oriented: *spin*	*1*	woson	swoson
+ *EM charge*	*1 1*	photon	sphoton
+ *color*	*1 1 1*	gluon	sgluon

This is to be expected if the supersymmetric particles are negative energy, rather than the positive energy being pumped in by CERN, and are the basic building blocks of system-building in the spirit realm in its top-down fashion. In the physical realm, the quanta of positive energy are twists is the physical metric; in the spiritual realm we can expect that the quanta of negative energy are twists in the spiritual metric.

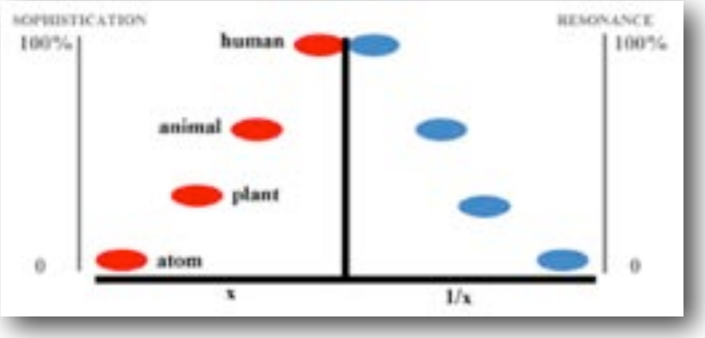
We again find that modern physics can readily accommodate a second realm without effort. Summarizing these theoretical discussions in the table, we now move on from theory to experiment.



We will assume that the quanta of negative energy are twists in the three spatial dimensions, and that the twists can be either oriented (the bosons) or nonoriented (the fermions.)

That these spiritual quanta do not interact with the physical quanta is not so unusual: the neutrinos, even through they are a part of the physical realm, hardly interact with with anything and sail just as easily through you, the earth, or the sun without interacting. It is, therefore, a problem of philosophy as to whether neutrinos are insubstantial or substantial physical matter.

As the same laws are acting in both realms, albeit in a complementary fashion, we can expect that there is a partial resonance between the two realms on an internal level, that is a resonance of 100% in a human who is in tune with the Logos.



The spiritual quanta composing such a spirit-self resonating with the Logos, would be tachyons of low negative energy spinning *right*, and moving at an unbounded speed, close to the infinite limit, on the other side of the spacetime metric.

The spiritual quanta, on the other hand, composing a spirit-self that did <u>not</u> resonate with the Logos, would be tachyons of high negative energy spinning *left*, and moving at a slow speed, close to the light speed limit, also on the other side of the spacetime metric.

The systems in heaven are fast, hot and extended on the other side of spacetime; the systems in hell are slow, cold and condensed on the other side of spacetime.

Almost all the great religions teach that. corresponding to the healthy physical diet, there is a spiritually healthy *diet* of right and good actions that involve simple things like:

1. True parental love in the family, true conjugal love between spouses, and education of children in true filial love and sibling love.
2. Live for the sake of others, give and forget you gave.
3. Forgive and forget the mistakes of others. Teat strangers as you would members of your own family.
4. Do not be a foolish immortal. Try to take the big, long viewpoint and don't sweat the small stuff.

The major religions also teach that, just as a rotten physical diet will have unhealthy consequences for the physical self, a rotten spiritual *diet* of self-centered, unloving actions will have unhealthy consequences for the physical self.

It will only be towards the end that we will be in a position to discuss why the vast majority of humans are not in tune with the Logos and do not resonate with the spiritual world except partially in dreams and the like.

The chart summarizes how current theory in physics readily allows for a second, complementary realm.

This concludes an overview of the theoretical possibility in modern physics of a second substantial realm in the cosmos. With a minimal manipulation of what is already known about substance in the physical reality, we see that modern science is quite comfortable with a second realm coexisting alongside the physical in the cosmos.

REALM	PHYSICAL	SPIRITUAL
LOGOS	*natural law*	
SYSTEMS	bottom-up	top-down
METRIC	t, xi ***L***	ti, x ***R***
ENERGY	+E	–E
QUANTA	familiar tardyons	supersymmetric tachyons
ADDING ENERGY	Speed up 1/v → 1	Slow down v → 1
ASYMPTOTIC SPEED LIMITS	0 → c	c → ∞
GRAVITY	Collapse	Expand
COSMOLOGICAL CONTRIBUTION	$+10^{100}$	-10^{100}

EXPERIMENT

It is one thing, of course, to state that a spiritually-substantial realm is *theoretically* possible, while it is quite another for scientific experiment to demonstrate that this is actually the way the universe is. Our attempts to understand the structure and function of the natural world began with the stuff that was easily accessible through our senses. The start of what is now modern science studied the three familiar phases of matter—the solids, liquids and gases to be found in the substantial material of the everyday world.

The study of the night sky suggested that there were things beyond the earth that obey a different set of principles—the Moon and planets seemed to move without friction and the sun poured out endless amounts of energy—but Newton was the first to show that the same principle that governed the falling of an apple could also explain the movement of the Moon, and so much else.

It was the exploration of the heavens that revealed that the familiar solid, liquid and gas was actually a minor component of the universe: that most of the visible matter in the universe, contained in the myriad stars, was actually in the form of a *plasma*—a form of matter in which are no atoms, just high-energy free electrons and atomic nuclei flying about freely. A roughly equal amount of almost invisible matter was later found to be distributed throughout the vast spaces between the stars and galaxies in an ultra-low density of gas that was a better vacuum than those created in the most high-tech laboratories.

Both the stars and interstellar gas, however, had a similar makeup: both were composed of 75% hydrogen-1, 24% helium-4 and 1% all the other elements combined. All were made of the same basic stuff: the ‘baryons’ of the atomic nucleus (protons and neutrons) and the electrons. Since the electrons contributed less than 1/2000th to the mass-energy, these components are together called ‘baryonic matter.’ The amount of baryonic matter in the visible universe is measured in units where our sun has a mass-energy of 1 SU: the visible stars in our home galaxy have a mass of ~10^{10} SU, as does the interstellar gas and dust. This is all positive energy, which gives the galaxy a powerful force of gravitational attraction.

A further component to the universe was added with the discovery of the Cosmic Microwave Background, the discovery that all the vastness of interstellar space is filled with of microwave photons. Their numbers are huge: for every baryon in the universe, there were 10^{11} microwave photons. Each photon had a positive energy and thereby also contributed to the gravitational field. But, since each photon had a very small energy, and since the CMB photons were evenly distributed throughout intergalactic space, their contribution could be ignored.

Dark Matter

This ‘baryonic’ did not stand up to scrutiny when the rotation motions of galaxies were studied in detail. There are two extremes of rotational motion about a center: a solidlike rotation in which the rotation of the parts is constrained, or a gaslike rotation where the is no constraint.

An example of a solidlike rotation is two markers at different distances from the center of a phonograph turntable. The outer marker moves faster than the inner, and they both make one rotation in the same time period. The constraint is the electromagnetic interaction which makes the turntable rotate as a solid unit. In such solidlike rotation, the outer marker goes at a faster speed than the inner one. As the distance that each travels with one rotation is 2πd, a marker that is twice the distance from the center will travel at twice the speed. The velocity is proportional to the distance.

$v \propto d$

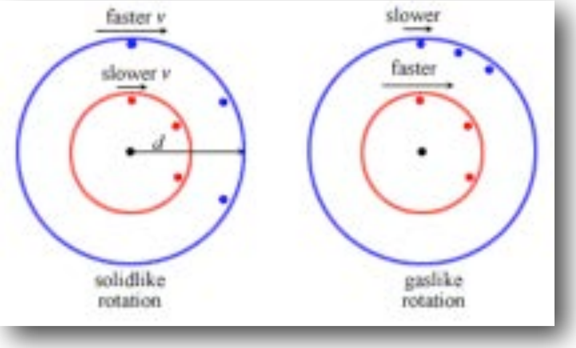
$v = kd$

$1 = 1$

$2 = 2$

$3 = 3$

A example of a gaslike rotation is the orbits of the satellites rotating about the earth: The international space station orbiting hundreds of miles up and just above the atmosphere moves very fast and orbits the earth 19 times each day. The geosynchronous TV satellites that orbit thousands of miles up move much slower and take 24 hours to make a complete circuit. The Moon which is hundreds of thousands of miles up moves even slower, and takes a whole month to make a single circuit about the earth. There is nothing constraining them except the inward gravitational tug of the earth keeping them in free-fall. This is the situation in a gas where there are no constraints on the movement of molecules.



This gas-type of rotation also has a defined relation between speed and distance of the markers: the cube of the velocity is proportional to the square of the distance—as the distance increases, the velocity rapidly decreases.

$$d^2 \propto \frac{1}{v^3}$$

$$d = k\sqrt{\frac{1}{v^3}}$$

1 = 1
2 = 0.35
3 = 0.19

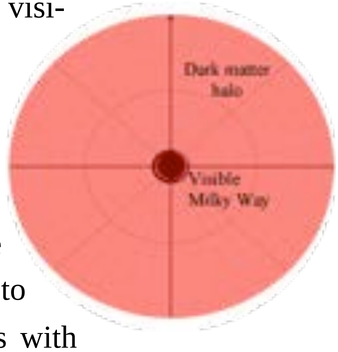
To a high accuracy, the satellites orbiting the earth, and the planets orbiting the sun all have a gaslike rotation.

When the techniques were developed that could measure the velocities of the stars in the galaxy as they all rotated about the billion SU black hole at the very center, it was expected that the stars at the very periphery would be moving with a speed about the center that has a gaslike relation to the speed of stars much closer in.

This expectation was found to be incorrect; the speeds were found to be almost solidlike, and the galaxy rotated almost as a solid disk. The only explanation was that the galaxy was embedded in the center of a rotating invisible mass that was so much vaster in extent than the inner and outer stars that they were all roughly the same distance from the center. If the radius of this rotating invisible mass is 100, and the radius of the galaxy is 1, then the difference in speed between the peripheral and inner stars would not be that different.

A second surprise emerged when the behavior of clusters of galaxies was explored. Our home galaxy, for instance, belongs to the Local Group, with Andromeda as a similar-sized galaxy and about a dozen smaller-sized galaxies such as the Magellanic Clouds. Clusters and superclusters can have thousands of galaxies in them.

The dynamics of the gravitational attraction between galaxies, however, could only be explained if each one of them had a mass that was 10 times bigger than the baryonic matter in them. For instance, the mass of all the stars in the home galaxy is 10^{11} SU, as is the mass of the tenuous interstellar gas and dust, giving a total mass of $2x10^{11}$ SU. The same applies to Andromeda. The dynamics of the Local Group, however, can only be explained if the Milky Way and Andromeda both have a mass-energy of $20x10^{11}$ SU that extends 10 times as far as do the galaxies' visible components.



This invisible-to-our-instruments mass is called 'dark matter. The home galaxy is at the rotation axis of an enormous halo of dark matter.

Every galaxy is similarly endowed, and galaxies are often strung out in fuzzy lines along great webs of dark matter, with superclusters where the lanes cross. Between the lanes of dark matter, the holes in the web so to speak, are the Great Voids that span hundreds of millions of light-years with hardly any visible matter within them.

Yet again, a readjustment had to be cosmology to the recognized constituents of the physical realm: Baryonic matter is a ~10% minority in a physical universe whose large scale structure is governed by the 90% majority of dark matter.

Identity of dark matter

At the current time of writing this, the identity of dark matter is a known unknown. A few things, however, are expected to hold for dark matter.

1. Dark matter is positive mass-energy and has the usual attractive gravity.
2. All energy is quantized. It comes in integer amounts, so dark matter is quanta of positive energy that has a complex wavefunction that determines its history-over-time.
3. It is expected that the quanta of dark matter are either already known or at least compatible with the current Standard Model of subatomic physics.
4. The quanta must not interact with any type of photons; it must be 'dark' at all radiations from radio waves to visible light to gamma rays.
5. It is expected that the density of dark matter at the center of the halo is greater than at the periphery, so the Milky Way, and hence our laboratories, is embedded in a higher-than-average number of dark matter quanta. Yet no experiment as yet performed has been sufficiently sensitive to notice this plethora of particles. The quanta of positive energy can interact with regular matter by gravity, but not in detectable amounts by the strong, the electromagnetic, or the weak fundamental forces (coupling with bosons).
6. There are two basic possibilities for the dark matter quanta: Either there are relatively few of them, each with a large rest mass-energy, or there are a numerous host of them, each with a tiny rest mass-energy.
7. The current theory of the Big Bang origin of baryonic matter must also explain the prevalence of dark matter.

Neutrinos

The neutrino, in all its forms, satisfies all of these requirements, except for one caveat we will discuss at the conclusion.

The neutrino is a single nonoriented twist in spacetime, a quanta of positive energy that is so small it is difficult to measure. The rest mass-energy of a twist-along-time in one spatial dimension, the electron-neutrino, is <1 eV; the rest mass-energy of a twist in two dimensions, the muon-neutrino, is probably >5 eV; and the rest mass-energy of a twist in all three dimensions, the muon-neutrino, is probably >15 eV.

In comparison, the rest mass-energy of an electron is ~500,000 eV and that of a nucleon is ~900,000,000 eV. The baryonic matter in the universe is ¾ hydrogen (with 1 nucleon) and ¼ helium (with 4 nucleons). If the mass of dark-matter neutrinos is to be 10 times that of the baryonic mass, there has to be a host of them that outnumber each nucleon a billion fold. For every hydrogen atom in the Milky Way, there would have to be billions of neutrino's for them to comprise the dark matter.

Is it possible that, for every molecule of air, there is a haze of a billion neutrinos, but no one has noticed it? This is quite possible.

The neutrino can only interact with other quanta by coupling with virtual weak bosons. These have such an enormous mass-energy of 70,000,000,000eV that the quantum probability of a neutrino coupling with one while passing near an electron or quark is infinitesimal. A neutrino could sail through 10 light-years of solid lead with a high probability of not interacting with anything.

The neutrino is utterly indifferent to photons except when they ever-so-briefly decay into a virtual electron-positron pair. It is also utterly indifferent to gluons, except when they ever-so-briefly decay into a virtual quark-antiquark pair.

So, as far as neutrinos are concerned, there is no difference between sailing through intergalactic space and sailing through the earth, and a billion fold haze of neutrinos would be currently quite undetectable. A neutrino approaching the earth will accelerate in the gravity well, and pass through the center of the earth at high speed. As it climbs up out of the gravity well, it will decelerate and leave the earth's opposite surface at the speed it entered. When it is far from the earth, it will have the speed it originally had before the earth exerted any influence.

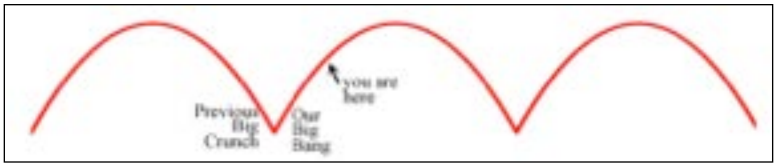
To complete the neutrino's case for being dark matter, a billion fold excess of neutrinos in the Big Bang is almost required by the Standard Model of subatomic particle physics.

NEGATIVE ENERGY

In fact, for many years the great debate in cosmology was about the overall curvature of the universe and its eventual fate. There were three possibilities:

1. An Open universe has a negative curvature and the expansion continues while getting incrementally slower. There is not enough positive energy—bosons, photons and dark matter—to completely slow down the expansion.
2. A Flat universe has a zero curvature and the expansion eventually stops, but it takes an eternity to actually get there. The expansion slows asymptotically to zero as there is just enough positive energy to stop the expansion given an eternity. The fate of the Open or Flat universe is essentially the same. This is not so for the third possibility.
3. A Closed universe has a positive curvature and the expansion eventually stops. There is more than enough positive energy to completely stop the expansion. Like a ball thrown upwards, the universe does not stop there; it starts to contract. The CMB starts gaining, not losing, energy and the temperature starts to rise. Cosmic history would repeat itself as the universe headed towards the Big Crunch. From there it could rebound with another Big Bang and so the cycle could continue again and again without any loss during the cycle—there wasn't anywhere to lose it to (and who is to say whether this was the first

time around or not). It was this possibility that motivated the measurement of the historical rates of expansion.

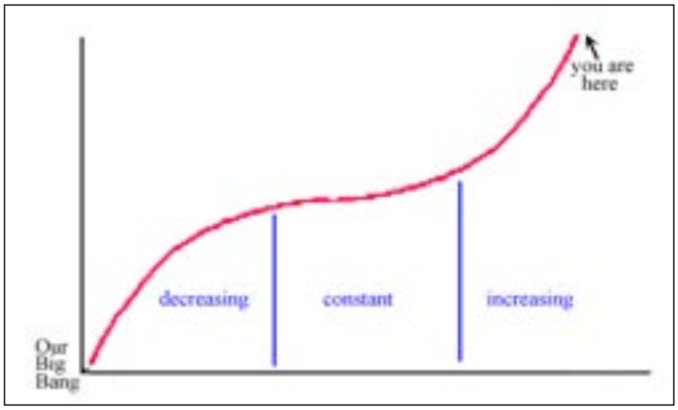


Measuring the expansion

All of these fascinating speculations had to be abandoned when sensitive techniques were developed that could peer into past eras and actually measure the expansion rate as the universe matured.

It should be remembered at this point that, while all the universe is the same age, the cosmologically-slow speed of light means that the farther away things are, the younger is the stage that we observe them at. For instance, a couple of billion years after the Big Bang (~10 billion years ago) was the epoch of galaxies forming, each with a massive black hole at the center. So massive is the energy output during the formation of the black hole that we can observe them as quasars at a distance of 10 billion light-years, while the protogalaxies are hardly visible. (They are quasi-stellar objects because, at that distance, they appear as points, as do most stars even when viewed through the most sensitive instruments.)

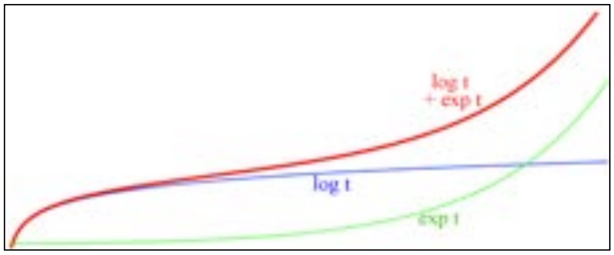
If we could instantaneously teleport an observer to one of the quasars, however, he would find himself in a quiet, mature galaxy much like our own. Moreover, looking back across the void at the Milky Way galaxy, he would observe it in early stages when the central galactic black hole was forming and it would appear to be a quasar.



The result of such peering back into the expansion history of the universe was quite unexpected. This is what was found:

1. For the first third of the universe's history, the first 'trimester' of 5 billion years, it behaved as expected, the rate of expansion fell off with time.
2. In the second trimester, the expansion was constant and unchanging.
3. In the third trimester, our current era, the universe started to expand at an ever increasing rate.

A curve of this shape can be obtained by adding two curves together, the (natural) log function and the exponential function. The log function starts off fast but has an exponentially decreasing rate of growth similar to that of a universe of positive energy with a closed, positive curvature. The exponential function, on the other hand, starts off slow but has an ever-increasing rate of growth. The sum of the two creates a curve similar to that of the universe's rate of expansion.



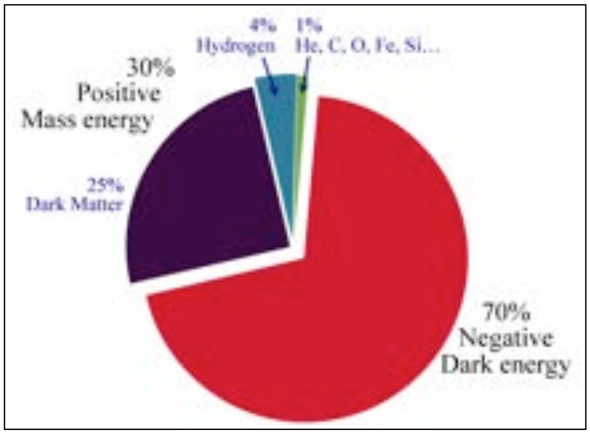
Because it is not possible for positive energy with gravity to increase the rate of expansion, cosmologists realized that there was another component to the universe made of negative energy with an antigravity action.

This negative energy is currently called Dark Energy, and since it is currently overwhelming regular matter that is trying to slow down the expansion, there is more negative energy than positive energy in the universe.

To my mind, the term *Dark Energy* is so easily confused with *dark matter* that it is better dropped. While dark matter and dark energy are both dark because neither interacts with photons, the great difference is in the gravitational effect. For this reason, we will call it negative energy to make this distinction clear.

Current techniques of detecting dark matter are so crude that we have little idea as to how this dark energy is structured, but it seems to be relatively uniformly distributed throughout all of space.

The best contemporary estimate of the current composition of the universe is that the physical realm of positive energy amounts to 30%, and that the realm of negative energy accounts for the remaining 70%.



Quantized energy

Some thinkers have proposed that this negative energy component of the universe is a continuum. As noted earlier, this goes against the very core of quantum theory that all energy is quantized. Unless shown otherwise, we can assume that any negative energy in the universe will be quantized, and that such energy will appear in one of the ways in which the 'other' metric can be twisted. As noted, quanta of negative energy will be either tachyon particles or speed-of-entanglement couplers moving, as we have suggested, in the spiritual metric that complements the physical metric.

We suggest that the quanta of dark energy are the fundamental components of the substantial spiritual realm, and that its structure fills all of space. This behavior is the exact opposite to that of physical energy that clumps into suns which, while large from our parochial point of view, are small on the scale of interstellar and intergalactic space.

As mentioned earlier, our physical substantial bodies are composed of entities that are moving at high-speed. Electrons move at thousands of miles a second while photons move at light speed. Yet, when they are confined by the internal quantum wave, they result in bodies that have small relative motions.

In a similar way, to suggest that the substantial spirit body is composed of elements that move at greater than light speed is not to suggest that spirit bodies are zooming around at high speed. When confined by the spirit mind, the tachyon fundamental components of the spirit body can also make up a body at rest.

So, while spirit ‘atoms of solid’ have constituents moving at multiples of light speed, the wave confines them into structures that can be at rest, albeit ones that are much more extended than those in the physical world.

If there is a second substantial realm, we will, as the simplest of assumptions, expect it to also have a similar structure to that of the physical realm:

One Universe, Two substantial realms	
small condensed structures emergent substantial physical realm	vast extended structures emergent substantial spiritual realm
30% **Dark & regular matter** **regular tardyon particles** **quanta of positive energy**	**70%** **Dark Energy** **SUSY tachyon particles** **quanta of negative energy**
xi yi zi t	x y z ti
physical metric	spiritual metric

1. Spiritual systems are a hierarchy of interacting subsystems.
2. The foundation of the hierarchy is a set of fundamental spiritual entities.
3. The fundamental spiritual entities interact with each other, but they do not interact with the fundamental physical entities
4. The fundamental spiritual entities are quanta of an energy that is not identical to physical energy. The quanta are twists in a spacetime that cannot be identical to physical spacetime.
5. The spiritual quanta are confined by a progressively more-structured and intricate internal wave.
6. The spiritually-substantial form of any system over time is a reflection of the form of its internal wave.
7. We shall tentatively suggest that the internal wave aspects of the physical and spiritual are identical.

Substantial experience

From all accounts, the subjective experience in the substantial spirit world is remarkably similar to that experienced here in the physical realm. If our thesis is correct, then the substantial spirit body is composed of tachyons interacting by speed of entanglement couplers all confined by a quantum wavefunction. We shall now examine whether this could possibly be the basis for a subjective experience of a substantial world.

To see that this is possible, we start with an overview of our subjective experience of the physical world as being substantial and solid. Even the most erudite of scientists has difficulty experiencing everyday life as a being of quintillions of quarks and electrons all coupling with photons and gluons, confined by a quantum wavefunction. While this is the reality, we do not experience it directly; we do so through our senses. Our physical senses are triggered by a multitude of electromagnetic interactions with the objects around us. The quality of these interactions is converted into digital information that is sent along nerves to the brain where it is further digitally processed. The results of this digital processing are converted back into analog form which then merges with our mind.

A very similar sequence can be proposed for the subjective sensing of the spirit world as a substantial realm just by replacing physical particles with spiritual particles; the rest is the same. In either case, there is nothing really ‘solid’ there but, in our mind. our experience is of substantial solids.

Two beings composed of sub-luminal particles in the physical metric experience a handshake just like two beings composed of super-luminal particles in the spiritual metric. In either case, the experienced solidity of the handshake is all in the mind.

Creation of Spirit Realm

Unification Thought is not specific about the order of creation. Some think that the spirit world was created first and the physical world created later on that foundation. The process of origin-division-union, however, suggests something more elegant; that creation involved Nothing being separated into two complementary realms at the same moment. In this thesis, we suggest that four of the eight components of complex space-time were twisted into a left-handed configuration—the physical metric—while the remaining four were twisted into a right-handed configuration constituting the spiritual metric. This would account for the distinct left-handedness of particles and, it is thought, the excess of matter over antimatter in the physical realm—a fact otherwise to explain in current theories.

> It was a revolution whose implications are not completely resolved today. Wolfgang Pauli captured the idea best in a phrase calling God ‘a weak left-hander!’ He initially used those words to dismiss the results, and did not accept the fall of parity until he read papers produced by physicists who confirmed [the] result in various other experiments.[5]

We can speculate that the left-handed metric at the moment of Creation was the tiny bit of ‘false vacuum’ popular in current cosmology. This Planck-sized speck inflated rapidly creating the space of the physical universe. This exponential inflation was abruptly slowed by the strong force which converted the inflation into positive energy, the hot Big Bang. A more sedate expansion continued, matter and antimatter annihilated, and the remnant matter eventually cooled and condensed into galaxies, stars and planets.

> False-vacuum-dominated inflation is dramatically different from the usual true vacuum case, both in its cosmology and in its relation to particle physics.[6]

We can speculate that the right-handed entity followed a quite different history. It doubled in size at a constant sedate rate and has been doing so ever since. It seems that the (moderate) inflation phase of spirit-world history never ended and never will.

The inflation phase of the physical world was very rapid and stretched the false vacuum at a constant energy density: at the strong braking, this accumulated energy was dumped into the energy of the hot Big Bang and has been a constant ever since.

For the first few billion years, there was a preponderance of positive physical energy in the universe and this slowed down the residual expansion. The spirit world, with its much slower but never-ending inflation, added negative energy to the universe at a constant rate. Since the positive energy in the universe is a constant, at some point in time the amount of negative energy equaled and then surpassed the constant positive energy. This apparently happened ~5 billion years ago, ~8 billion years after the Big Bang. At this point, the decelerating influence of the positive energy on cosmic expansion was replaced by the accelerating influence of the excess negative energy.

Theology suggests that the modest inflation phase of the spirit world is eternal, that it will never stop as did the violent inflation phase of the physical realm.

So, we conclude that current theory is quite comfortable with two substantial realms—one an emergent property of wave-confinement of positive energy quanta in the physical metric—the regular particles—and the other an emergent property of wave-confinement of negative energy quanta in the spiritual metric—the SUSY particles.

The physical realm of our everyday lives includes qualities of real *substance*—e.g., weight, color, sound, touch, etc.—and qualities of abstract *mind*—e.g., love, generosity, hate, jealousy, etc. Since we have postulated that the physical and spiritual realms are complementary, it suggests that, in the spiritual realm, the reverse is the case. Qualities of substance are love, generosity, hate, jealousy, etc., while qualities of mind are weight, color, sound, touch, etc.

One Universe, Two Realms

When the physical world alone is taken into account, the universe is almost empty. The 100 billion stars in our home galaxy, for instance, take up a negligible amount of space even when their solar systems are added into the calculations. Over 99.999% of the galaxy has no physical structures in it except for wisps of gas. Why all that ‘wasted’ space in God’s creation.

This is an even more pressing question when we look beyond the galaxy, inasmuch as there is even more seemingly wasted space out there. This is not immediately obvious when looking into the night sky, which seems quite populated. Almost everything we see there with our naked eye, however, is local and belongs to the home galaxy, the Milky Way.

If all the other galaxies in the universe disappeared, we would notice no difference in the night sky to the naked eye other than the absence of a small hazy patch in Andromeda. This is the Andromeda Galaxy with 100 billion stars and is as big as the Milky Way. But it is almost invisible to the naked eye for, while it is huge and packed with stars, it is 4 million light years away—a vast, empty distance. All the other billions of galaxies God has scattered across space are far too distant and far too faint to be seen without a telescope. Even with the most sophisticated telescope, their domain is limited to the galaxies in the *visible* universe, since the universe is not yet old enough for light from the rest of the physical realm to reach us here on earth.

Intergalactic space is vast and physically empty. A simple calculation reveals that the regular matter in the physical universe (mainly in the form of stars) takes up only 0.000,000,000,000,000,000,000,000,0002% of the volume of the visible universe[7].

Now a fundamental axiom of Unification Thought is that the universe is designed, and in fact, is specifically designed for human beings. So there must be a reason for all that vast space, especially as it seems to otherwise conflict with the ‘home for Man’ concept.

Did God create all this empty vastness just to make travel between the stars and galaxies through the hostile-to-life vacuum difficult for Man? This does not make sense in light of the following reasoning based on the Divine Principle:

God’s plan was for Adam & Eve <u>not</u> to Fall. If they had not fallen, they would have multiplied a family of True Love—presumably quite a large family.

Their descendants would also multiply such families of True Love. Assuming large families as the norm, it is not unreasonable to expect that the human race would double in size every 25 years or so, since war would be unthinkable and disease would be controlled far better than it is today.

The population by year N00 would be 2^{4N} and the population would reach the current levels of 10 billion in just 800 years after the first humans! Given that 100,000 years have passed since Adam, the current human population would be $2^{4,000}$ or, roughly, a trillion trillion trillion trillion trillion trillion billions. Clearly the earth would NOT be room enough for such a vast population, and either stringent birth control would ensue or, God having planned ahead, a way to expand to all the billions of earth-like planets out there would be easily found. One way, of course, would have been to have all the other planets close at hand: but they are not.

As birth-control is not DP-compatible, we can assume that there is a easy way to reach other earth-like planets. The best possibility for such easy intergalactic travel that I can envisage based on current knowledge involves the phenomenon of entanglement.

An entangled pair of particles have an instantaneous connection that can span the universe.

Many phenomena over the past 13 billion years have created such pairs of particles that have since been separately cruising through the universe at light or sub-light speed.

The Earth (or better, the Moon without an atmosphere to destroy the entanglement) is bombarded each second by billions of entangled particles whose partners are spread across the visible universe.

A technology based on this gift from God could open the way for travel between the stars and galaxies. Admittedly, science has just started to explore this phenomenon so it is a ways off yet. At this point, however, it is instructive to remember a legend from the birth of the electric age. In the mid 1800s, William Pitt, the Prime Minister of Great Britain, was touring the laboratory of the Royal

Society when he encountered Faraday playing around with wires and magnets. “Of what possible use is all this?” he politely enquired. “I have no idea,” replied Faraday, “All I know is that you will be taxing it in 50 years.”

As Father Moon has often pointed out, the entire physical universe was created as the home for True Love mankind. So, such speculation is not unreasonable based on both science and religion.

Just an infinitesimal fraction of all the vastness of space is used for life in the physical world involving the stars and planets. In this paper we suggest that all this vastness is not wasted space; it is where the spirit world resides. It is certainly parsimonious to suggest that, rather than wasting all this vast space, God had a purpose for such vastness to contain the spirit realm. We have one universe containing two complementary substantial realms.

> “Do you know how infinite and unchanging the spirit world is? We are now aware of the vastness of the universe. The universe is over 22 billion light years across. How big is that? Light travels 300 million meters in a second. In one second, light can go around the Earth seven and a half times. The distance light covers at that speed in one year is called a light year. Light takes 22 billion years to cross the universe, not 200 days. So how vast is the universe? The entire universe is the stage for our activities….” [8]

CREATION OF THE PHYSICAL REALM

In *Volume Two*, we discussed the Big Bang in detail. Following is a summary of the sequence of events that took place in the Big Bang.

Time Zero

In the beginning, there was an abstract hierarchical structure of a finite number of complex dimensions. The four dimensions at the foundation of the hierarchy were asymmetrically separated into two orthogonal chiral constructs, the L-physical metric and the R-spiritual metric. The structure in the remaining upper dimensions is the Logos, the natural law. The two realms followed an external history determined by the Logos.

Exponential Inflation

In *Volume Two*, we discussed the pixelation of space—the *Planck Length*, pL, measuring ten trillion, trillion, trillionths of a meter—and the pixelation of time—the *Planck Time*, pT, measuring ten billion, trillion, trillion, trillionths of a second. We also discussed the physical limits on temperature that can only be approached asymptotically by regular matter. The lower limit of temperature is called *Absolute Zero*, 0°, while the upper limit of temperature is called the *Planck Temperature*, pK, one hundred million trillion trillion degrees Kelvin or 1.4×10^{32} K which corresponds to thermal photons with the Planck energy, pE, of 1.2×10^{28} eV = 1.2×10^{19} GeV.

The p-metric construct that emerged from Time Zero is called the ‘false vacuum.’ It had an extension in the spatial dimensions of 1 pL and an extension in time of 1 pT. This pixel of metric was at temperature pK, and the energy amounted to the Planck Mass of ~1 microgram. The inherent Leftness gave the false vacuum a negative pressure, which drove an exponential inflation of the spatial dimensions. A separation of 1 pL became 2 pL each pT.

The era of inflation lasted until ~10^{-36} seconds after time zero, a period of 100 million pT, during which the doubling occurred 100 million times. A separation of 1 pL, in this brief instant, became $2^{100,000,000}$ ~$10^{30,000,000}$ pL. The tiny speck of physical metric became enormous, on the order of $10^{29,999,965}$ meters = $10^{29,999,949}$ light-years

In natural units, light speed is 1 pL/1 pT, so during this time light speed influences could only travel 100,000,000 pL = 10^8 pL, which is infinitesimal compared to the exponential distance. The contents of the false vacuum were separated at hyper-luminal velocities.

Creation of energy

This hyperinflation did not have any consequences due to the weak and electromagnetic interactions between the quanta in the false vacuum because both decrease in energy as separation increases. The gravity of the initial µgm. of energy is negligible and also falls off with separation.

The color interaction between the quarks and gluons, however, has the rather counterintuitive property of increasing with separation. While the energy in the electromagnetic interaction is *inversely* proportional to the square of the separation, the energy of the color interaction is directly proportional to the sixth power of the separation.

At the Planck Temperature, the two forces have the same energy, and we can set the energy of both interactions at 1. At the end of inflation, the energy of the electromagnetic interaction will be infinitesimal, while the energy between the separated quarks and gluons will be cosmically enormous.

	$t = 0$	$t = 10^{8} P \sec$
E_{EM}	1	$\frac{1}{\left(10^{60,000,000}\right)^{2}} = 10^{-120,000,000}$
E_{QC}	1	$\left(10^{60,000,000}\right)^{6} = 10^{360,000,000}$

The impetus of inflation flashed over into positive energy at almost the Planck Temperature. This enormous positive energy had an equally-great gravitation that opposed the inflation, and the exponential increase was braked to a more moderate expansion rate.

The inflation slowed from an exponential rate to an ever-decreasing rate of expansion. The now-considerable-sized physical universe was an ultra dense plasma of every and all kinds of particles. This would also hold for the ultra massive X-bosons with all three fundamental charges, predicted by group theory, that interconvert quarks to and from neutrinos and electrons. Theorists who do not accept an asymmetric origin pin the prevalence of matter on an asymmetric decay of these hypothetical X-bosons. The X-boson, however, predicts that the proton should be unstable but, while avidly searched for, the decay of a proton has never been observed.

All the bosons and fermion/antifermion pairs were equally represented, the original Leftness now being expressed in the slight inequality between matter and antimatter fermions.

$$\frac{matter}{antimatter} = \frac{100,000,000,001}{100,000,000,000}$$

Freezing Out

So, just 10^{-36} seconds after the Origin Event, the physical universe was an expanding -dense plasma of every kind of subatomic particle whose history was determined over time by the wave-function reflecting the very lowest levels of the Logos.

The era that followed the braking of inflation generation of the hot Big Bang by quantum color separation involved a series of ‘freezing out’ of particles. This is a technical term that, while based on the freezing of ice, has nothing to do with cold. It is based on the phase-change that occurs with falling temperature as the water turns to ice. In this general sense, steam freezes at a specific temperature to water, and liquid iron freezes at a specific temperature to a magnetic state (even though this Curie Point is almost 1,000°F).

As the universe cools from the trillion-degree temperatures of the start (where the characteristic energy is in the trillions of terra-electron-volts) over a period of ~10 minutes to where the characteristic energy is less than 1 MeV, the universe goes through a series of phase-changes as particles ‘freeze-out.’

The temperature-energy at which a particle freezes out depends on the rest mass-energy of bosons (twice this for fermions that only come and go in particle-pairs). If the temperature-energy is above this rest mass-energy, then the particle (or particle-pair) is in equilibrium with the photons and all the others that are currently present, and it travels at light speed.

The rule is, at temperature-energies well above the rest mass-energy, the particle is abundant and travels at essentially light speed. The Planck Temperature-energy of 10^{28} eV is far, far above the rest mass-energy of every particle discovered so far in any experiment.

The hot Big Bang was a menagerie of every known particle and antiparticle in an ultra dense state which rapidly (but not exponentially) continued to expand, cool and become less dense. All three quantum interactions, even the weak, were on an equal footing. This is the state above the Grand Unification Temperature (GUT). This equivalence did not last long.

As the universe grew less dense, the quarks, antiquarks and gluons avoided being separated by collecting into colorless hadrons—such as a proton or pion. The color force froze out of the GUT state. As the temperature-energy was still vastly greater than the rest mass-energy of the hadrons, they continued in equilibrium with all the others.

The weak bosons (Z, W^+, W^-) have a mass-energy of ~80 GeV, so when the temperature-energy fell below this, these previously abundant bosons disappeared from the plasma. Only the tiny halos of virtual weak bosons remained, and the weak force froze out leaving only electromagnetism.

Ignoring gravity for the moment, since it is not a simple quantum force, the three forces progressively froze out of the GUT state.

$$\boxed{\begin{aligned} \frac{nucleon}{antinucleon} &= \frac{100{,}000{,}000{,}001}{100{,}000{,}000{,}000} \\ &\xrightarrow{freeze} \frac{1\ proton}{200{,}000{,}000{,}000\ photons} \end{aligned}}$$

The rest mass-energy of the nucleon pairs (proton and neutron) is ~2 GeV and, when the temperature-energy fell below this, the matter/antimatter pairs froze out of equilibrium as they annihilated into photons.

The resultant plasma had 1 proton and 1 neutron to half a trillion photons (which equilibrated with the others that had yet to freeze out).

When the temperature-energy fell below 10 MeV, the neutrons (which, being heavier, were less numerous and unstable) could stick to the protons by a derivative of the strong color force forming deuterons (heavy hydrogen-2), almost all of which rapidly united together as very stable helium-4 nuclei. It is the tiny fraction of neutrons that did not end up in helium-4 that has allowed science to accurately understand this phase in the physical universe’s history. The end result was ~70% hydrogen-1 and 30% helium-4.

About 10 minutes after the Origin Event, the temperature-energy had fallen below 1 MeV, the rest mass-energy of the electron-positron pair. They disappeared from the universe, as they fell out of equilibrium and annihilated into photons, leaving behind the small excess of electrons that electrically balanced the small excess of protons.

Proto-universe

All that emerged from the Big Bang were the tiny number of hydrogen and helium nuclei plus the electrons and a huge excess of photons, neutrinos and antineutrinos (of all three generations).

The key point is that the neutrinos had fallen out of equilibrium once the weak force had frozen out. A neutrino is a single nonoriented twist and it can combine with an antineutrino to form a single oriented twist, a weak boson. Because a neutrino/antineutrino pair do not have sufficient mass-energy for this, this is not possible. Also, they cannot unite as a photon, since this involves two oriented twists.

The only remnant of the once abundant antimatter was in the anti-neutrinos. Ignoring the antimatter difference, for every nucleon that emerged unscathed from the Big Bang, there were 100 billion gamma ray photons and 100 billion neutrinos/antineutrinos.

If the mass-energy of the neutrino is 1/10 eV, and there are one hundred billion of them for every nucleon, the ratio of boson mass to neutrino mass is within the range of the experimentally-calculated ratio of regular matter to dark matter in the universe.

$$\begin{aligned}\frac{mass\ bosons}{mass\ neutrinos} &= \frac{1}{10^{11}} \times \frac{10^{9}\,eV}{0.1\ eV} \\ &= \frac{1}{10} \\ &= \frac{regular}{dark}\ matter\end{aligned}$$

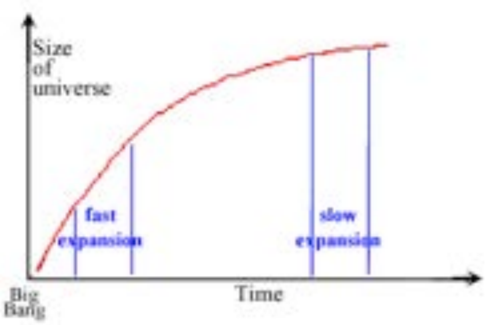
Resisting Expansion

The energy in the Big Bang photons and neutrinos is all positive, and it has an attractive gravitational effect which opposes, and slows, the expansion of the universe. Energy is lost in opposing this outward thrust. As the photons lose energy, their period increases and they fade from gamma ray through X-ray, UV, visible light, IR to the microwave photons that flood the universe as the Cosmic Microwave Background, CMB, of our current era.

The neutrinos lost energy by slowing down becoming the slow, relic neutrinos that also pervade the universe. It is a matter of debate as to whether or not this slowing down was sufficiently rapid for their mutual gravitation to amass them into the condensations and filaments of dark matter that are currently observed.

What is not up for debate is that matter and relic photons/neutrinos are all positive energy that has been opposing, and slowing down, the expansion of the universe—somewhat like a ball being thrown up in the air, slowing down under the influence of gravity. It seemed hardly worthwhile to test the implication of then-cosmology that the universe had been slowing down in its rate of expansion for all the 13 billion years since the Big Bang.

The diagram is what the early expansion of the universe was expected to look like if and when it was actually measured.



Reference Frame

Now that we have established the basics of system-building and the unified systematic hierarchy, we can apply these to the next stages of the universe's development in time. As most of the gamma ray photons created by the Big Bang have yet to interact with anything, and have been stretched by the continuing expansion of space-time into microwaves, the CMB provides a universal and absolute reference point for the measurement of physical time.

As our galaxy is, and always has been, essentially at rest with respect to the CMB, and there is essential agreement between our time scale and that of the Universe.

One Logos, Two Realms

$$\begin{tikzcd}
 & \uparrow \arrow[r, "Logos"] & P\ universe \\
O \arrow[r, "Logos"] & + & \\
 & \downarrow \arrow[r, "Logos"] & S\ universe
\end{tikzcd}$$

The emergence of the Logos in the Abstract Realm preceded the Origin Event of the Big Bang. The Logos separated Nothing into two abstract pixels with a quality that, for simplicity, we can equate with Left action and Right action. We will later discuss what is being twisted. This 'something out of nothing' is a similar dynamic to the vacuum creating a virtual particle pair (such as an electron and positron pair that do not have a pixel of action between them), i.e., or the reverse of the equation, $(+1)+(-1)=0$.

The separated Left and Right pixels, obeying the Logos, developed in a complementary manner into two complementary realms, the S universe and the P universe.

The Left pixel developed, obeying the Logos, and resulted in the P universe, the hot Big Bang and the development of the physical universe. This development is quite well understood from the merest fraction of a second after the very start of the process up to the present day, and this we will focus on. The complementary S universe was only detected in the last decade of this writing, and we will later discuss what little is known to science about it, and offer a précis of what other disciplines have inferred about it.

Structure in Spirit Realm

While both realms are substantial, there is no requirement that they have similar structures—in fact, we might expect them to have quite different structures. The physical world involves matter clumping together under attractive gravity into relatively small aggregations called galaxies, stars, planets, etc.

What is the structure of the spirit world? The current techniques of detecting dark energy are too crude to tell us much, but they indicate that it is not in clumps but fills all of space. The little communication that has occurred between the spirit world and the physical world suggests that the structure of spirit world involves vast layers, extensive and endless substantial planes that are not wrapped around little planets.

This speculation about the spirit realm is from *The Great Divorce* by C. S. Lewis, about a bus trip from the outskirts of Hell to the edge of Heaven. First, consider the vision as the aeronautic bus soared up away from the miserable bus stop in Hell:

> We were now so high that all below us had become featureless… I got the impression that the grey town filled the whole field of vision… astronomical distances… millions of miles away, Millions of miles from us and from each other…”[9]

Then, arriving in the at the edge of Heaven:

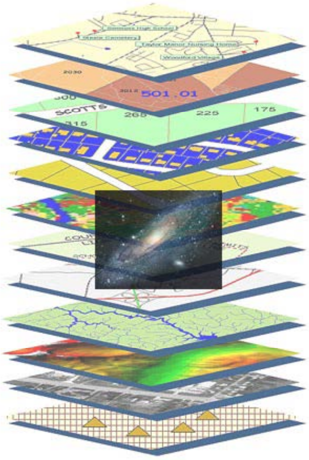
> A cliff had loomed up ahead. It sank vertically beneath us so far that I could not see the bottom, and it was dark and smooth. We were mounting all the time. At last the top of the cliff became visible like a thin line of emerald green stretched tight as a fiddle-string. Presently we glided over that top: we were flying above a level, grassy country through which there ran a wide river.… I got out… I had the sense of being in a larger space, perhaps even a larger *sort* of space, than I had ever known before: as if the sky were further off and the extent of the green plain wider than they could be on this little ball of earth. I had got ‘out’ in some sense which made the Solar System itself seem as an indoor affair.[10]

A similar sense of the vastness of the substantial spirit world is from *Life in the World Unseen:*

> Space *must* exist in the spirit world. Take my own realm alone, as an example. Standing at the window of one of the upper rooms of my house I can see across huge distances whereon are many houses and grand buildings. In the *distance* I can see the city with many more great buildings. Dispersed throughout the whole wide prospect are woods and meadows, rivers and streams, gardens and orchards, and they are all occupying space, just as all these occupy space in the earth world. They do not interpenetrate any more than they interpenetrate upon the earth-plane. Each fills its own reserved portion of space. And I know, as I gaze out of my window, that far beyond the range of my vision, and far beyond and beyond that again, there are more realms and still more realms that constitute the designation *infinity of space*.[11]

Assuming that the dark energy of modern cosmology is in the quanta of the spirit world, and that this negative energy has a structure (and this is an open question in astronomy) arranged in vast layers that cross the vastness of space, we can combine this with the physical world, ending up with a composite picture of “one universe: two substantial realms” that looks something like layers stacked upon layers.

In this view, the vast empty intergalactic physical vacuum is not an unnecessary “waste of space” but room for the substantial spirit world to develop and fill. A house in the highest spirit realms could share space with a supercluster of galaxies. They would not inconvenience each other, being on different sides of spacetime, one extending in the spiritual metric, the other in the physical metric.



The universe is expanding and the positive energy of physical matter is getting even more spread out. The dark energy component of the cosmos is not like this, it just keeps on growing as the spiritual metric expands. This makes sense for an eternal spirit world: it just keeps on getting bigger. This is not the case for the physical world; it has an expiration date. In 60 billion years or so, all the fuel in all the stars in the physical world will have run out and the galaxies will go dark and life, as we know it, will become impossible. We can assume that God has foreseen this and is confident that humans will have figured out how to trigger our own Big Bangs and make new universes with them. The spirit world, on the other hand, will just keep on getting bigger into eternity.

To conclude, we have expressed the internal truth of two substantial realms in the language of modern quantum physics in a plausible, if not necessarily correct, way.

Sir John Templeton, who dedicated his fortune to a Foundation for the reconciliation of theology and science, and who passed away in July 2008, espoused what he called a “humble approach” to theology. Declaring that relatively little is known about God through scripture and present-day theology, he once predicted that “scientific revelations may be a gold mine for revitalizing religion in the 21st century.” [12]

We can hope that he was correct.

THE PHYSICAL UNIVERSE

The pixel of Left (or ‘false vacuum’ or ‘inflaton’ as it is variously called) was at the Planck temperature (~10^{35}K) and had a negative pressure. Driven by this negative pressure, this pixel entered a period of inflation during which it doubled itself with everyPlanck tick of time.

Quantum pixels

We have noted the difference between a discrete situation and a continuum when we briefly looked at the types of infinity in *Volume Two.* We saw how a discrete situation, such as the countable fractions between 0 and 1, can look just like the continuum of the uncountable irrationals between 0 and 1 when the precision is not too great.

Whatever the abstract construct at the start, the physical world that emerged from it is most decidedly of the discrete variety. Things that appear continuous to us, and were considered so in classical science, only appear such because our precision of observation was too rough to notice. This is similar to how the screen of my computer looks white to me, but under a magnifying lens is actually seen to be equal numbers of red, blue and green pixels all ablaze together. Again, similar phenomena occur in science when nature appeared to be continuous—e.g, space, time, energy, existence, etc.—

until we developed the technology capable of such precision and resolution that the discrete nature of most things was revealed.

The discrete pixels are called quanta (*sing.* quantum) in science, and as Max Planck was the first to notice this in the quantum of action (existence), the units are named after him.

Measure	Unit	Value
Existence	Planck's Constant	$6.6\times10^{-34}\,kg\ \text{sec} = 4.1\times10^{-15}\,eV\ \text{sec}$
Time	Planck Time	$5.4\times 10^{-44}\ \text{sec}$
Space	Planck Length	$1.6\times 10^{-35}\,meter = 4\times 10^{-33}\,inch$

In natural units, all pixels have a size of 1 with all larger measures being integer multiples of this. In human units, the pixels are so inordinately small that the numbers would be huge. The speed of light is 1pL each 1pT in natural units of space and time, while it is 299,792,458 meters each second in human-scale units.

The Hot Big Bang

The initial pixel of spacetime, driven with Left, doubled each Planck tick of time for a time period that is estimated to have lasted for 10^{-35} seconds which, while brief by human standards, is 10^9 quantum ticks. And the number of pixels doubled each tick. The final number of ticks is roughly $2^{10^9} \sim 10^{33,333,333}$. As the current volume of the visible universe has ~$10^{30,000}$ cubic Planck units in it, we are only able to see a fraction of the entire physical universe that is, though invisible, the same age as our visible piece of it.

This exponential expansion phase in the universe's history was brought to a close when the separation of fundamental entities with a color charge braked the inflation and converted the potential energy of expansion into the positive energy that we call the Hot Big Bang. This energy appeared as an intense mangling of spacetime pixels into every kind of particle and antiparticle, fermion and boson. The average energy was 10^{28}eV, the Planck temperature of 10^{32}K so everything was moving at light speed, and the universe was an ultra dense fluid of bosons and fermions with an equal amount of left and right, in which the original Left was only an insignificant asymmetry to the whole.

The pixels of spacetime, throughout this time retained their entanglement, and have done so up to the present. This global entanglement is observed today in the absolute nature of inertial mass and angular momentum. The Logos determines that this entanglement also has a local aspect that attracts, which we call gravitational mass.

In the early universe, the mass density was enormous, as was the gravitational attraction, but equal in all directions; it was *isotropic*. It resisted expansion, further slowing down the inflation of the universe.

As the universe expanded, the temperature fell, and one by one all the matter-antimatter froze out and all that remained was mainly photons, neutrinos and antineutrinos, with the original Left emerging as a 1 in 100 billion number of electrons, protons and neutrons.

The first system building was when the density and temperature were not sufficient for free quarks and gluons, and they condensed into hadrons and ended up in the two nucleons, the proton and neutron. (During the first minute, the 11-minute half-life of the neutron was long enough not to alter the equality of protons and neutrons.) By the time it was cool enough, however, for the deuterium nucleus to be stable, the balance had shifted towards the protons, and all the neutrons ended up in the helium nucleus. Both of these system building interactions were governed by the Logos.

Cooler still, and the electrons and anti-electrons annihilated leaving behind the 1 in a 100 billion excess of left-handed electrons, a diluted version of the original Left, along with the quarks.

The neutrinos and antineutrinos had stopped interacting once the average spacing became much larger than the weak force radius and, while a few of them did get close enough for matter-antimatter untwisting, most did not. As neutrinos can travel through light years of solid lead without ever interacting, and the antineutrinos are a lot less densely packed than lead, the 200 billion neutrinos and antineutrinos are around to this very day. They, like the photons, have had almost all of their kinetic energy reduced by the expansion of spacetime. All they have left is their rest energy which, while only a few eVs, mounts up into the billions, and these relic neutrinos are the best candidate of the dark matter in the universe that is ~10 times as great as that of the nucleons in the universe.

Unlike the early Hot Big Bang where the braking of the exponential inflation had jangled all of spacetime in every possible way, spacetime was much calmer now, with energy locked up in discrete quanta and there was the beginning of a separation of matter and the vacuum. While the vacuum was still being disturbed by the passage of photons and neutrinos, this became less and less as time went by until we have the placid vacuum today of the Voids in which spacetime is hardly ever disturbed.

The pixels of this ‘perfect vacuum’ have an internal wave aspect that is usually cancelled out by all the others around. When this cancellation is disturbed by energy passing through, the result is the local effect we call gravity. The internal aspect of the spacetime pixel also has an excited, but not twisted, state. This high-energy state is called a Higgs Boson, and it has no spin, no charge, and no color. A search is currently on to detect a Higgs, and the current lower bound for its rest mass energy is ~160 GeV, about 160 times the energy in the gluon field inside a proton. If it has a quantum of action, it is a real boson with a verygreat mass; if it does not it is a virtual boson and, not actually disturbing the pixels, has no mass at all.

Just like the other three forces, gravity can be described as coupling with virtual bosons, though not with a spin of 1. The local aspects of gravity (the disturbance of the pixels of spacetime entanglement) appear as local coupling with massless spin-2 bosons called gravitons, while the global aspects of gravity, the entanglement of all, appears as a global coupling with the massless, spin-0 Higgs. This was explored by Richard Feynman before the Higgs entered the scientific lexicon.

While spacetime is discrete, at a low enough resolution it can be treated as a continuum, and the mathematical tools dealing with the smooth continuum are well-developed. This was pioneered by

Einstein who described both the global and local aspects of gravity as a bending of spacetime in his epochal General Theory of Relativity.

Clumping

As noted, the early universe was isotropic, but grainy. This graininess was magnified by inflation so that at the end of the Hot Big Bang there was a slight variation, just 1 part in 10,000, between different areas of the early universe. This slight anisotropy began in the neutrinos, the dark matter, and these gravitating clumps and strings of dark matter were the seeds around which the regular matter later clumped together around at start of superclusters of galaxies.

Gravity, however, did not come into its own as a system builder until the universe had cooled sufficiently for the electromagnetic interaction to convert the universal plasma of electrons and nuclei into neutral atoms of hydrogen and helium. This is called the ‘recombination period’ (a bit of misnomer inasmuch as there had only been a plasma up to this point in history).

At this point, the photons became ‘decoupled’ from the matter and travelled freely hereafter. It is these photons that, having all been stretched by the expansion of spacetime, fill the universe today with the CMB. The CMB is isotropic to one part in 10,000, which is how we know of the slight bumpiness in the early universe. It was only after this decoupling from the overwhelming number of photons that clouds of ~75% hydrogen-1 (protons) and 25% helium-4 could start to condense around the dark matter.

The gravitational instabilities in these clouds fragmented them into galaxies and then into stars. The gravitational potential energy of the in-falling and colliding atoms was converted into kinetic energy, and the clouds started to warm up and emit thermal radiation. This radiation pressure opposed the gravitational collapse, but had little impact on the collapse at first.

As this collapse continued, the atoms re-ionized back into a plasma, and when the core temperature and pressure reached high enough values, the protons started to fuse together as a deuterium (hydrogen-2) nucleus (with the emission of a positron that annihilated with an electron into gamma rays) and so on to helium-4. The star ignited.

The radiation pressure outwards was now as great as the inward pull of gravity, and the star reached an equilibrium where the two were balanced. It took up a position on the *Main Sequence, MSS*—the linear relation of mass, temperature, luminosity and lifetime of 99% of all stars—that is determined solely by its mass accumulated before the increasing heat blew the rest of the natal cloud of gas away.

As massive stars have a greater inward pull, they need to be at a higher temperature to reach equilibrium, and they blaze with an intense violet-white light for a brief, by stellar standards, profligate 10,000 years of brilliance that ends in a great cataclysm. These are the O-class stars on the high end of the MSS.

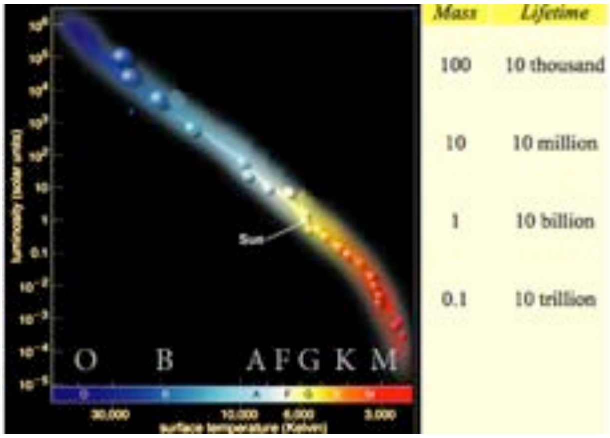
Small mass stars, on the other hand, reach the same equilibrium but generating a miserly red light for hundreds of billions of years of their dim lifetime. These are the M-class stars.

Our medium-sized Sun is a G-class star that will prudently shed its beneficent light for another 20 billion years or so.

As hydrogen and helium are poor couplers with photons, massive clouds could condense before the radiation pressure blew the outer layers away, so the first generation of stars were very massive, of the O class on the MSS. Before the stars ignited, the universe had been dark since all the gamma photons of the Big Bang has lost so much energy opposing the expansion of the universe, that they were now infra red, and so this period is called the Dark Age. This period of darkness ended with the ignition of the first stars, and visible light reappeared in the universe. (It should be noted that all the billions of stars in the billions of galaxies, over all 13 billion years of shining, have added but a tiny fraction to the number of photons in the CMB.)

The Main Sequence

The equilibrium between gravitational collapse and radiation inflation is reached at the same temperature for stars of the same mass powered by hydrogen-to-helium thermonuclear burning at the core. This relation of temperature and mass is the MSS bracketed by the massive O-class stars radiating intensely in the X-ray-UV-violet white at the high end of the sequence, and low-mass. M-class stars dimly radiating in the red at the other end.



The amount of energy needed to power the intense radiation of massive stars is such that they run out hydrogen to burn very much more rapidly than the low mass stars, at which point they leave the MSS.

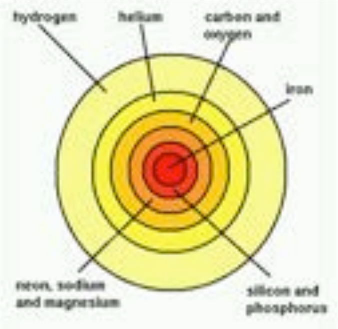
A blue-white O-type star with a mass 100 times that of our sun, has a surface temperature of 30,000K and emits 100,000 times as much energy as the sun. It runs through its hydrogen in only 10,000 years before leaving the main sequence. A red M-type star with a mass just one tenth of the sun's dribbles out just a ten thousandth of the sun's energy and can last over ten trillion years.

The 1st Generation of Stars

The First Generation were O-type stars and, within the first million years, had used up all the hydrogen in their cores and moved off the MSS. The reduced radiation pressure allowed the core to collapse until the temperature became high enough for helium to start to fuse. The energy released by this process, and all the subsequent stages, liberates only a fraction of that released by proton fusion, and so the lifetime remaining is proportionally much less.

At the bloated out surface, the increased amount of energy is spread out over a larger area, so each square centimeter will be cooler. The surface will have a red color because it is so cool and it will be much farther from the center than when young and on the MSS. Despite its cooler surface temperature, the red giant is very luminous because of its huge surface area. An example is of a red supergiant is Betelgeuse, a pink star that can be seen with the naked eye. If it were placed at the center of our solar system, all of the planets out to Jupiter would be inside its bloated surface.

The beryllium-8 nucleus formed out of 2 heliums is very unstable, but it lasts long enough for a third helium to add on, creating a carbon-12 nucleus.



When the core runs out of helium, it heats up until the nuclei fuse into oxygen, then neon, sodium and magnesium, then silicon and phosphorus, and finally into iron and nickel.

This is the end of the line, as iron has a minimum binding energy, and no more energy can be released by further fusion. At this point, the star has an onion layer structure, with the lighter elements around the core. The collapse continues and the core reaches a temperature and pressure at which reverse beta decay becomes possible—absorption of electrons by protons—and neutrinos are produced in great abundance. These leave the core at light-speed thereby removing energy and cooling the core. The core and then the outer layers commence collapsing. The release of gravitational potential energy heats the entire star, and it explodes as a supernova. The star shines out with the brilliance of 100 billion regular stars, and the elements heavier than helium (all called *metals* by cosmologists) are scattered, adding themselves to the primordial hydrogen and helium.

Star Death

Stars have a lifetime that starts when the core of the collapsing cloud of hydrogen/helium reaches a high enough pressure and temperature for it to ‘ignite’ the thermonuclear fusion of hydrogen and the star enters the MSS. It stays on the MSS for as long as it takes until the core hydrogen is all used up. The helium ‘ash’, along with the primordial helium, then ignites and the metals start to be formed in quick succession up to iron/nickel.

The final stages of a star depend on its mass, and can end in a whimper or a bang. For stars about the size of the sun, the core never reaches the extreme conditions necessary for the heaviest metals to be produced. So the thermonuclear reactions cease somewhere between the carbon and silicon stage. At this point, the star is no longer able to create the radiation pressure to oppose gravitational collapse, and star shrinks. The outer layers heat up and prolong the collapse, but the star inexorably shrinks into a “white dwarf” which is at a high temperature but has a small surface area, so is much less luminous than a star at the same temperature that is still on the MSS. At this point, another factor comes into play—the fermion nature of the electrons in the star’s plasma.

As mentioned earlier, the quantum probability of two fermions being in the same state is zero; it is impossible. As the volume of the white dwarf shrinks, the electrons reach a “degenerate” state in which they are on the verge of being forced to enter into the same state. The impossibility of this happening prevents any further collapse. As the white dwarf continues to cool, the volume remains a constant, held up by the ‘degeneracy pressure’ of the electrons, as it slowly cools through yellow heat to red heat and ends as a black dwarf. The mass is still that of the sun, but the volume is about the size of the earth’s. The universe is too young for even the first generation of G-type stars to have turned into black dwarfs. This is the ‘ice’ ending to a star. (As our sun will end its life as mainly carbon, I like to think our sun will end up as a great big diamond.)

For stars much bigger than the sun, the core does turn into iron/nickel and the star goes supernovae. Much of the star is ejected to fertilize the primordial hydrogen for the next generation. The force of this ejection compresses the remaining core and smashes through the electron degeneracy. Rather than be forced to do the impossible, the electrons take the only alternative route and combine with the protons to create neutrons.

If the mass of the core remaining after the ejection is not too great (~2 solar masses) the neutrons, being fermions, also have a degeneracy pressure, and refuse to do the impossible and share a state. This can stop any further collapse, and the result is a neutron star that retains its size as it slowly cools of from the millions of degrees at formation as a gamma star through X-ray, UV, white, yellow, red stages towards blackness.

The neutron star has the mass of the sun in a volume the size of a comet. The density of this ‘neutronium’ is that of the atomic nucleus. The neutrons are stable because it is the proton/electron, in such a situation, that has the most free energy.

If the remaining mass is too great for the neutron degeneracy to resist the intense gravity, the collapse continues and a ‘black hole’ is the end result. To understand a black hole, we need the concept of escape velocity.

Black Holes

We have already discussed the interconversion of kinetic and potential energy in the simple pendulum in a gravitational field. A similar thing happens when a bullet is shot straight up in the air. As it rises in the gravitational field of the earth, it slows down until it comes to a momentary halt. All the kinetic energy of the bullet leaving the gun has been sapped away and stored as potential energy. It then falls towards the earth with increasing speed until (ignoring the frictional heat lost to the air) it hits the ground with its original speed. The energy is now all kinetic and, when it hits the ground, this is randomized as heat.

The consequence of the gravitational disturbance of physical energy is attractive, and this applies to all forms of physical energy, including that of a photon. Just like a rising bullet, the gravitational field drains energy from a photon. Since a photon is always moving at light speed, it does not slow down, the energy is drained from the photon. It is redshifted as its wavelength is stretched, its period increases and its frequency decreases.

Gravity is, however, an extremely tiny effect. Two positive protons will, for instance, repel each other with a force that is a billion trillion, trillion, trillion times the attractive force of their mutual gravitation as a consequence of their physical energy.

For example, the earth and a human body both have equal numbers of positive and negative charges, and the virtual photons are all well-confined. The electromagnetic interaction between the two is minimal, and even a minuscule imbalance is quickly restored by a flow of current, such as a static spark or lighting stroke.

Unlike electromagnetism, however, which has an equally powerful repulsion between like charges, physical energy is only attractive, and does not have an expansive effect. (We will encounter an expansive form of gravity when we get to the section that explains why we are using the term ‘physical energy’ rather than just plain energy.)

Gravitation is cumulative, and even an infinitesimal value can amount to a large value if it is multiplied by a big enough number. Most of the mass-energy of an atom is in the blaze of gluons that is the nucleons, and it is this energy en masse which gives rise to the gravitational mass of a composite body. The human body is a unified wave confining and giving form to ~30,000,000,000,000,000,000,000,000,000 quarks, electrons and an even greater number of gluons and photons. The earth has 2×10^{22} as many of them confined. Each one of these quanta of energy is gravitationally attracted to all the others, and the consequence is the force of gravity that keeps us on the earth’s surface.

Sir Isaac Newton, while entertaining no hypothesis about the internal workings of gravity, derived these very useful approximations about the external nature of gravity that are all still most useful to this day:

1. The mass of an extended rigid body can be treated as localized at a point within the rigid body, its ‘center of mass’ which, for an isotropic sphere, is coincident with its geometric center.
2. The attractive force between two extended bodies is proportional to the product of their masses.
3. The attractive force between two extended bodies is inversely proportional to the square of the distance between their centers of mass.

The surface of the earth, and thus the position of the center of mass of the human body, is ~6,400 km from the center of the earth. The tiny force of attraction between all those zillions of quanta sums up to our ‘weight’ that holds us to the earth’s surface, a force of 9.8 newtons for each kilogram of mass.

In an airplane flying at 10 km (33,000 ft), we are at a greater distance from the earth’s center, and the force is proportionately reduced. The the proportional change is very small, however, and a person of my weight of 170 lbs. only weighs 8 ounces less at this altitude than on the ground.

$$9.8 \times \frac{(6,400)^2}{(6,410)^2} = 9.77$$

Even on the International Space Station, at an altitude of 370 km, the force is still 8.76 and I would weigh 152 lbs. It is by no means a gravity-free environment, the weightless experience is a product of ‘free-fall’ and is akin to the weightless feeling momentarily experienced on a roller coaster.

$$9.8 \times \frac{(6,400)^2}{(6,770)^2} = 8.76$$

At the distance of the Moon, the force of attraction is reduced to just 0.003 newtons/kilo.

$$9.8\times\frac{(6,400)^2}{(376,400)^2}=.0.003$$

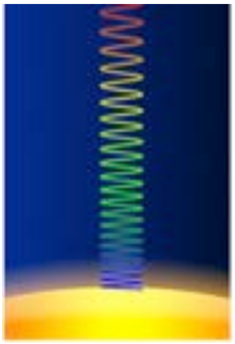
The Moon is 1/80th as massive as the earth, but the surface is just ¼ of the distance to the center, so the surface gravity of the moon is 1.62 newtons, about ⅙th that of earth's, not $^{1}/_{80}$th.

The sun is 332,950 times the mass of the earth, but its visible surface is 109 times as far from the center, so the surface gravity of the sun is just 28 times that of the earth. Just as a bullet fired from the earth loses kinetic energy rising against the pull of the earth, so a photon leaving the sun's surface loses energy and is red-shifted, but only by about one millionth of its energy (and the red shift on leaving the earth is proportionately even smaller).

A bullet fired from the earth's surface is slowed until it stops, and then starts to fall back. The faster the bullet rises, the higher it will climb. But as the bullet rises, the force of gravity falls off. At a high enough initial velocity, the bullet will rise so far that the gravity is too weak to stop it so it never comes to a full stop but continues to climb. This initial velocity is called the 'escape velocity' (EV) and is a useful measure of the gravity gradient of a body. The earth's EV is 11 km/sec while a bullet from an M16 rifle travels at 10 km/sec and would be almost fast enough to never fall back again if air resistance didn't sap much of its energy.

body	EV (km/s)
Earth	11.2
Moon	2.4
Sun	618
White dwarf	5,200
Neutron star	100,000
Black hole	299,792

It would, however, easily escape the Moon because the EV is only 2.4 km/sec. At the sun's visible surface, the EV is 618 km/sec, but the concept can be applied to any distance from the center. At the 'surface' of a sphere as large as the earth's orbit, the escape velocity is down to 42 km/sec, so even though the bullet can escape from the Moon, it cannot shake free of the sun.



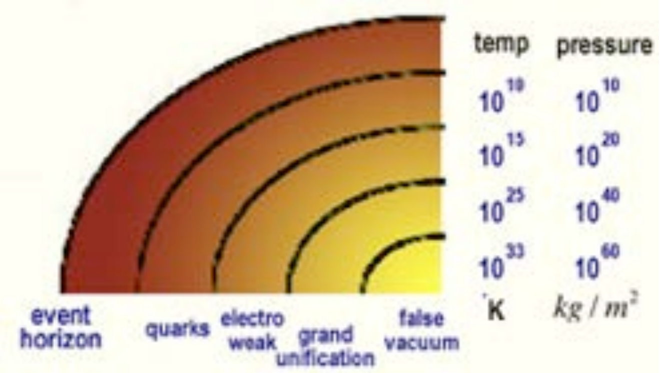
The surface of a white dwarf has an EV of ~5,000 km/sec, and a photon rising against this gravitational field experiences a significant redshift.

The surface of a neutron star has such an intense gravitational field that the EV is >100,000 km/sec, or one-third the speed of light. When a neutron star implodes, all the mass collapses through a surface, the event horizon, at which the EV is the speed of light. A photon attempting to escape from the event horizon has an infinite red shift that is indistinguishable from no photon at all. Nothing, not even photons, can escape from the event horizon. It emits no light, hence its name.

Structure of a Black Hole

No one has ever seen inside an event horizon, even in a thought experiment, so we can only theorize. Some think that the mass collapses into the infinite density of a point, a singularity. Quantum physics, however, suggests something that does not involve an infinite quantity since it connects separation of particles with energy. The closer two entities get, the higher is their kinetic energy and thus the temperature.

As the collapsing star breaks through the neutron degeneracy pressure, rather than do the impossible, they first dissolve into a quark-gluon plasma. As they are compressed ever closer, the temperature reaches the stage at which average energy is capable of creating electron/positron pairs and then nucleon/anti-nucleon pairs. At even higher temperatures the electromagnetic and weak interactions unite as the kinetic energy soars above the rest mass of the weak bosons and so on back to the earliest stages.



These are the last stages of the Hot Big Bang, and as the temperature rises in the collapsing core, the stages reappear in reverse order. The outward pressure of this recreated primordial plasma prevents further collapse. Just how many stages are necessary to stop the collapse depends on the in-falling mass. The very largest Black Holes—greater than the mass of a billion suns—probably have to go all the way and recreate a few pixels of false vacuum at the very center whose enormous expansive pressure holds up the layers above.

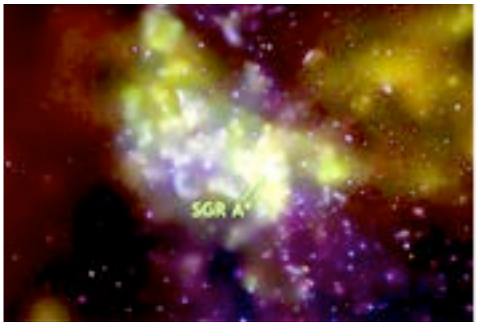
2nd Generation stars

There are only three possible endings for a star that has exhausted its fuel:

1. White dwarf stars, which cool off into black dwarf stars, held up by electron degeneracy pressure.
2. Neutron stars, which start at an ultrahigh temperature, but will eventually cool to darkness, held up by neutron degeneracy pressure.
3. Black holes, which emit no light from their event horizon, held up by a reversal of the Hot Big Bang, a small ‘crunch’ as it is technically known.

The stars of the first generation were massive (>100 suns) and in their death throes that scattered metals into the primordial gas, turned into black holes.

At the center of the galaxy where the stars were closely packed (for stars, that is) these black holes merged into the central black hole with a mass greater than a billion suns. The energy liberated in this merging of black holes formed the active core of a quasar which, being so bright, can be seen across a distance of 10 billion light years.

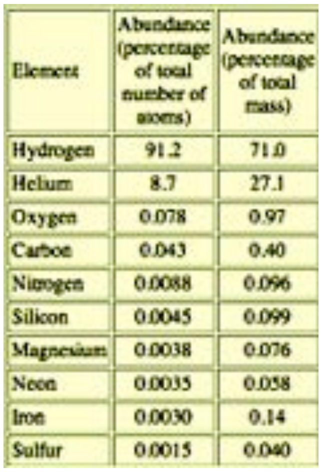


Our galaxy went through this stage until everything settled down ~10 billion years ago. The black hole that lives in the center of our galaxy is named *Sagittarius A** (pronounced “Sagittarius A-star”). It is ~26,000 light-years from Earth and its event horizon is measured to be about 14 million miles across. This black hole would fit inside the orbit of Mercury and is estimated to have the mass of ~4 billion suns.

The rest of the 100 billion stars in our Home Galaxy, the Milky Way, rotate roughly in a plane about this central point with an orbital period of ~250 million years. We can consider this a galactic year. Our earth is ~4 billion earth-rotation years old, so we can consider our home planet to be a youthful 16 year-old on the appropriate timescale.

All of the processes just described—from galaxy formation to 'metal' production in stars—occur under the direction of the Logos, and the end result was that the clouds out of which the second generation of stars formed had a smattering of the 'metals' in them. The 'metals' are much more efficient at coupling with photons, and the second generation tended to have smaller masses than the first generation. They were still large, however, and by about 5 billion years ago, they had also gone supernova and further enriched the interstellar medium.

While only about 1%, there was still enough 'metals' around that when the third generation of even smaller stars ignited and blew away the outer hydrogen and helium, there was enough 'metals' remaining to form dust, which amalgamated into planetesimals and then into planets. Also about this time, it has only recently been discovered, the heretofore unknown form of energy, called "dark energy" (not dark matter) began to show its influence. The third generation of stars to emerge were enriched with metals. Our sun is a third-generation star and has a significant enrichment in the 'metals' at 71% hydrogen, 27.1% helium, 1.3% carbon and oxygen, and less than 0.7% all the other 'metals'.



Element	Abundance (percentage of total number of atoms)	Abundance (percentage of total mass)
Hydrogen	91.2	71.0
Helium	8.7	27.1
Oxygen	0.078	0.97
Carbon	0.043	0.40
Nitrogen	0.0088	0.096
Silicon	0.0045	0.099
Magnesium	0.0038	0.076
Neon	0.0035	0.058
Iron	0.0030	0.14
Sulfur	0.0015	0.040

A small fraction of the collapsing gas did not fall into the sun. The metals remained in orbit and combined into molecules, grains and planetesimals, while the hydrogen and helium was blown away by the solar wind. Such aggregates condensed to form the proto-earth about 5 billion years ago.

A collision with another small planetesimal created the Moon—the splash condensed at half the distance it is now). The original crust of the proto-earth was like that of Venus, all of one piece, but this impact cracked the shell into tectonic plates that are shifting around to this day. The Moon also stabilized the axis of the Earth's rotation at a ~23° inclination instead of it wandering all over the place as happened to the planet Mars.

While the water molecule is small, it is chemically attracted to minerals and aggregated with them. Along with the water contributed by the comets during the heavy bombardment phase of the earth's formation, the water condensed on the cooling Earth into oceans that were saturated with reduced, soluble iron in the ferrous state. The Moon raised enormous tides which eroded the land and created great beds of porous clay in the cracks in the ocean floor. These faults between the tectonic plates circulated seawater through the crust as black and white smokers perfusing they clay beds. The intense UV light and lightning drove many organic reactions in the dense atmosphere of carbon dioxide, ammonia and nitrogen.

The history of the universe up to this point has evolved under the direction of the Logos, particularly that aspect we earlier described as the Perfect Wave. Many waves combine over time into a wave with unique properties. As the science describing the formation of ‘rogue waves’ and ‘perfect storms’ is in its infancy, this period is as yet only imperfectly described.

But one thing is known for certain. The end result of this 13-billion-year history was a womb perfect for the origin of life to occur with relative rapidity (a few hundreds of million years). As we shall see, the influence of the Moon was crucial to the rapidity of the origin of life. As very few planets can be expected to have such a large moon, we can expect that life was kick-started on the Earth, and has only slowly developed on the moonless majority of planets in the *Goldilocks Zone*—being neither too close or too far from the sun to allow for liquid water. It is to be hoped that most of these planets will have at least developed photosynthetic bacteria and an oxygen atmosphere by the time we get to them.

The emergent properties that were inherited from the Logos made the earth a perfect womb for the emergence of life, the transition from systems characterized by chemistry to a new set of systems that were predestined to be the subsystems of Life. Perhaps slighting the stars that incubated all the ‘metals’, the early earth is our first example of an eden that provides a womb that is ‘just right’ for the origin of systems with a much higher level of sophisticated properties that are inherited from the Logos.

THE PROKARYOTES AND *VITAL UNITS* OF LIFE

Under the direction of the Logos, the system-building of simple systems becoming the interacting subsystems of more sophisticated systems continued as the earth cooled and liquid water accumulated.

In the scientific hierarchy of ‘systems of study,’ physics and chemistry deal with systems that are decidedly not living systems, while biology deals with systems that are decidedly alive. The gap between the two is the province of biochemistry.

The systematic hierarchy of living systems that emerged has, at its very lowest level a system that does not have a given name, so we will call it the *vital unit*. We will define a *vital unit* as a volume of water confined by a surface with portals, whose analog form and function is determined by stored digital information.

The simple living systems called bacteria are a single vital unit. These are called the *prokaryotes*. Sophisticated living systems have many, even trillions, of interacting vital units as their basic subsystems. These are the *eukaryotes*, the fungi, plants and animals.

We will start our exploration of the systematic hierarchy of living systems at the very bottommost level, with the biochemistry common to all vital units.

FUNDAMENTAL BIOCHEMISTRY

Biochemistry, the study of the chemical subsystems of life, is the discipline where the great division of the sciences into two ways of viewing the world occurs.

Worldview One

This is the classical view of the world as matter in motion. All systems have only an external aspect that needs to be taken into consideration. Physics pre-1900, chemistry pre-1950, and all current biology, genetics and on up to the brain sciences are classical Worldview One. The math is all real numbers and $i=\sqrt{-1}$ rarely appears in the descriptions.

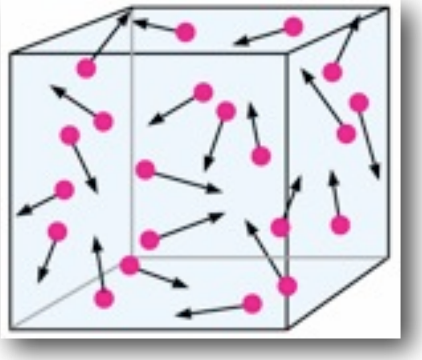
Pedagogically, all of science up through high school is strictly Worldview Two and the math is in real numbers and $i=\sqrt{-1}$ is strictly for the pure mathematicians and a mystery to be introduced only to the few at the university level. Quantum science would be so much more accessible if complex numbers were introduced in early schooling somewhere after fractions.

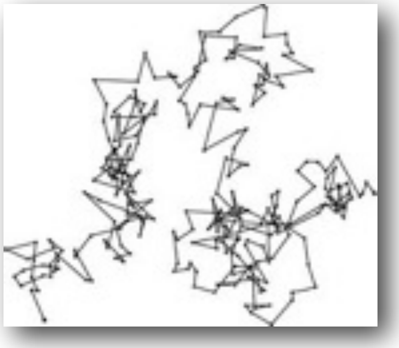
The concept of probability in this view is strictly classical probability, which is founded on the axiom of independent assortment. It is not considered a fundamental aspect of reality but rather an admission of incomplete understanding.

Classical probability excels in situations where independent assortment applies. An example is the kinetic theory of heat and the Gas Laws, which precisely relate the pressure, temperature and volume of a perfect gas. In a perfect gas, the atoms do not interact with each other except to bounce off each other as perfect Newtonian spheres. The helium in a ballon is an example of a perfect gas.

If, however, the atoms interact in any way—they are sticky—small corrections have to be made to the perfect gas laws. When two water molecules bounce off each other, for example, their interaction creates a tug opposing the rebound. Energy is removed from kinetic motion and the rebound is much slower than it would be in a perfect gas. At temperatures lower than 100°C, there is insufficient kinetic energy to separate the molecules, and the gas laws are ignored as the water liquifies.

A molecule of glucose added to liquid water will be pushed about on a ‘random walk’ through the volume of water. This is the kinetic diffusion of a glucose molecule through water that obeys classical probability—the distance travelled from the starting point is proportional to the thermal velocity and the square-root of the number of collisions along the way. In this ‘Brownian motion’ through the water, the glucose molecule will sweep out a volume that is proportional to time.





Worldview Two

The modern sciences of physics and chemistry share a worldview in which all systems have an internal wavefunction (complex numbers) that gives an external form (real numbers) to a set of confined and interacting subsystems. All the math of physics and chemistry is in complex numbers and $i=\sqrt{-1}$ appears in all the fundamental, and highly accurate, equations of these Worldview Two sciences.

Probability, in this worldview, is a fundamental aspect of reality on a par with location in time and space. This quantum probability is not classical but comes in two varieties, both of which are founded on dependent assortment, not independent assortment.

Quantum probability determines, over time, what happens in space; in bounded situations such as systems where the Law of Large Numbers applies, the internal form to the quantum probability completely determines the external form of the system.

Unfortunately, all the way up to high school level, the teaching of physics and chemistry is classical and deals only with the external aspect and not the internal, which is mentioned only in graduate school.

Biology and the higher sciences share a worldview that is strictly classical. The internal aspect so central to Worldview One is utterly ignored and is no longer considered a part of the picture.

Schizoid Biochemistry

The switch in the consensus from the external-only Worldview One to the internal/external Worldview Two falls uncomfortably within biochemistry. There, while the internal wave aspect is accepted as important in the catalytic activity of enzymes, by far the most important concept in the rest of biochemistry is that of the ‘lock-and-key’ as two molecules externally fit together as 3-D jigsaw puzzle pieces.

This specific ‘binding’ of two molecules that neatly fit together is found throughout biochemistry. Examples are:

- The specifically folded chain of amino acids in the active form of a protein
- A specific substrate bound to its enzyme
- A steroid molecule bound to its receptor
- A strand of DNA bound to its complementary RNA
- A calcium ion bound to a muscle protein
- A virus bound to the surface of its host-to-be.

Internal quantum probability plays no role in all these examples of the lock-and-key motif. All follow the same basic steps:

1. The thermal motion of the molecules brings them into contact
2. The two molecules bind together
3. The bound complex goes through a conformal change in shape and function
4. The two molecules can stay together, or changes occur and the molecules separate and go their separate ways

Unified Science

It is the intention of this work to illustrate how internal quantum probability plays a central role in all the sciences. Inclusion of the internal at every level of the science hierarchy, as we shall see, solves a lot of problems that do not follow independent assortment and classical probability.

We shall call a science ‘unified’ if it considers the internal quantum probability aspect of matter to play a primary role in the systems under study. In this view, the sciences of physics and chemistry are unified sciences, biochemistry is partially unified, while biology and on up are not unified sciences. The goal of this work is to include the internal aspect in all the sciences and see what results from the extension of the worldview.

As befits the scientific, bottom-up approach to a systematic hierarchy, we shall start at the very bottom with the external concept of lock-and-key binding so central to biochemistry.

Lock and key

The lock-and-key motif is most simply demonstrated in the study of enzymes.

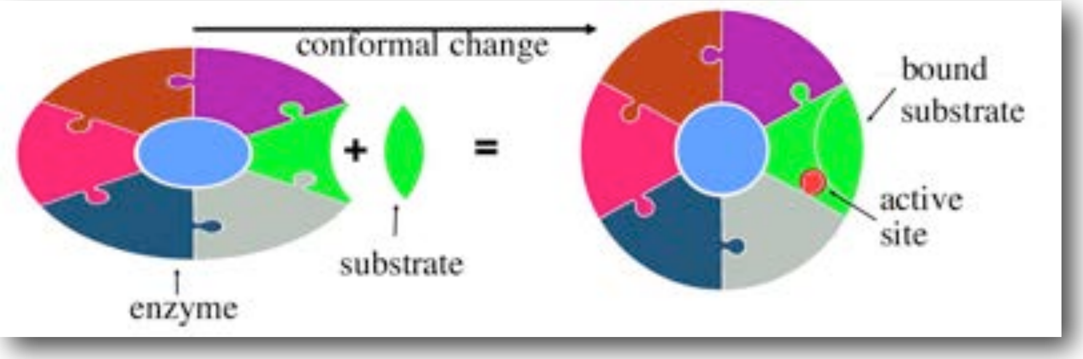
The ‘lock’ is a large protein enzyme. This is a linear polymer of amino-acid monomers that have ‘folded’ into a precise form—roughly spherical in the simple, globular enzymes—as the amino acids fit together as a 3-D jigsaw puzzle.

Almost the entire surface of this amino-acid globule has the property of H-bonding nicely with the surrounding water molecules except for a patch that does not. This water-hostile patch is the ‘binding site’ where the key is inserted into the lock.

The ‘key’ is a specific small substrate molecule—say D-glucose—that perfectly fits into the binding site. The bound complex now has an entire surface that perfectly H-bonds with the surrounding water molecules. Even a very similar molecule such as L-glucose is the wrong key and will not fit.

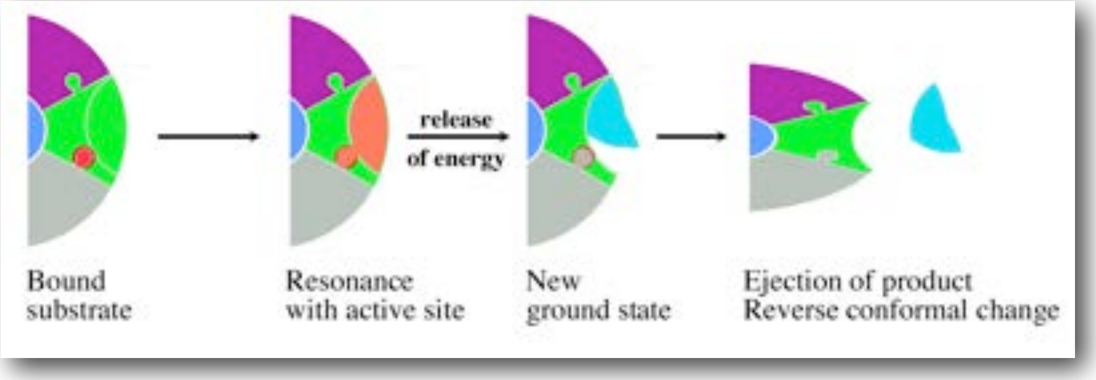
The lock and correct key come together as their thermal motion brings them together. When they bump into each other on their random, classical walk through the water, the substrate slots into the binding site of the enzyme; the key is inserted into the lock. Only the precise substrate will fit perfectly, the very similar molecule L-glucose will not do the trick.

When the key is inserted, the entire protein undergoes a conformal change in which an internal section close to the substrate becomes the ‘active site.’ This is ‘turning the key’ and the lock is activated. The active site is now positioned next to the substrate.



This is where current biochemistry makes the switch to a unified view. The internal quantum probability wave aspect of the substrate and active site blend together into a new probability form. The external alters to reflect this new form and the external form of the substrate takes up this altered form of the metabolite product.

No longer fitting neatly into the binding site, the metabolite is ejected and they go their separate ways.



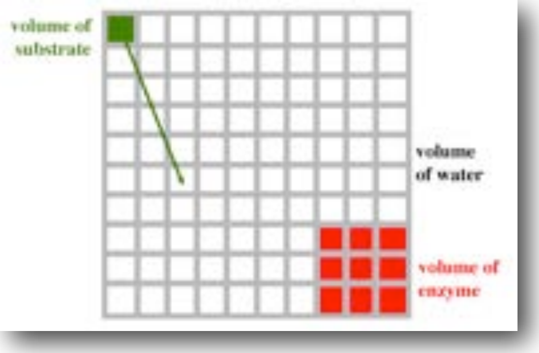
The only difference between the classical view of enzymatic and a unified view is in the very first step, the probability that the substrate will bump into the binding site on its thermal random walk through the water.

The classical view is that of independent assortment. The probability will depend on the random walk of the substrate molecule coinciding with the random walk of the enzyme macromolecule. The volume swept out over time will depend on the thermal velocity. The thermal velocity is inversely proportional to the square-root of the molecular weight. A substrate-glucose molecule has a molecular weight of 180, while that of hexokinase, an enzyme with a binding site for glucose, has a molecular weight of 100,000, so it moves only at 1/20th the speed of the glucose and can be taken as stationary to simplify the discussion.

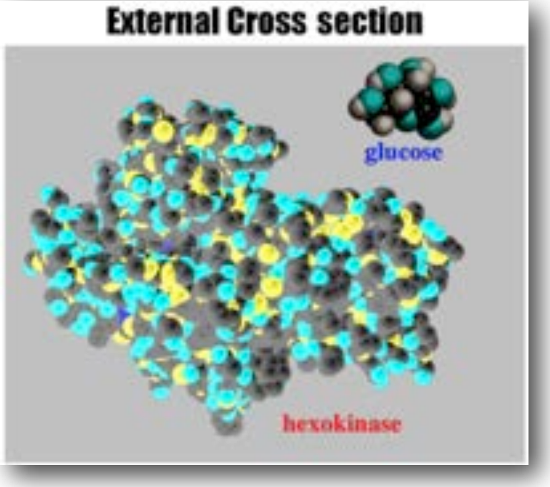
Using a 2-D illustration, the volume of the water, W, is 100, the volume of the enzyme is 9, and the volume of the substrate is 1.

The ratio of the stationary enzyme volume to the water volume is E/W = 9/100. If the substrate has a speed of 5, it will sweep out a volume of 5 in 1 second. The probability that they will coincide by independent assortment is 9/100 : 5 which is 9/20 : 1 or about 45%.

The volume of a glucose molecule in very small, ~5x10^{-23} cm^3 and that of the enzyme is just a few magnitudes or so greater. This is their cross section for interaction if only the external aspect of the enzyme and substrate are taken into consideration.

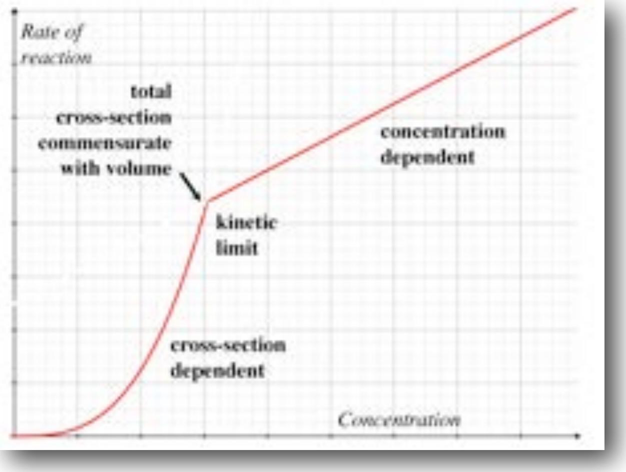


For a reaction to occur, the total cross section of all the enzyme macromolecules plus the total cross section of all the substrate molecules must be commensurate with the volume of the water they are moving through with thermal motion.



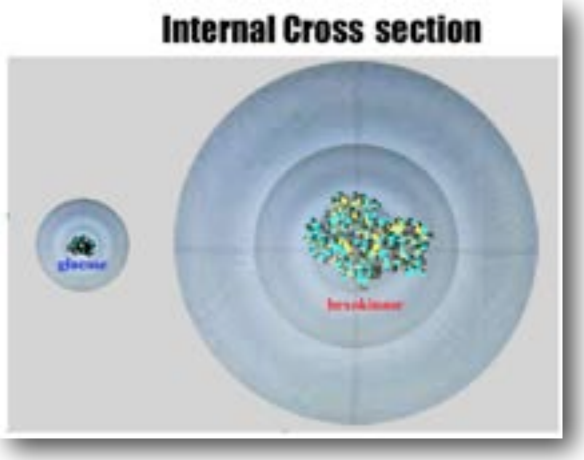
In typical milli-molar enzyme experiments, the volume of solution is usually in the cubic-centimeter range. There are trillions of enzyme molecules and substrate molecules wandering about and their combined cross section is greater than this so they do not, so to speak, need to waste time in finding each other. The probability is high that many encounters will happen each second and the reaction will proceed at a reasonable rate.

At extreme dilutions, however, the total cross section for bumping into one another becomes less than the total volume, and they now have to spend time waiting for an encounter, and the rate falls off exponentially with further dilution. The cusp point in the reaction rate is called the kinetic limit and is a measure of the cross section of the substrate and enzyme.



The classical view predicts that the cross section for interaction will be commensurate with the external size of the two molecules. The substrate and enzyme follow independent assortment and only influence each other when in local proximity. The cross section volumes of substrate and enzyme are known, and it is simple to calculate the expected concentration at which the total cross section volume will fall below the solution volume and the kinetic limit will begin to dominate the reaction rate. As the external cross section is so small, the kinetic limit is calculated to be at a relatively high level of ultra dilution.

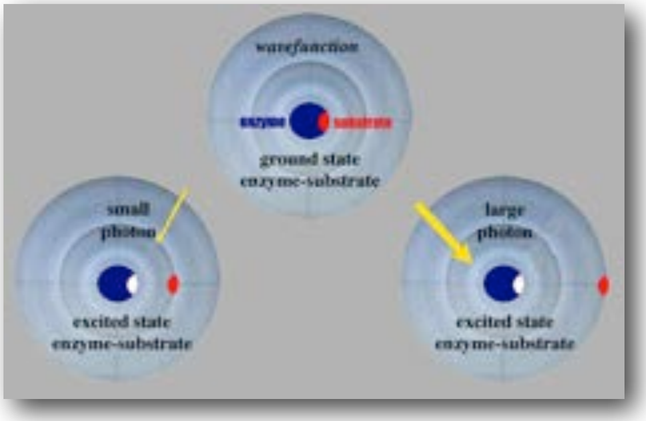
Excited States



In the unified view, the substrate molecule is a system of interacting subsystems in the ground state of the internal wave aspect. The wavefunction extends outwards in a set of unoccupied states, and the system can be excited into these states.

The same thing applies to the enzyme, its subsystems are in the ground state and they can also be excited into the wavefunction that extends outwards.

The very first step in any interaction is the overlap of the internal aspects of the two systems. The resonance between the two determines the probability of external coupling with subsystems—the internal interaction is primary; the external coupling is secondary. The cross section for the internal aspects of the substrate and enzyme to overlap is very much greater that their external cross sections would suggest.



If, in the instant in which the substrate fits into the binding site but before the active site swings into action, a photon of just the right energy hits the complex, the substrate will jump to a higher excited state. A larger photon of just the right energy will kick the substrate into an even higher excited state.

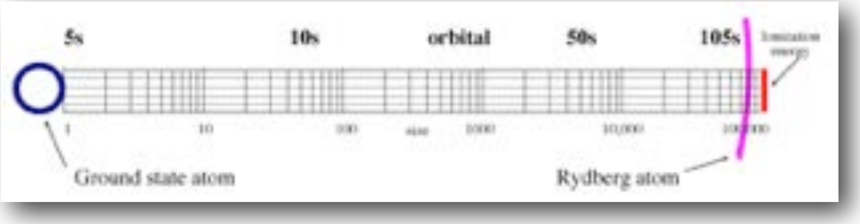
This type of behavior is exhibited on a smaller scale in Rydberg Atoms.

Rydberg Atoms

The size of an unexcited atom is ~10^{-10} meters, possessing a volume of ~10^{-30} cubic meters. A low-energy photon of just the right energy can be absorbed and an electron will jump to a higher orbital, say from the 4s to the 5s orbital. This excited atom has a slightly larger volume than the ground state atom. The photon is rapidly ejected and the atom returns to the ground state.

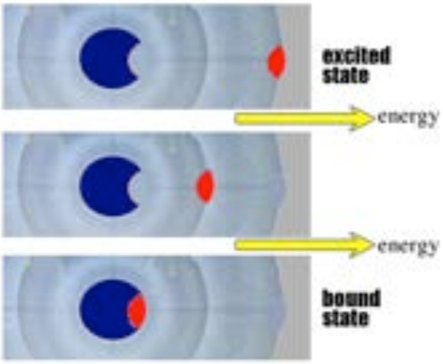
If an impinging high-energy photon is at or above the ionization energy, however, the electron shoots off at high speed and the atom becomes a positive ion that is smaller than the ground state atom.

By the careful use of tuned lasers, photons of an intermediate energy can kick the electron to orbitals that are fractionally less than the ionization energy, e.g., from the 5s to the 105s orbital. Such a *Rydberg Atom* is somewhat stable—its chemistry can be examined—but the electron soon ejects a cascade of photons as it jumps back towards the ground state.



The size of such a Rydberg Atom is ~10^{-5} meters with a volume of ~10^{-15} cubic meters, a volume that is a million billion times as large as the ground state volume, and is approximately the size of a bacterium. This illustrates how non-local the wave aspect of a system can be, and it should be recalled when we discuss internal waves embracing a mere million or so atoms.

A substrate at a distance far from the enzyme but close enough for their internal aspects to overlap significantly is akin to the excited electron in the Rydberg Atom—it ejects a cascade of photons and jumps towards the ground state. Rather like the tractor beam of science fiction, the enzyme reels the substrate in from a distance.



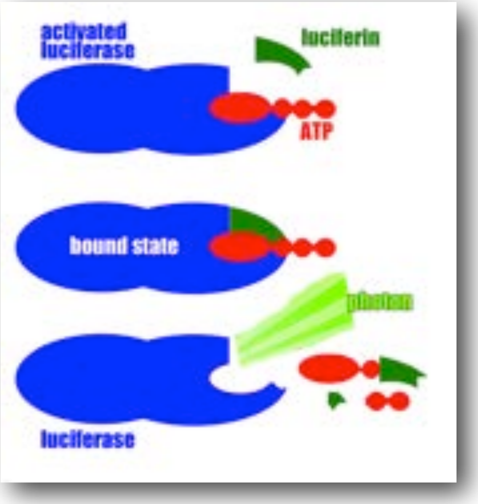
Experiment: Internal or external

Unlike many other disciplines, science insists that experimental protocols have to be devised that can decide if it is the external cross section or the internal cross section that is involved in the very first step of an enzyme and substrate interaction.

If I now had the access to a modern laboratory that I had in my callow youth, I would perform the following experiment to distinguish between the two views using the glowing tubes of greenish lights that appear at many after-dark celebrations. Inside the main tube is a thin-walled glass container that must be crushed to start the contents glowing.

The mix contains the substrate luciferin, a small sulfur-containing molecule, and the 550-aminoacid enzyme, luciferase activated by ATP. The enzyme adds its energy to the substrate and the excited luciferin drops to its ground state with the release of a yellow-green photon. This is the green glow which lasts until either all the ATP or luciferin is used up. This is how fireflies generate light on a summer's evening.

Modern single-photon detectors are quite capable of noting the interaction of a single luciferin molecule with a single activated-luciferase. When solutions of one luciferin molecule and one luciferase are mixed together, the time it takes for the two to bind can be measured. Given a fixed final volume, repetition will give the average time it takes for the two molecules to find each other and bind. Altering the final volume will give an experimental measure of the cross section for the luciferin and luciferase to interact.



This can be compared with the external cross section which is readily calculated from their sizes when in crystal form.

Lacking access to such a laboratory, however, we will look to the literature and what experimentalists have already noted about ultra-dilute enzyme reactions.

The Literature

As early as the 1980s, violations of the thermal diffusion kinetic limit expected in enzymatic interactions had been recorded, but not dealt with. A textbook from that era gives it a single sentence, "The action of an enzyme in bringing together two different substrate molecules is more rapid than the rate of combinations which result from chance collision of molecules."[13] No explanation is offered.

Such unexplainable rates were also noted in 2002:

> "The [rates] of the enzymes superoxide dismutase, acetylcholinesterase, and triose phosphate isomerase are [above the kinetic limit]… In these cases, there may be attractive electrostatic forces on the enzyme that entice the substrate to the active site. These forces are sometimes referred to poetically as Circe effects."[14]

The collective wisdom of the Wiki in 2013 also notes the violation of the classical, external expectation:

> "Some enzymes operate with kinetics which are faster than diffusion rates, which would seem to be impossible. Several mechanisms have been invoked to explain this phenomenon. Some proteins are believed to accelerate catalysis by drawing their substrate in and pre-orienting them by using dipolar electric fields. Other models invoke a quantum-mechanical tunneling explanation, whereby a proton or an electron can tunnel through activation barriers, although for proton tunneling this model remains somewhat controversial."[15]

In simple enzymes, the protein is large and the substrate is small. In other situations, the roles are reversed and it is the protein—thousands of atoms—that is small in relation to the 'substrate' it binds to, such as DNA with billions of atoms:

> "A number of vital biological processes rely on fast and precise recognition of a specific DNA sequence (site) by a protein. How can a protein find its site on a long DNA molecule among [a billion or so] decoy sites?"[16]

The binding process is impossibly fast if taking only the external size of the molecules, and only sensible in this age if the internal aspect of an extended quantum probability is included in the picture.

While these few quotes googled from the literature are just hints and intimations, they do give me confidence that the ultra dilute luciferase experiment just outlined would show that the internal cross section was involved in the interaction (though one can never be absolutely sure of experiment) and not support the classical expectation of an independently assorting external cross section.

INFLUENCE OF THE INTERNAL ASPECT

The natural question that now arises is, "Just how far does the influence of the internal aspect extend beyond the external aspect?"

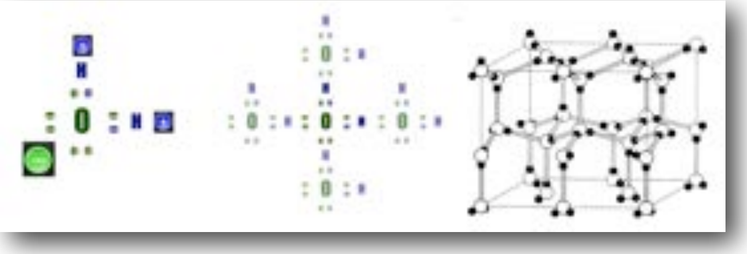
The answer to this could be measured directly in the luciferase experiment. Lacking this, we can get a rough estimate by looking at the relationship between two of the main molecules that are the basic subsystems of life. The first is the very smallest molecule of all, with a molecular weight of only 18, the water molecule that abounds in great numbers in all life. The second are the much larger and less numerous molecules, the proteins with molecular weights in the hundreds of thousands.

Water structure

Over 75% of the subsystems of a living system are water molecules, and the structure of this water is directed and controlled primarily by proteins. The structure of bulk water is a reflection of the structure of the water molecule, and this is a reflection of the internal wavefunction.

The oxygen atom has two singlet electrons while the hydrogen atom has one singlet electron. One oxygen and two hydrogen atoms satisfies the valence requirement of paired electrons in filled orbitals in the water molecule. The wavefunction of the covalent bond is such that the electrons spend more than 50% of the time about the oxygen and less than 50% of the time about the hydrogens. The net result is that molecule is polar, with a net negative charge on the oxygen atom and a ½-positive charge on each hydrogen.

This separation of charge on the water molecules makes them very sticky, they are strongly attracted to each other. This is why water molecules are only a perfect gas in steam well over 100° C. The geometry of this charge separation is fully satisfied in a structure when each negative O atom is near to two ½-positive H atoms, and vice versa. The H atom vacillates between the two O atoms as a hydrogen-bond. These requirements result in the open structure of solid ice. In plain water, however, the molecules can only settle into this low energy ground state at 0° C. Above this temperature, the kinetic energy constantly disrupts this stable structure and the water is liquid.



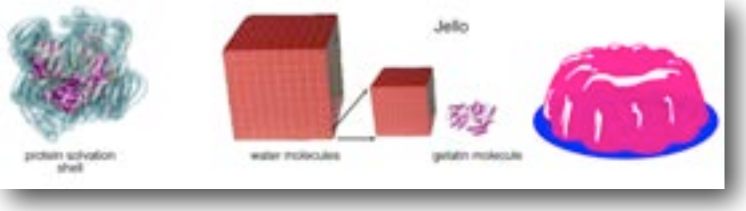
Warm ice

There are macromolecules, however, that can generate a powerful wavefunction in which the ice structure of the surrounding molecules is stable at 20° C and above, a wavefunction in which the stable structure is no longer disrupted by the thermal energy.

Proteins are excellent examples of such water-organizing molecules, and a familiar example is the ‘active ingredient’ in Jello™ dessert, i.e., the protein ‘gelatin.’ This is created by methods best-not-discussed of breaking down the large, insoluble proteins of animal cartilage into smaller, soluble proteins.

The contents of a Jello™ packet are mainly sugar along with only about one gram of the dried gelatin protein (which is why the package demurs it is “not a good source of protein”). It is dissolved in two cups (500 grams) of hot water which, when it cools to room temperature, turns into a solid. The majority of the water molecules are now in the ice-like structure even though the temperature is well above the freezing point of sugar water.

The confinement of the water is not perfect—the jello is much softer than ice—and jello left at room temperature will slowly weep water as the molecules escape from the wavefunction of the gelatin.



In a jello, one gram of protein is structuring 500 grams of water. The molecular weight of gelatin is ~300,000 and that of water is 18. In solid jello, for each molecule of protein present, there are ~8,000,000 water molecules, all of them being provided a wavefunction in which they can settle into the stable ice-like structure.

Another biological, if less appetizing, example is to watch a drop of blood flow from a small wound and then, in seconds, turn into a jello-like clot, triggered by a small amount of inactive protein in the fluid blood flipping to a gelatin-like active form and sealing the breach.

In a terminology that we will find useful, we can say that a small number of proteins are 'generating' a wave in which a huge number of water molecules are 'resonating'. This is akin to the role of a small number of musical instruments structuring the large amount of air in a concert hall during the performance of a symphony.

Each gelatin macromolecule can be considered the center of a sphere of eight million water molecules. The influence of the internal aspect of this small protein is magnitudes greater than its external aspect. In earlier terms, we would say that the cross section of the gelatin molecule for interaction is its global internal aspect and not its local external aspect.

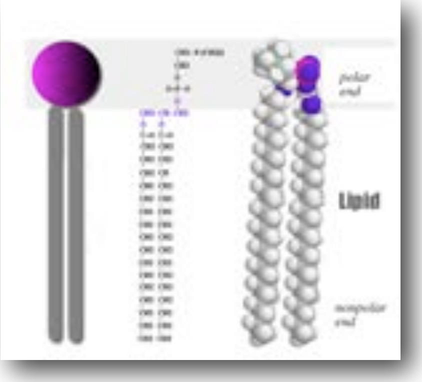
THE VITAL UNIT

Now eight million water molecules is a large number of molecules. The smallest systems that are unequivocally alive are the bacteria. A typical bacterium, with a mass of ~10^{-15} grams, contains on the order of ten million molecules of water. So just two gelatin molecules are quite capable of generating a wavefunction that allows all the water molecules inside a bacteria-sized container to fall into the stable state. The water is a solid gell.

This bacteria-sized container of water is significant in understanding the basic living system, what we shall call a vital unit. The bacteria-sized containers of the 10 million or so water molecules in a living bacterium is the water-impassible bi-lipid membrane that is an essential component of any living system.

The Bi-lipid Membrane

Lipids are based on the glycerol molecule with its three hydroxyls. Two of these hydroxyls are ester-bonded with two organic acids having long linear nonpolar hydrocarbon chains, about twice the length of those in gasoline, that are utterly incapable of forming H-bonds with water molecules.

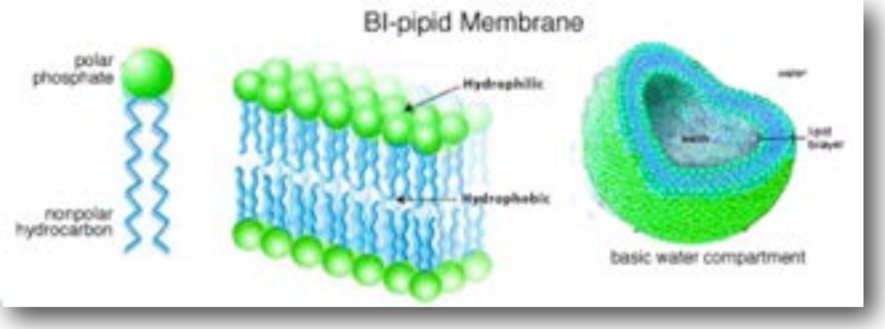


The third hydroxyl is bonded to a variety polar groups, often containing phosphate, and very capable of forming H-bonds with water molecules. The molecule has two ends, one hydrophilic (*water loving*)—the phosphate, and one hydrophobic (*water hating*). All soaps and detergents have these opposite ends.

The stable state for all concerned is when the polar end of a lipid is in water and the nonpolar end is not. Both ends are in a stable state in a double layer of lipids, with the polar ends of both layers facing the water, and the nonpolar ends facing each other in between.

The bi-lipid membrane is very ancient inasmuch as it occurs in every living system without exception. For all but the slightly different lipids used in the most ancient lineages of bacteria, the basic structure is identical.

In the bi-lipid membrane, the lipid chains are stacked inside with the polar ends on either surface facing water on both sides of the membrane.



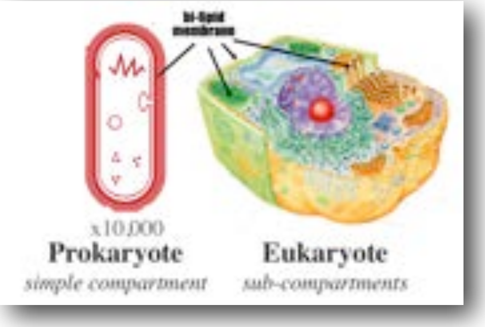
Water structuring wavefunctions do not penetrate through a bi-lipid membrane. What the water structure is on one side has no influence on what it is on the other. A drop of water coated with such a bilayer, dropped into cooling jello, will remain liquid. The internal waves generated by the gelatin cannot penetrate into the compartment. They are completely blocked and the water inside the compartment remains liquid.

It is customary to consider the cell as the basic unit of life, and the bacteria as having particularly simple cells. The eukaryote cell in this view is basic, and is a view that we think should be reconsidered.

All eukaryote cells—animal, plant and fungi—have an external boundary of bi-lipid membrane just as the bacteria do. The vast difference between the two is that while the water-containing compartment of a tiny bacterium is simple, the much larger eukaryotes are all divided into subcompartments by internal bi-lipid membranes.

These eukaryote subcompartments are of the same magnitude as the bacteria and, in fact some of them are unequivocally descended from bacteria. Each of these subcompartments has portals that connect it to other compartments or to the environment outside the cell.

Molecules, other than proteins, do have a role in controlling the water structure of living organisms. We earlier mentioned that the Rydberg limit was about the size of a bacterium. All living things are composed of compartments of about this size that confine water structuring within a *bi-lipid membrane*. The prokaryotes (bacteria) have an outer lipid membrane and are on the order of this size, while eukaryotes (animals, plants and fungi) are composed of ~10,000 compartments, defined by internal lipid membranes, that are also about this size. The nucleus is also divided into this size subcompartments, but here the work is by proteins and nucleic acids, not lipids.



In the systematic hierarchy of the inorganic realm, the atom is the fundamental subsystem. We propose that the fundamental 'atom' of living systems is a volume of water commensurate with bacteria of ~10 million molecules confined by a bi-lipid membrane. Since we will often refer to it, we will call such a volume of confined water a vital unit. Bacteria are then single vital units. Eukaryote cells are 'vital molecules' whose interacting subsystems are vital units.

System	Interacting subsystems	Examples
Vital molecule	Vital Units	Eukaryotes: plant, animal cell
Vital Unit	~10^7 H_2O + bi-lipid membrane	Procaryotes: bacteria

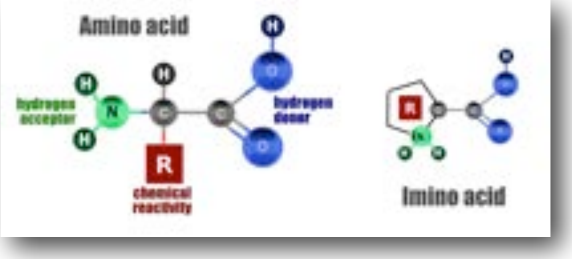
In the next section, we discuss how proteins generate wavefunctions that structure the water of a vital unit and, in the section after that, how the analog wavefunctions generated by proteins is recalled from digital memory stored using nucleic acids.

PROTEINS

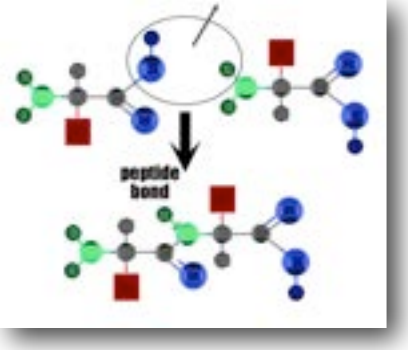
Proteins are often subsystems of higher structures—such as membranes—but we start by discussing simple proteins that perform their role in isolation. Proteins have a set of emergent properties that are preeminent at manipulating and controlling the analog forms of molecules, such as the ice structure of water, and the analog form of single molecules, such as in the metabolism of glucose.

All living systems use the same set of 20 'natural' aminoacid monomers that are linked together as protein polymers. Proteins have a wide variety of chemical properties and can basically do all the possible chemistry of carbon-containing compounds in an aqueous environment at regular temperatures. Proteins are master chemists; they can do chemical manipulations still impossible in the laboratory.

All aminoacids have a similar structure with one end a strong hydrogen donor, the other a strong hydrogen acceptor. All of the natural aminoacids monomers of protein chains are linear, except for proline (technically an iminoacid), which puts a kink in any chain. In



between these complementary polar ends are attached twenty different radical groups with a variety of chemical reactivity, symbolized by R. This radical part of each aminoacid gives each of the 20 a unique set of overlapping chemical reactivities.

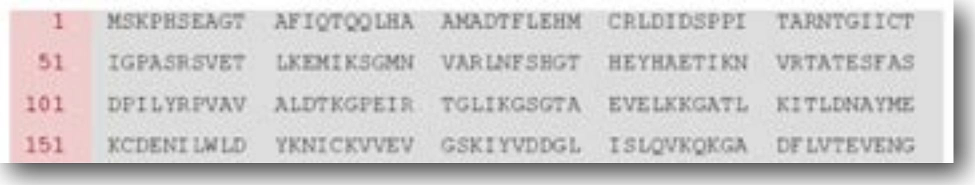


A protein chain is created by linearly connecting the complementary ends of two aminoacids by the elimination of water, creating a peptide bond. Both the oxygen and nitrogen atoms in the peptide bond are still quite capable of hydrogen bonding. At one end of an aminoacid polymer is a free amino group, while at the other is a free acid group.

Unlike most of the chemical manipulations in living systems, the wavefunction for connecting aminoacids with peptide bonds is not provided by a protein but by a nucleic acid assisted by proteins.

Protein structure

Proteins are long linear chains of amino-acids linked by peptide bonds. The order of the aminoacids in the chain is called the *primary structure* of the protein, and is read from the amino to the carboxylic end. These are the first 200 of the 525 aminoacids in the primary structure of human pyruvate kinase, using the one letter code of biochemistry.

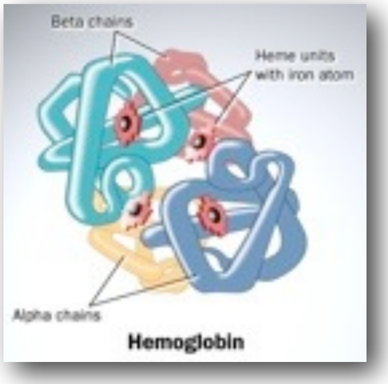


1	MSKPHSEAGT	AFIQTQQLHA	AMADTFLEHM	CRLDIDSPPI	TARNTGIICT
51	IGPASRSVET	LKEMIKSGMN	VARLNFSHGT	HEYHAETIKN	VRTATESFAS
101	DPILYRPVAV	ALDTKGPEIR	TGLIKGSGTA	EVELKKGATL	KITLDNAYME
151	KCDENILWLD	YKNICKVVEV	GSKIYVDDGL	ISLQVKQKGA	DFLVTEVENG

A chain can link to itself or another by a disulphide bond between two cysteine aminoacids. This is the *secondary structure* of the protein.

The much smaller hormone, insulin, has two chains with 1 intra- and 2 inter- disulphide bonds as its secondary structure.

The folding of the secondary structure into the active folded form with its active sites for water and substrate is called the *tertiary structure* of a protein.

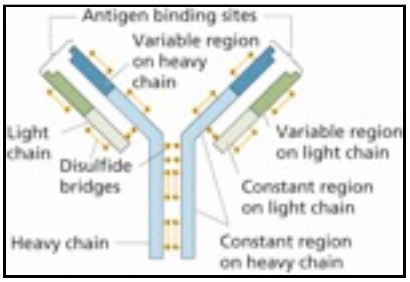


Some active proteins contain more than one folded protein, and they way they fit together with a surrounding water shell is called the *quaternary structure*. Hemoglobin has four protein subunits—with two primary structures—each with a heme group attached.

The way that the unified wave of the complex changes when a substrate binds to one, two, or more active sites is called *allosteric* conformal change. Haemoglobin is actually a rather poor absorber of oxygen. When one oxygen binds, the whole wave alters and monooxyhemoglobin is a much better absorber of oxygen. The wave shifts with another oxygen and di-oxyhemoglobin is much, much better at absorbing oxygen. The wave shifts with another oxygen and tri-oxyhemoglobin is most avid at absorbing oxygen. It is this allosteric effect on the unified wave that allows hemoglobin to pick up oxygen where it is plentiful in the lungs and release it where the concentration is low.

This most useful property comes from the Logos; it is not accidental. Given a primary sequence, a particular form is received from the Logos which, when expressed in particle density, determines which waves are generated and what substrates will resonate with them.

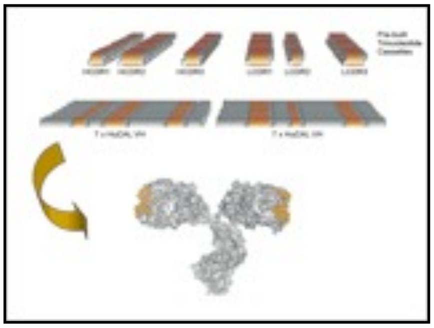
Finite set of forms



How many such distinct forms does the Logos hold? The workings of the immune system suggest, as follows, that this is a finite number of about 100 billion. The immune system recognizes any non-self macromolecule, the antigen, and generates a barrage of a protein, the antibody, specifically tuned to bind the antigen. Antibodies are ‘Y’-shaped with a two-pronged variable end, where the binding occurs, and a constant region which, when the binding occurs, flips from an inactive form to an active form. This active form is recognized by a protein that initiates the destruction of the antigen-antibody complex.

All such antibodies to any macromolecular non-self form are made by the lymphocytes—with each lymphocyte making only one antibody,— all with the same variable region.

While still in the womb, cells in the bone marrow proliferate into immature lymphocytes. Every one ends up programmed to make a different variable region by being given a permutation of a small set of digital ‘cassettes.’



Each one of the 100 billion different permutations are given to one of the 100 billion immature lymphocytes that are generated in the marrow. This army can make an antibody to any macromolecule, which is why we can say that the Logos has a finite number of forms of about 100 billion.

These immature lymphocytes then travel to the thymus where they display their particular antibody for testing by a thymus cell. If its antibody happens to be tuned to a substrate the thymus cell can make, the thymus cell orders the immature lymphocyte to self-destruct. If the antibody passes this test, the lymphocyte is ordered to mature and is released back to the blood.

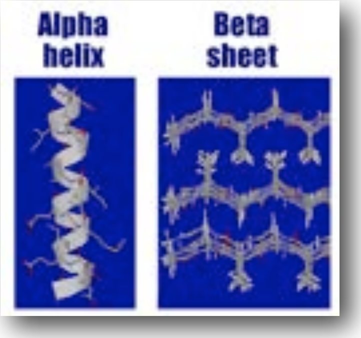
There it circulates for years with its antibody poking out of its surface. The army of mature lymphocytes is now capable of recognizing any of the 100 billion macromolecular forms from the Logos that are not made by the body itself. When this elimination of self-forms misses one by mistake, an autoimmune disease develops.

Protein Active Form

Each amino acid in a long chain has a set of chemical reactivities that must be satisfied either by interactions within the chain or by interactions with the surrounding water. Some of these chemical ‘needs’ come from the peptide bonds linking the chain together.

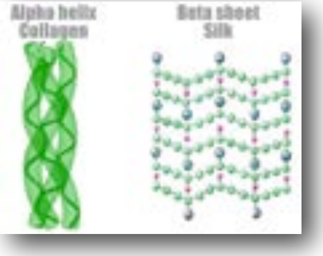
In a long chain of amino acids, the hydrogen bonding activity of the polar O and N atoms in the peptide bonds can either be satisfied by H-bonding with water molecules or with polar atoms elsewhere in the same chain or in another chain.

This self H-bonding of the polar peptide bond creates two well-studies motifs that appear in the structure of many different proteins.



One is the alpha helix, in which the aminoacid chain coils as a spring; the other is the beta pleated-sheet in which parallel chains are arranged in layers.

The chemical reactivity of an amino acid in a chain includes the tendency to form an alpha helix or a beta sheet. Those good at being in a helix tend to be poor sheet makers, and vice versa. The kink-creating proline is good at neither and tends to disrupt both structures when it is present.



Some proteins are mainly of aminoacids that are very good at helix creating or sheet creating. An example is the protein that makes up collagen, which is rich in aminoacids that are good helix builders. (Incidentally, it is collagen that is broken down in gelatin.) The coils are then supercoiled giving the composite great stretching ability. Another is silk that is rich in sheet building aminoacids. It is this sheet structure that gives silk its extraordinary strength.

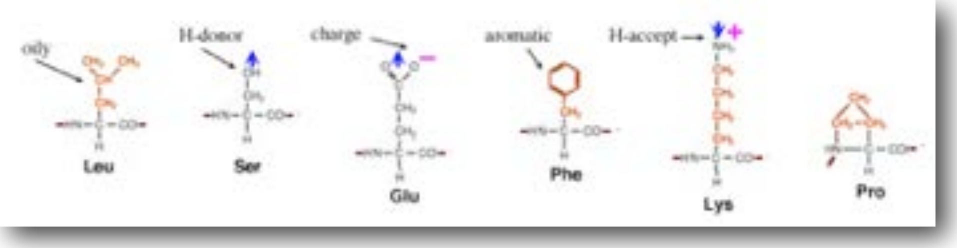
Depending on their geometry, all amino acids have an alpha ability—we can assign it 0 for alpha-disruptive, 1 for a mild alpha, and 2 for a strong alpha tendency—and a beta ability—also 0 1 or 2. A list of the 20 will include this in the reactivity and it will look something like this:

	REACTIVITY	
AMINOACID	ALPHA	BETA
aa A	1	1
aa B	2	0
aa C	0	2

A long chain of aminoacid B would have a strong tendency to helix while a chain of aminoacid C would have a strong tendency to sheet.

Reactivity

The various side chains add to the set of reactivity for the aminoacid, except in glycine with a single hydrogen which adds little to the tally. The side groups on the aminoacids are chemically active, which is probably why protein, unlike other vital macromolecules, is not stored in an inert form



to any great extent in living systems. There are 20 universal amino acids used in living systems, each with is own set of chemical reactivities, a few of which are illustrated. Proline always puts a kink in the chain and is used to terminate alpha helixes, composing 17% of collagen fibers.

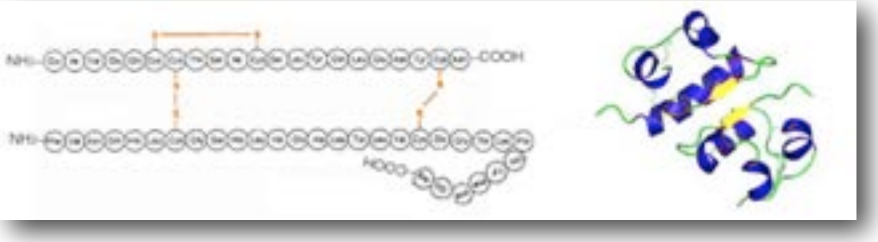
The side groups can be acidic, basic, reducing, oxidizing, H-donor/acceptor, hydrophobic hydrocarbons, etc.—all in different amounts—pretty much covering all the reactions possible in water solutions.

This set of 20 different arrays of chemical reactivities in the natural aminoacids is important in the transition of an aminoacid chain from the linear form of its synthesis to the folded active form of the protein.

Each living system has a specific set of proteins that it employs. Some of these sets are so central to life that they are in constant use, the 'housekeeping' proteins, while others in the repertoire are only called upon during certain occasions.

Each of the proteins in this repertoire has a specific and exact 'primary' sequence, the linear list of aminoacids in the chain. The assembly of each protein chain always starts at the free amino end of the chain and concludes at the free carboxyl end.

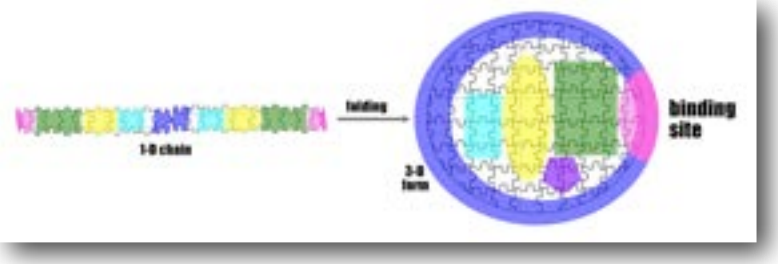
Each of these linear aminoacid chains in the repertoire then, interacting with the surrounding water, rapidly folds into a 3-D shape with a surface and an interior. The shape that each chain folds into is precisely the same for each primary sequence. This precisely-folded aminoacid chain is the active form of the protein. Many chains spontaneously fold just interacting with water, others need the participation of other proteins called chaperonins. In either case, the end result is a precisely-folded, active protein.



One of the milestones in 20th-century biochemistry was the elucidation of the primary and secondary structure of the small, but important, protein called insulin. It contained two aminoacid chains—one with a proline kink—linked by covalent disulphide bonds between cysteines. X-ray crystallography later revealed the 3-D structure of the precisely folded active insulin protein with its internal coils and sheets.

In the ground state, folded protein, all the chemical requirements of the aminoacids in the chain are satisfied. Examples are the hydrophobic side groups that all cluster in the interior and the alpha-beta requirements of the peptide bonds. Those with an aromatic ring like to stack up together inside, the bent proline does not want to be stressed and the sulfurs like to be paired up. H-acceptors need to be near H-donors in the interior or water at the surface, while H-donors want to be near H-acceptors in the interior or water at the surface. Positive charges must be near negative charges, and so on for all the chemical reactivities.

In the folded state, every chemical requirement is met except for those surrounding the binding site. Every one of the chemical requirements of each aminoacid in the chain is fully met in the precise folding of the active form except at the binding site. The H-bonders at the surface, excluding the binding site, are all perfectly spaced for ice-like bonding with the surrounding water, which it participates in structuring.



Protein Folding

So each aminoacid ends up in its correct place in the active form in which all its chemical reactivity is balanced. This is akin to connecting all the pieces of a completed jigsaw puzzle to a thread and then jiggling the jigsaw into its component pieces. Protein folding is then putting all the pieces back together again.

The lock-and-key concept of classical biochemistry, which does not take the internal aspect into consideration, has a major problem with random thermal collisions precisely folding a long chain. The problem is there are far, far more ways of incorrectly folding than there are of correctly folding. This problem—and it is known as the Protein Folding Problem—of finding the least energy configuration by exploring all possible configurations is known as the *traveling salesman problem*, TSP.

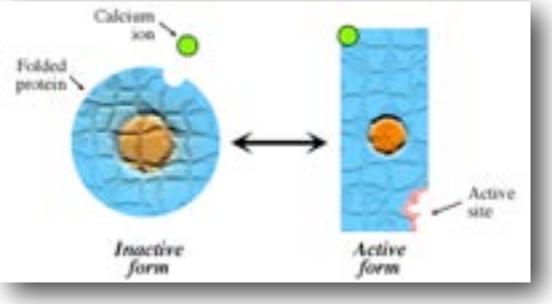
The task in the TSP is to find the shortest route when a set of towns have to be visited. When there are just a few in the set, exploring all possible routes—the brute strength approach—is feasible. The number of possible routes increases as the factorial, however, and this approach becomes unfeasible for larger sets. The number of pixels of spacetime in the visible universe is minuscule compared to factorial two hundred, 200! = 10^{100} x 10^{100} x 10^{100}. The problem is that chains of aminoacids 500 or more long are quite common.

n	n!
5	120
10	3.6 million
25	15 trillion, trillion
50	3 trillion^5
100	>google
200	>google^3
500	>google^{11}

Allosteric proteins

Even worse, the addition of a simple calcium or phosphate ion can cause the whole chain to fold in a completely different way into another precise form of a protein with a completely different set of properties.

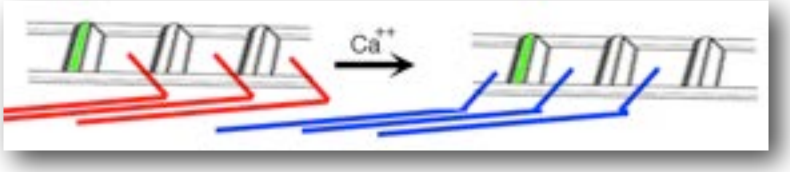
The concentration of calcium ions in solution is firmly controlled in all living systems, and is usually very low inside cells and higher outside. Many proteins are to be found in cells in their folded, but inactive form. They remain inactive until the cell membrane lets calcium ions, in response to some external stimulus, flood into the cell interior. The ions attach to the inactive proteins which all flip into their active form with a set of coordinated consequences, such as a muscle cell contraction.



The calcium is quickly cleared from the cell and expelled back to the outside, the ions disassociate from the proteins and they all, in coordination, flip back to their inert forms. The cell is now ready to respond to the next stimulus.

Such ‘allosteric’ enzymes often work in cascades. A tiny influx of calcium activates a few thousand molecules of an enzyme that phosphorylates another inactive protein. The addition of the phosphate causes this inactive form to flip to an active form. This active protein then processes thousands of another protein to activate them. By such a cascade, a few calcium ions can alter the activity of huge numbers of proteins.

This change of protein form with the influx of calcium can be forceful, as we routinely experience in the contraction of our muscles, powered by the breakdown of adenosine triphosphate, ATP, the ubiquitous carrier of energy in all living systems. The head of the protein myosin has a bound ATP in an inactive form that is inserted in a ladder-like actin protein. When a calcium ion appears—allowed into the cell by a nervous impulse—the myosin breaks the ATP and changes the protein form that, like a cog, ratchets the actin forward a notch. It is the coordinated stimulation of this conformal change in myosin folding that is the contraction force of a muscle



External only

Both chains of aminoacids folding into precise form and allosteric flipping between forms need to be explained. Classical biochemistry looked to the external aspect of the aminoacids and the thermal motions of the chain bringing them into external contact to explain both folding and flipping.

The speed of thermal motion is known, and the number of random collisions the aminoacids in the chain have with each other and with water molecules can be estimated. From this, the time can be estimated for a 500-aminoacid chain to fold precisely if only the collisions of the external aspect are taken into account, as in classical biochemistry. A similar calculation estimates the time for the precise reconfiguration of the chain when a calcium ion arrives. The chart gives typical examples.

Classical biochemistry	**Estimated time**	**Measured time**
Folding of 500-aminoacid chain	> trillion years	>> second
Flipping form on addition of Ca	> trillion years	>> second

The magnitude the discrepancy between the estimated time for folding and flipping, considering just the external aspect, and the observed time of flipping and folding in experiments is immense. This is why it is called the called the protein folding *problem*.

Including the internal aspect

There are enzymes of ~5,000 aminoacids that are reversibly denatured by heat. Heat a solution of the active folded enzyme above a certain temperature and the enzymatic activity disappears since the proper folding is disrupted by the thermal energy. When the solution is cooled, the enzyme activity returns as all the trillions of enzyme molecules spontaneously refold back into the same precise configuration. Not only does this not take eons, as the lock-and-key concept predicts, it happens so quickly that the process is difficult to observe.

This problem of explaining protein folding with classical concepts is akin to the problem that physics had when attempting to explain the structure of the atom using classical concepts. For, in a universe that obeyed classical concepts, the powerful electric attraction between the proton and electron should pull the two tightly together, just as two powerful magnets cling together so that separating them is difficult. Yet the electron does not cling tightly to the proton, it remains at a distance that is ~10,000 times the diameter of the proton. What could possibly be holding the electron up there against the powerful force of attraction? Nothing in the classical panoply would suffice.

It was only when classical concepts were abandoned and the internal wave aspect was taken into account that the extended structure of the atom began to make sense. Following this clue, we will see what protein folding looks like when the internal aspect is taken into account.

A classical solid is always local and never nonlocal. A classical solid is never in two places at the same time, and needs to traverse the spatial separation between them to get from one place to the other. Classical biochemists consider the atoms in an aminoacid chain to be classical solids that are always local and never nonlocal. They might admit that the atoms were made of things, such as electrons and photons, that had decidedly nonlocal behaviors, but that this was a subtlety that could be ignored when considering something as large as a 500,000-aminoacid chain.

But it is this very ignoring of the non-local, non-solid internal aspect of the atoms that creates the protein folding problem. We earlier saw that the system wavefunction of the helium atom totally confines all its subsystems, none of them—electron, virtual photon, quark and gluon—escape or enter the atom in normal circumstances. The wavefunction itself is confined, and is everywhere zero beyond the bounds of the atom.

The helium atom does behave as a classical solid, a Newtonian massy sphere, and is a perfect gas when all other atoms are not. In its thermal collisions, it behaves exactly as would two colliding billiard balls. Only when the thermal kinetic energy is minimal near absolute zero do helium atoms all abandon their classic perfection and, with utter abandon, merge their internal aspects into a single wavefunction, and the atoms are united as a superfluid—superconducting quantum fluid—that has properties that are decidedly nonlocal.

To a lesser extent, all the other noble gases, such as neon, are classical solids like helium that have a system wave that perfectly confines the subsystems. None of these elements has a role in living systems, however, and all the other atoms are characterized by a system wave that does not perfectly confine the subsystems; they have chemical reactivity. In certain situations, the atoms used by living systems are nonlocal and do not behave at all like a classical solid.

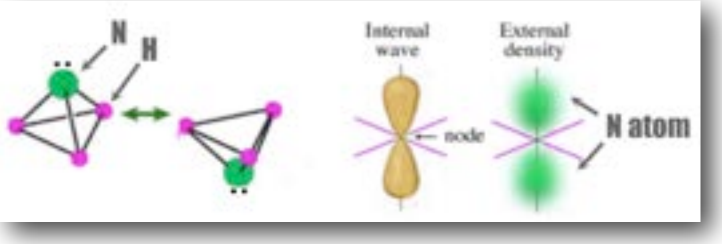
Not-solid atoms

Two examples of the atoms in aminoacids behaving non-locally and not as classical solids in everyday situations are the nitrogen atom in the ammonia molecule and the carbon atom in the diamond atom.

Earlier we discussed internal nodes in standing waves, where an electron was 50% in both lobes but never in between the two lobes. A similar situation is found in the ammonia molecule—three hydrogens bonded to a single nitrogen atom—where thermal energy has kicked it into a slightly excited state.

The nitrogen atom has five electrons in the valence outer shell of electrons. In ammonia, three of these couple a covalent bond with the three hydrogens, and the remaining two are in a lone pair that the ammonia molecule can share with others. Its core subsystems that do not participate in coupling are the two inner electrons, seven protons, seven neutrons and innumerable photons and gluons of the nucleus that are all firmly confined.

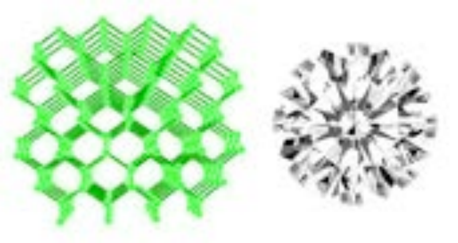
The slightly-excited ammonia molecule resonates at a constant frequency between two configurations; the core nitrogen can be above the plane of the three hydrogens, or it can be below it. The lone pair is on the top of the molecule in one configuration, at the bottom in the other. The core nitrogen vibrates between these two states at a constant frequency while the H atoms remain stationary.



The internal wave has a node in the H-plane and the probability of the nitrogen core being there is exactly zero. This is similar to the p-orbital we have already discussed—the electron is 50% in either lobe and never in between them. An electron behaving strangely is one thing, but the nitrogen is substantial matter, at least in the classical view. This substantial atom is 50% in one place, 50% in another place, but never in between them. All 40-odd core subsystems and the lone pair are 50% in one lobe and 50% in the other, but none of them is ever in between the two lobes. Teleportation perhaps, but the technical term is *tunneling* between the two lobes. This is an odd tunnel; it has zero length but its two ends are in different places.

The nitrogen atom is clearly capable of non-local behavior that is decidedly not what a solid, massy local atom is supposed to do.

Carbon atoms can go in quite a different direction from being a local, solid atom when zillions of them blend their individual internal aspects into a single entity. The wavefunction of a diamond, a giant molecule of just carbon. This wavefunction so fiercely confines its subsystems that diamond is a super-solid and is the hardest known solid. In a natural diamond, while most atoms are C-12, a few are C-13, C-14 and N-14, which spoils the overall perfect resonance. When pure C-12 diamonds are created, they are expected to be harder than natural diamonds.



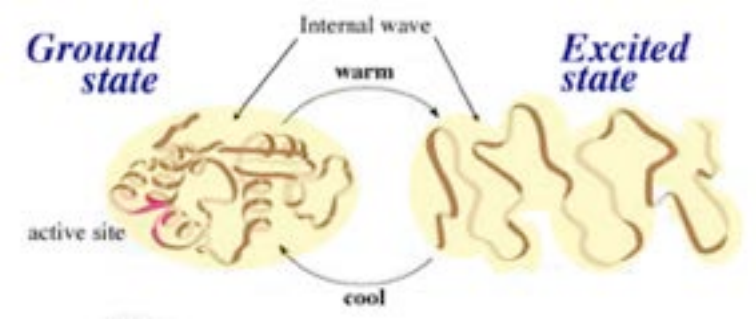
This non-local behavior of carbon atoms, like that of nitrogen, is not what local, classical solid atoms are supposed to do.

If carbon and nitrogen atoms can behave in a non-local fashion in one molecule, there is no good reason to expect that every atom in a long aminoacid chain cannot do likewise.

Protein Folding

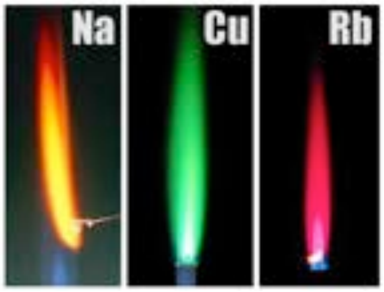
Just as a single nitrogen can tunnel, all we are suggesting is that all the atoms in all the aminoacids in an extended chain ca also tunnel from the excited state to the ground state without being anywhere in between. The linear chain of core atoms and coupling electrons and surrounding water is in an excited state, just like a Rydberg Atom but on a larger scale. This excited state then rapidly sheds a cascade of energy as it jumps to the ground state, and becomes a precisely-folded protein surrounded by structured water.

A measure of the energy difference between the ground state and the first excited state is the transition temperature below which reversible enzymes are in the active ground state, while above that temperature, they are inactive and in an excited state. This is a sharp transition point where the average kinetic energy at that temperature equals the energy of the first excited state.



The probability density of the atoms changes from the ground state to the excited state, a non-local change in the wavefunction, without atoms having to move as solid massy spheres would move in a local fashion. On cooling, the macromolecule sheds energy and falls into the ground state, the precise form it had before the warming episode.

This transition from an excited state to the ground state occurs quickly. This can be observed in the distinctive color of sodium atoms when kicked into the first excited state by the thermal energy of a flame. The excited atoms, all in the same state, quickly jump back to the ground state, releasing a flood of identical, yellow photons. The same color is created in street lights using electric energy to excite the sodium atoms (Na). In my high-school chemistry class, I spent many a pleasant hour identifying elements by their various colors. Copper (Cu) gives a green flame, rubidium (Rb) a crimson, etc.



Each photon liberated has 1 unit of the action but differently distributed between the energy and time period of the electromagnetic oscillation in the oriented boson. In natural units, the energy, E, and time period, T, are the reciprocals of each other. The Rb’s red photons have the least E and most T, the Cu’s green photons have the most E and least T, while the Na’s yellow photons have an intermediate value.

$$E = \frac{1}{T} \qquad ET = 1 \qquad T = \frac{1}{E}$$

This rapid transition to the ground state applies to the natal aminoacid chain in its unfolded, extended linear form. It is in one of the excited states and the macromolecule sheds energy and falls into the ground state, which is the precise form of the protein. All the aminoacids are in stable surroundings except for those in the active site. The jigsaw has a mold to fall into, so to speak.

Unified biochemistry	**Estimated time**	**Measured time**
Folding of 500-aminoacid chain	>> second	>> second
Flipping form on addition of Ca	>> second	>> second

The addition of a calcium puts the chain in an excited state, and it sheds energy and jumps to the new ground state, the allosteric twin of the original form. As jumps between quantum states occur with great rapidity, the folding and flipping of an aminoacid chain can be expected to happen very quickly. When the internal aspect is included in the picture, the protein folding problem disappears.

When the internal aspect is included in the picture in a *unified* biochemistry—one where both the internal and external aspects are taken into account—the estimated and observed times are no longer in violent disagreement. This is just how physics was forced to accept the wavefunction as being real, since it kept the atom from collapsing. Protein folding, for the opposite reason, will eventually force all biochemists to include the internal aspect in all the foundations of living systems.

It is only at this point that biochemistry can be called a unified science.

Sense of smell

That the internal wave aspect cannot be ignored in macro systems—and this is the prevailing view—but plays a role at every level is supported by the science of smell. This was originally explained by the lock-and-key concept, i.e., the odor molecule would fit into a receptor and trigger a response. The problem was that odor molecules whisk by so rapidly that there is no time to stop and bind.

A competing theory proposes that the odor molecule and the receptor protein resonate together momentarily on an internal level without the molecule actually stopping, an example of an excited state that can bring about a change in the protein structure and register a signal. Support for the resonance view over the locking view is growing, as noted in a recent review article:

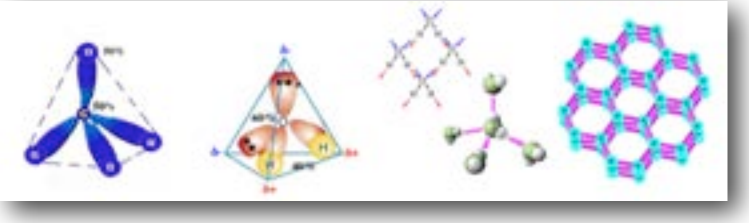
> How does the sense of smell work? Today two competing camps of scientists are at war over this very question. And the more controversial theory has just received important new experimental confirmation.
>
> At issue is whether our noses use delicate quantum mechanisms for sensing the vibrations of odor molecules (aka odorants). Does the nose, in other words, read off the chemical makeup of a mystery odorant—say, a waft of perfume or the aroma of wilted lettuce—by "ringing" it like a bell? …
>
> The predominant theory of smell today says: No way. The millions of different odorants in the world are a little more like puzzle pieces, it suggests. And our noses contain scores of different kinds of receptors that each prefer to bind with specific types of pieces.
>
> The finding represents a victory for the vibration theory….[17]

WATER STRUCTURING

In the methane molecule, one carbon and four hydrogens, the internal wave is such that electrons are 50% with the carbon and 50% with the hydrogens. This is a nonpolar covalent bond. In the water molecule, one oxygen and two hydrogens, the internal wave is such that the electrons are 60% with the oxygen and only 40% with the hydrogens. The hydrogens, so to speak, each have a 10% positive charge and the oxygen has a 20% negative charge. This is a polar covalent bond.

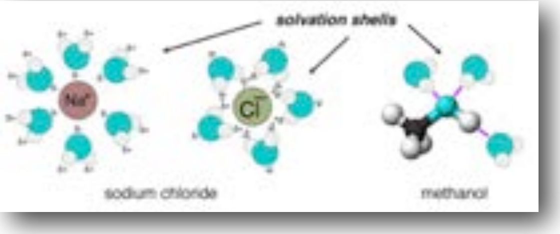
One of the fundamentals that influence the wavefunction is a separation of charge, the ground state will either spread out the charge as much as possible, or unite it with an equal and opposite charge. This is accomplished in a water molecule having two positive hydrogens from other molecules attached to the negative oxygen, and its positive hydrogens attached to two negative oxygens on other molecules.

The stable H-bond is very directional, the coupling H is on a straight line, any asymmetry of the 180° line is not stable. In the three dimensions, the ground state of H-bonding is open hexagonal rings. This is the structure of ice when all the H-bonds are in their ground state.



The great difference that H-bonding creates is seen in the difference between the boiling point of methane and water. The boiling point is when all intermolecular interaction is overcome by the thermal energy and the molecule flies free as a gas. The molecular weights of the two molecules, 16 for methane and 18 for water, are similar. Methane has a boiling point of 109° K (degrees above absolute zero) while water has a boiling point of 373° K, a difference of 264° K. This difference is due solely to the H-bonding capacity of water. The attraction that water molecules have for each other can be directly observed as the considerable surface tension at a water/air interface.

When a crystal of sodium chloride dissolves in water, it does so because each ion becomes surrounded by the appropriate end of the water molecule—the positive sodium by the negative oxygen end and the negative chloride by the positive hydrogen end. This is the solvation, or hydration, sphere that spreads out the charge to such an extent that the attraction holding the two ions together in the crystal is neutralized and the ions move into solution. The hydroxyl in methanol has H-bonding capacity, and it is also soluble in water with an H-bonded solvation shell.



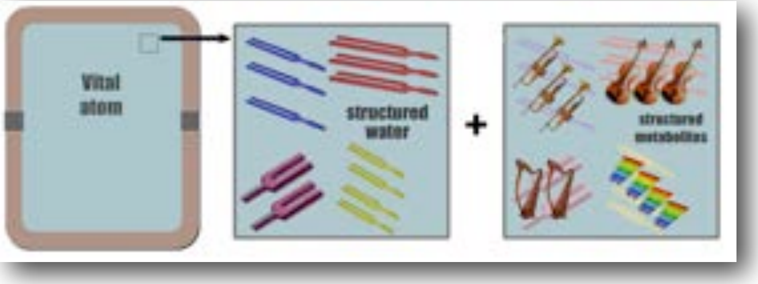
In living systems, proteins are all surrounded by water and they also have a solvation shell about them (even if, for other reasons, they are not in solution). In fact, many of these water molecules should really be considered subsystems of the protein since they are a constant part of the folded structure. This also happens when ions come out of solution and form a crystal. Both sodium and chloride ions abandon their water companions, but this does not always happen. When zinc and chloride leave solution they usually take four molecules of water with them into the crystal, the ‘water of crystallization’.

This applies to the ground state of a folded protein. The pattern of electric charges and H-bonding must allow the surrounding water to take up the stable ice-like configuration. The ground-state internal wave of the protein is structuring this water shell as much as it is structuring the aminoacid chain.

Vital Unit water

In a vital unit, each small volume contains proteins that generate a resonance that structures the surrounding water—solid, liquid or in between. This water, which is ice-structured by the internal waves generated by proteins, is akin to the air in a concert hall being pressure-structured by the external waves generated by musical instruments. Each particular state of the water is the harmony of all their waves.

The proteins also generate waves that resonate with their particular substrate. This is like harps, trumpets, etc., all playing at the same time in the harmony.



Just as a listener has no problem distinguishing the sound of the tuning forks, the sound of the violins, or the sound of the xylophones, the substrates have no problem distinguishing their particular protein ‘instrument’ playing in the harmonious resonance of the vital unit.

All living systems are 75% water, and the structure all of this water is firmly controlled at all times in the healthy organism. Almost all of this structuring is accomplished by proteins although the other vital macromolecules do play a role. As 75% of a living system, we can say that 75% of the collective wavefunction generated by proteins is structuring this water. The other 25% of the collective wavefunction being generated is structuring all the other molecules in the ‘symphony’ that is the healthy cell. This water-structuring role can be preeminent, such as it must be in growing embryos that can be greater than 95% water, with everything else being less than 5%.

While proteins structuring water in a harmoniously-unified thriving vital unit is more sophisticated than musical instruments structuring air in the performance of a harmoniously-unified symphony, the analogy is useful and informative in generating the following summary.

Generator and resonator

In a symphony, a small number of massive, multimolecular instruments generate waves that structure a large number of light-weight resonating air molecules.

In a living system, a small number of massive proteins generate internal waves that structure a large number of light-weight water molecules.

Confinement and portals

In a concert hall, the resonating air molecules are confined by the surrounding soundproof walls (it is this lack of resonance that makes an outdoor symphony sound so flat). In this confining barrier, however, there are portals that allow for interaction with the outside, the passage through these doors being highly controlled, such as in Carnegie Hall, and involve an expenditure of money.

In a vital unit, the resonating water molecules are confined by the water-impassible bi-lipid membrane. In this confining barrier, however, there are portals that allow for interaction with the outside, the passage through these portals being highly controlled by proteins that span the membrane, and involve an expenditure of energy.

Lipids are occasionally enzymatically attached to proteins whence they radically alter the internal wave. There is a whole class of proteins that have a hydrophobic middle with two hydrophilic ends. They span the membrane and perform dozens, if not hundreds, of roles in connecting what is going on on either side of the membrane.

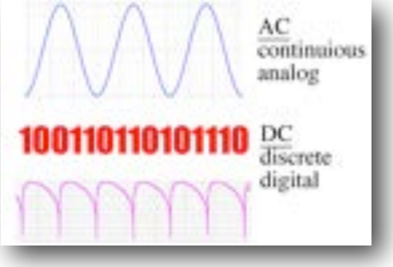
A membrane-spanning protein for a particular small molecule—the ligand—has a binding site at its outside end that recognizes and binds the ligand (just as enzyme and substrate do).

The ligand-protein flips its conformation with a variety of consequences:

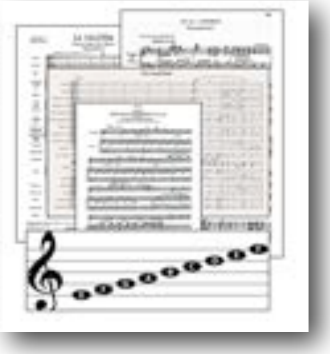
- The ligand is now on the inside where it is released. This is ‘passive’ transport and the ligand can pass out just as easily so the internal and external ligand concentrations will be similar. If an ATP is split during the conformal change, this is ‘active’ transport and is inwards only, so the internal concentration can be much higher than the external.
- The inside end becomes an enzyme. An example is the binding of a messenger molecule, such as insulin, to the outside end with the inside enzyme that generates a ‘second messenger’, which creates a cascade of consequences. An example is the inner end becoming an adenyl cyclase that converts ATP into cyclic-AMP (cAMP). Almost every living system uses cAMP as a second messenger even if the consequences that ensue can be very different.

If a single vital-atom bacteria is like a single symphony, then the compartmentalized eukaryote is like a vast multiplex where the soundtracks of the many movies playing do not interfere too much with each other. The main difference is that all the activities of each vital unit in the vital molecule are coordinated and unified, a topic we will discuss in detail when we eventually move from the simple prokaryotes to the eukaryotes.

Analog form and digital information



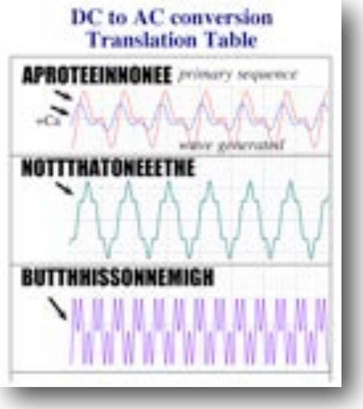
The final, and most useful, analogy between a symphony and a bacteria is the relation between analog form content and digital information content, which we will abbreviate as AC and DC. The key difference between the two is while AC involves smooth, continuous transitions, DC involves abrupt, all-or-nothing, discrete transitions.

A simple example of AC form is a sine wave and a simple example of DC information is a binary string.

Both the pressure waves in a concert hall and the wavefunctions generated by proteins in a vital unit are examples of complicated analog waveforms. The analog forms, in both cases, are generated according to digital information.

In a symphony, the music being played is determined by the score distributed to the musicians before the start. Each instrument translates its part of the DC score, generating an analog waveform that it contributes to the harmonious whole. If a different score is distributed, an entirely different analog form is generated.

There is a subtle difference between this method of generating analog waves from digital information and the method used in living systems. A musical instrument/performer is capable of generating a large number of different sound waves, and either generating or not generating them according to the digital score. The score and instrument are separate entities, and the score can easily be changed to a different one.

In living systems, the score and instrument are one and the same entity. The score itself is the generator of the analog wave, a wave that is generated continuously and never turned off. The wave only ceases when the protein is destroyed—and most proteins present in a vital unit are in a constant turnover—or it undergoes a conformal change and starts generating a new wave. Most proteins have at least two conformal states, and some have a dozen or more conformal states. Compared to a piano, a particular aminoacid chain has a small set of waves it can generate, and then only continuously.



The primary structure of a protein wave generator is digital, it is an all-or-nothing situation of a particular aminoacid being present in the chain. Each digital primary structure is an instruction to generate a particular wave. Biochemists have a single-letter code for aminoacids, so the primary structure, starting at the free-amino end, looks like a paragraph with no spaces between words. Each primary structure is a digital instruction regarding how to generate a specific waveform.

This is a ‘translation table’ that associates each primary structure with generating a specific analog wave, a DC to AC conversion.

A symphony changes the AC wave by changing the DC score, not the instruments. A living system changes the AC wave by changing the DC score and the wave generators. Most living atoms have a limited set of suites of proteins, of symphonies they can play—these are called the states of a bacterium.

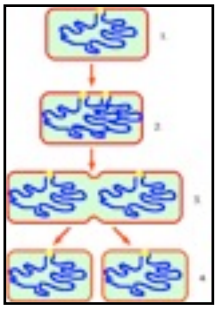
Bacterial states

A bacterium has set states that that depend on what is traversing its bi-lipid portals to the outside world, states that can be as different as Beethoven and the Beatles. A partial listing of these various states is:

Abundant state

Everything that is required is freely available from the outside. The suite of proteins that is deployed in this situation generates a wave in which metabolism is directed to grow and divide.

The members of the suite rise and fall as the stages are run through in cycles—the movements of the symphony—as the cell grows and divides. The suite of proteins is a suite of DC instructions that



are generating this analog wave. This is the digital Grow and Multiply score or, in computer lingo, the *GrowMultiply* program.

In an abundant environment running this program, a bacteria can divide in this way every 20 minutes, three times each hour. Assuming the food does not run out, in one day a single bacterium can multiply into 2^{72} bacteria, or about a billion trillion of them.

When running the *GrowMultiply* program, the vital unit makes a lot of housekeeping proteins and enlarges to a maximum size. Sensing that the compartment is growing to a size beyond the capacity of the wave, the cell switches to the *Divide* subroutine of asexual multiplication.

1. The cell reaches maximum size and the water-metabolic wave changes to the first movement of the *Divide* symphony.
2. Proteins and RNA copy the long-term digital information stored on DNA. The double helix is split into its two strands. Each strand is then complemented to create two double helixes identical to the original. The second movement of the *Divide* symphony begins.
3. Proteins physically separate the two duplexes and constrict the cell membrane between them. The final movement movement of the *Divide* symphony begins.
4. Proteins pinch off the cell membrane resulting in two separate compartments, two small but identical clones of the original mother cell.

Collegiate state

When a few bacteria scattered on a petri plate of nutritious jelly are left to incubate overnight, each cell multiplies into a ‘bacterial colony’ with a characteristic form and color.

The suite-of-proteins DC program that is running in each identical bacterium is Collegial, and this directs resources into recycling and maintenance rather than multiplication. The environment is mainly clonal sisters.

Scarcity state

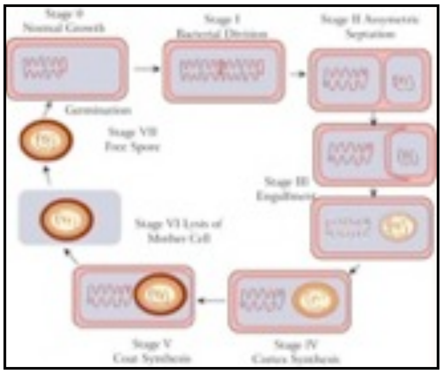
An isolated bacterium in a so-so environment will use the differential inputs of its portals to detect gradients. The suite of DC proteins deployed will then divert resources into its motile ability so that it moves up a gradient of molecules it likes, and down a gradient it dislikes.

Famine state

In a situation when the environment is totally hostile and core metabolism of ATP and glucose fragments starts to falter, the DC program being run is changed to Famine.

The suite of proteins now generates a wave that diverts all remaining resources to drastically altering water and metabolism in an asymmetrical cell division: one half self-destructs, while the other settles into a compact, dehydrated form, a spore with a very minimal metabolism.

If the symphony of life is liquid change, that of the spore is frozen stasis. Bacteria can remain in this frozen-life state for a remarkable length of time—the longevity of a dry dust of anthrax spores is legendary—and only a Phillip Glass symphony can rival such an endlessly unchanging chord as in Famine.



This dormant form includes a stash of ATP cached with the portal-detectors. When their binding sites signal both water and food, the conformal change generates a cyclase activity that turns the ATP into cAMP, the second messenger. This is the signal to switch the DC score and the spore awakes as the *GrowMultiply* program starts up.

Computer Programs

I have a friend who is a music composer. On his ever-versatile Mac he has what he calls ‘an orchestra in a box.’ It converts a DC score directly into an AC wave form that is an excellent facsimile of a recording by the Berlin Philharmonic. “You want 100 first-violins? 20 Renaissance horns? 10 timpani? 30 harps? No problem.” So the segue from music scores to computer programs is a smooth one.

In the computer world, the food-and-water detector of the spore is akin to a port that can be in state 1 or state 0, with the 0 state being absence of cAMP, and the 1 state being the presence of cAMP.

In a computer programming language, the Famine program would be an idle, do-nothing loop with an exit:

```
10.   IF PORT = 0 THEN RUN FAMINE ELSE RUN GROWMULTIPLY
```

To conserve resources, this program need only be run once an hour by the digital processing system we have yet to discuss. All living systems have such digital programming subsystems, and much of housekeeping metabolism is run by such routines.

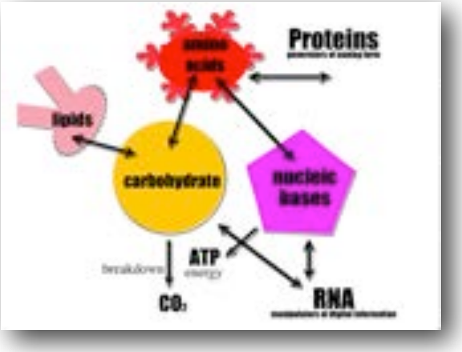
To understand the manipulation of digital information in living systems, we have to study another type of polymer—the nucleic acids, RNA and DNA. Just as the proteins are the master manipulators of analog form, the nucleic acids are master manipulators of digital information. RNA is also capable of a small, if primal, subset of the analog manipulations proteins are capable of. An example of this is the RNA that provides the wavefunction for the peptide-bond linking of aminoacids into a long chain.

In order to discuss the nucleic acids, however, we need to discuss yet another class of monomer-polymer, the carbohydrates, that are a component of nucleic acids.

Metabolic relations

Carbohydrates and carbohydrate-fragments are central to metabolism, all the other polymer-classes spin off from this center. The housekeeping core of all living systems, from bacteria to Man, are all remarkably similar.

The flow of atoms in this core metabolism centers on the carbohydrates, which can either be transformed into the other monomers or broken down to carbon dioxide and water, an oxidation whose energy is trapped in the high-energy bonds of ATP, adenosine triphosphate, one of the nucleic bases. This is an irreversible reaction. Plants and some bacteria use the energy of sunlight-photons to reverse this step and transform carbon dioxide and water into carbohydrate and free oxygen. From the carbohydrate, along with a few inorganic ions, a plant can synthesize all the other types of molecules.



Carbohydrates can also be reversibly transformed into lipids or, with reduced nitrogen added, into all 20 natural aminoacids. Fragments of these aminoacids are fused into rings to generate the four natural bases of RNA—adenine and guanine with two rings, and uracil and cytosine with one ring. A nucleic base attached to a carbohydrate (ribose) attached to a phosphate is the basic monomer out of which the RNA polymer is constructed.

A note about DNA. For a host of reasons we will later discuss, and central to the consensus about origins called the 'RNA World', DNA is actually just one of the many varieties of RNA. All the subunits of DNA are created by altering the subunits of RNA to reduce their polarity. The polar free hydroxyl on the ribose is replaced by a nonpolar hydrogen, and a nonpolar methyl group—a drop of oil—is added to one of the four nucleic bases. In the DNA polymer, all the polar hydroxyls along the backbone of RNA are replaced by nonpolar methyl groups—severely reducing the polymer's ability to H-bond with water—and one-quarter of all the bases have a small hydrogen replaced by a large methyl group—further enhancing the hydrophobic tendency of the ground state wavefunction. The 'deoxy' of DNA is a recognition of its drastic loss of polar attributes.

While most varieties of RNA are facile with water and fold up into a wide variety of analog forms with a wide range of activities, oily DNA folds into only one analog form, the famous double helix.

This oily variety of RNA has one preeminent property—it is a remarkably stable macromolecule. While the carbohydrates, lipids, proteins and RNA of insects trapped in amber in the dinosaur age have all disintegrated, DNA that has remained stable for 100 million years is still there, its digital information almost intact.

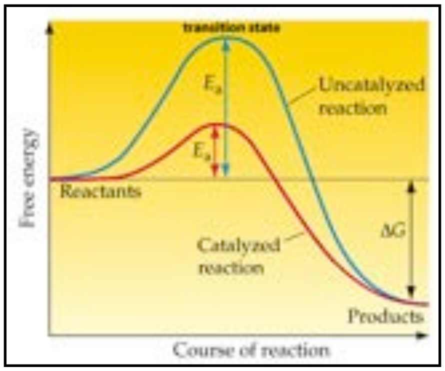
If the many digital manipulations by all the other varieties of RNA are likened to the active CPU of a computer, then the passive DNA is as a hard drive to which digital information can be written, duplicated, read and translated. DNA is a store of digital information that is stable down a lineage through deep time.

In most of the following, we will be discussing just RNA, but before we can do that, we have to understand its carbohydrate component. So, our discussion will progress from carbohydrate to RNA, and then finally to the manipulation of digital information.

Carbohydrates

All the manipulations we are about to describe are performed by protein catalysts. A simple 'catalyst' acts by providing waves in which the activation energy of the transition state is lowered. The thermal energy is then sufficient to excite the transition state and the reaction rapidly proceeds. The product, which no longer fits, is expelled and another substrate takes its place.

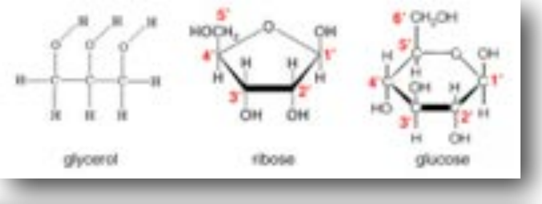
An example is hydrogen peroxide which has more free energy than water and oxygen. It is metastable because it has an activation energy beyond the reach of thermal energy. So a peroxide solution is quite stable. Put it on a wound, however, and the enzyme 'peroxidase' goes to work lowering its activation energy. The solution bubbles furiously as the peroxide decomposes into water and a singlet oxygen (which disinfects the wound by its reactivity).



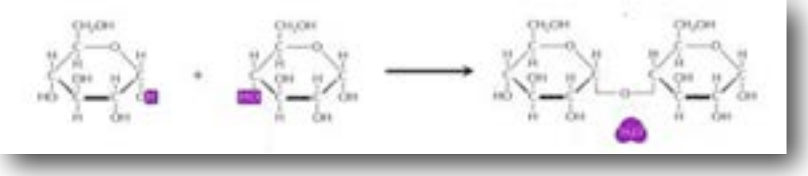
A single peroxidase molecule can do this for over a billion peroxide molecules a second.

A reaction can also go 'uphill' if an ATP supplies the energy that is in the products.

We will be using the term carbohydrate generically for polymers, monomers and monomer fragments. All carbohydrates are based on the motif H-C-OH, which looks like a carbon atom inserted into a water molecule, hence the name. They are classified by the number of carbon atoms: the glycerol bit in lipids being a linear 3-carbon molecule, the ribose bit in nucleic acids being a 5-carbon ring, and the glucose in sugar being a 6-carbon ring. Since the hydroxyls at different locations have different properties, the carbohydrates have a consistent convention for numbering the carbon atoms.



The hydroxyls of two monomers form a bond, eliminating water, and link up into carbohydrate polymers studded with hydroxyls that are excellent H-bonders with water or other molecules. In the illustration, the two glucose molecules are linked by a 1-4 elimination of water creating a maltose, a disaccharide. The most common organic compound on Earth is cellulose, a



large polymer of glucose all linked in the same way. The unused hydroxyls on adjacent chains can also form cross-links between chains.

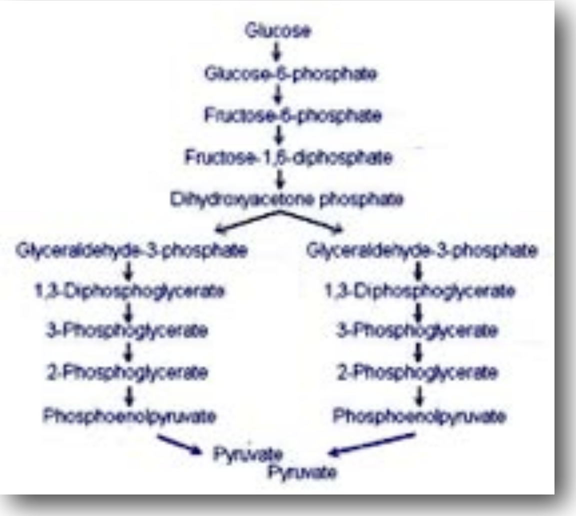
Most of the carbohydrates in metabolism have one or more phosphates ester-bonded to the hydroxyls. These phosphates are all stripped away and recycled in creating all of the end products except RNA, which has a sugar-phosphate backbone. It is this abundance of phosphate that is the acid in nucleic acid.

Central metabolism

In the lock-and-key classical picture, a metabolite moves through the system by thermal motion. The substrate molecule bumps into the first enzyme, is processed, then released. This first intermediate metabolite molecule moves about in thermal motion until it bumps into the second enzyme, is processed and released as the second intermediate. This moves about by thermal motion until it bumps into the third enzyme, is processed, and released as the third intermediate, and so on until the final step.

The view of metabolism that includes the internal wave is not so haphazard. Each intermediate is in an excited state with respect to the next enzyme in the sequence; it moves to the ground state of being bound to the enzyme from wherever it is within the lipid-bound compartment. There are no concentration gradients within the compartment because the internal wave ignores spatial separation on this scale. The metabolites are structured by internal waves generated by proteins, just as the water molecules are structured.

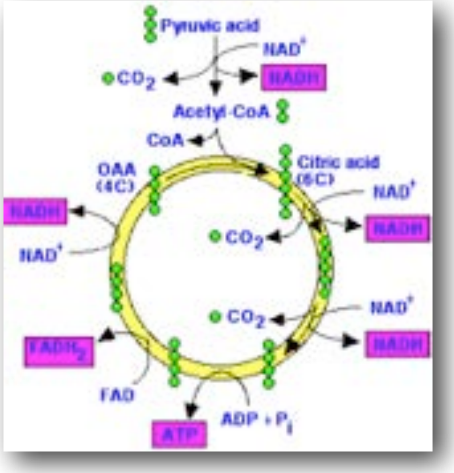
Either way, the steps by which molecules are transformed into other molecules are well-known. The diagram is the sequence of manipulations by enzymes wherein a 6-carbon glucose molecule is activated by the addition of a phosphate, flipped into fructose, and another phosphate added. The molecule is then split into two identical halves. The phosphates are then removed and, after one more transformation, the glucose molecule has been transformed into two molecules of 3-carbon pyruvate. This small molecule can be considered a central molecule in metabolism since so many metabolic paths lead onwards from it.



Pyruvate can go into lipids or aminoacids, or it can end up as alcohol or lactic acid in anaerobic respiration. In respiration using oxygen, the pyruvate is fed into a cycle of carbohydrates, starting with citric acid, that splits off carbon dioxide, feeds energy into ATP, and returns back to citric acid.

Krebs cycle

Pyruvate is one of the central molecules in the core metabolism common to all life. At the very core of metabolism is the Krebs cycle (aka the citric acid cycle) whose intermediates are important beginning points for the assembly of other molecules such as aminoacids and nucleotides. Running in the direction illustrated, the 3-carbon pyruvate first gives up a hydrogen to the carrier, NAD, and then releases a molecule of carbon and forms a thioester with a molecule called Coenzyme A. This transfers the 2-carbon fragment to the 4-carbon oxaloacetate (OAA) to form the 6-carbon citrate.



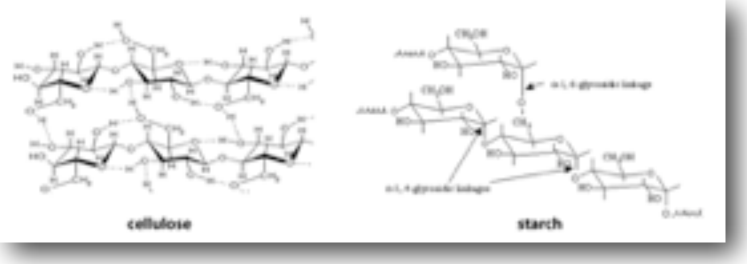
This progressively gives up hydrogen to the hydrogen carriers—the nucleotides NAD and FAD—loses two carbon dioxide molecules, phosphorylates ADP to ATP, and ends up as oxaloacetate to start the cycle again. The activated hydrogens liberated can be used by all organisms to drive chemical transformations and, in aerobic organisms, are fed into the pathway that combines them with oxygen powering the addition of phosphate to ADP generating ATP. Running in this direction, the cycle creates energy and releases carbon dioxide.

The cycle can also run in the opposite direction, given a source of ATP and activated hydrogen when it incorporates carbon dioxide into more complex molecules.

A more complicated cycle of carbohydrates, but in reverse, is used by plants to fix carbon. The cycle starts by combining phosphorylated-ribulose with a carbon dioxide molecule. It ends by turning three of them into one of the phosphorylated 3-carbon precursors of pyruvate plus a ribulose to start the cycle over again. The carbohydrate cycle of this 'dark process' is driven along by using the high-energy products created by the light-capturing mechanisms of photosynthesis. From this 3-carbon carbohydrate, core metabolism can create any of the other molecules of life, including the 5-carbon-ribose that is a subunit of RNA.

Polysaccharides

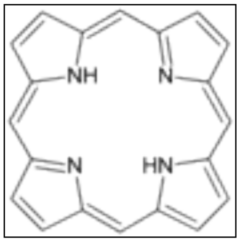
The table sugar we are most familiar with is a disaccharide, a linking of a 6-ring glucose and a 5-ring fructose. There are plenty of hydroxyl groups which are mild H-bonders: sugar is very soluble in water, and structures water somewhat; it gets viscous and sticky. The molecular wave embraces a small shell of structured water.



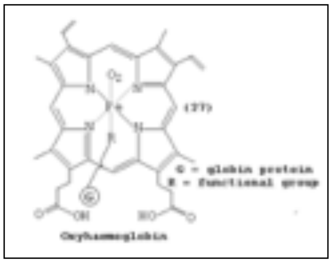
The most abundant polysaccharide is the cellulose that all plant cells construct for support. This is innumerable glucose units linked one way. Starch is also made of glucose, but they are linked a different, and branching way. Unlike cellulose, it is soluble in water and forms a sticky glue (or, more palatable to adults, a thick sauce when corn starch is used in cooking).

The very different and well-designed properties of cellulose and starch come from the Logos and are expressed in the unified, macromolecular chord of the quantum wave.

Saccharides often adorn proteins, put there by enzymes, and they tune the waves that are generated.



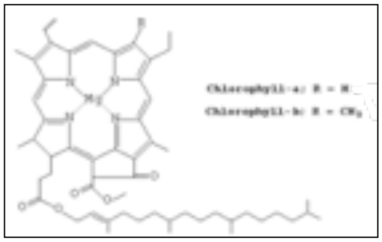
Some of the molecules constructed by manipulation of simple structures from core metabolism are large indeed and have remarkable properties inherited from the Logos. One of these is based on a ring called a porphyrin (pronounced POR-fur-in). It is a sophisticated wave with the form of 'aromatic' rings in an aromatic ring.



The porphyrin ring is adorned with a variety of 'handles' that allow it to link to other molecules. The hole in the center is filled by a metal ion coordinated by the four nitrogen atoms.

The most familiar porphyrin is haemoglobin (not used in bacteria), which has an iron in the center and four rings attached by their handles to a protein complex. It provides a wave that resonates with oxygen. In high concentrations, oxygen binds it to the iron; in low concentrations, it releases the oxygen. This is how blood carries oxygen from the lungs to the rest of the body.

Chlorophyll has a magnesium atom in the center, and its handles are also connected to a protein complex. A red or blue photon can merge its wave with the delocalized electrons, kicking them into an excited state, a state where they are localized where they can be syphoned off onto the top of a chute of 'electron-transport' proteins. As they fall to the ground state down the chute, their energy is captured in ATP, which can be used to turn carbon dioxide into glucose. This is how the sun provides all the energy for life.

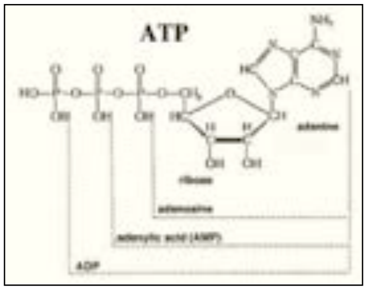


Most large molecules in living systems are polymers of small monomers, and the largest molecules are the nucleic acids that can contain billions of atoms.

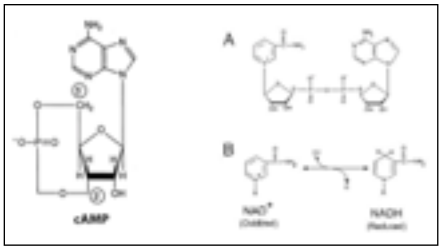
RIBONUCLEIC ACID, RNA

The RNA polymer is composed of nucleotide monomers all linked together by ether bonds between a sugar and a phosphate. There are only a few nitrogenous bases making up the natural nucleotides used by all living systems, these bases being synthesized from amino-acid fragments. The bases are linked to ribose which is linked to phosphate.

Nucleotides



The nucleotide, adenosine triphosphate, ATP, is the energy supplying cofactor in a host of enzymes, and energy is supplied by the breaking of the high-energy phosphate bonds. ATP is composed of a nitrogenous base, adenine, linked to the 1’-hydroxyl of ribose, linked via the 5’-hydroxyl to a polyphosphate.



Many other nucleotides and nucleotide-like molecules are used as cofactors in metabolism. Consider the following two examples:

1. Cyclic-AMP has the phosphate at 5’ linked back to the ribose at 3, and is a ubiquitous second messenger.
2. Replacing the final phosphate in ATP with a ribose attached to a nitrogenous base forms vitamin-B. This is nicotinamide adenosine di-nucleotide (NAD) that excels at conveying hydrogen atoms between molecules. NAD is used as a cofactor by almost as many enzymes as ATP.

RNA Folding

The chemical activities of the various side groups along the RNA, while not as diverse as in protein, have plenty of hydrogen bonding capacity, and an RNA molecule folds up into a precise form in water just as do proteins. The DNA variant of RNA replaces the free 2’-hydroxyl on the ribose with a hydrogen atom, becoming a sugar called deoxyribose. This DNA is also made more hydrophobic by adding a methyl group to the ~25% of the bases that are uracil, adenine’s partner. The base is now called thymine.

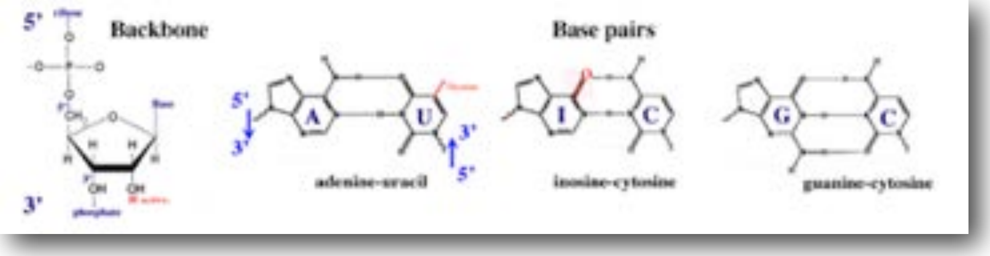
In proteins, the folded aminoacid chain binds sympathetically with water. The geometry of the H-bonding groups at the surface is just right for H-bonding with water. At the binding site, just about any type of molecule can be accommodated by the surrounding aminoacids.

The ribose-phosphate backbone of RNA excels at binding with water. The geometry of the H-bonding in the nitrogenous bases makes water-bonding awkward, but H-bonding with a complementary base is extremely easy. In the folded form, the H-bonding in the interior is very often between complementary bases, not with water. The ‘substrate’ of a nucleic acid is often another nucleic acid. In nonpolar DNA, all the interior bonding is entirely between complementary bases; none of the bases need to bond with water.

There are four natural nucleic bases with either one or two rings and capable of making two or three hydrogen bonds. The names come from early chemistry and are not particularly informative.

	1 RING	2 RINGS
2 H-BONDS	Uracil (thymine)	Adenine
3 H-BONDS	Cytosine	Guanine

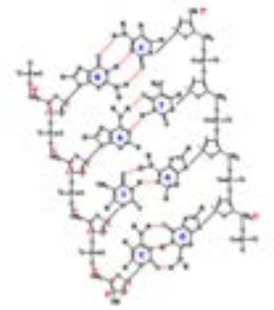
In an RNA polymer, one end has a free 5’-hydroxyl on the ribose while the other end has a free 3’-phosphate on the ribose. Synthesis of all varieties of RNA always starts at the 5’-end and concludes at the 3’-end, and base-to-base binding is always between ribose-phosphate chains going in opposite directions.



Base-to-base bonding always follows these two rules for *base pairing*:

1. The sum of the rings in the two nucleic bases is 3.
2. The difference in bonding number of the nucleic bases is 0.

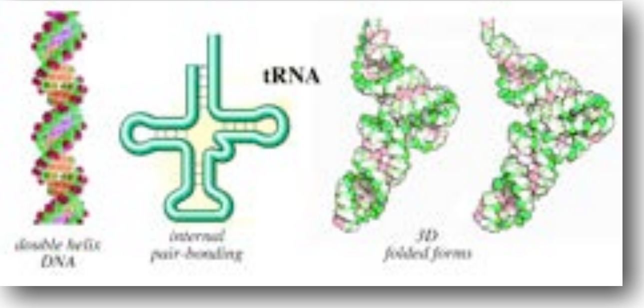
These requirements are met by the two pairs of complementary bases that sum to three rings and are commonly referred to by their initial letters, the two-bonding A–U(T) pair and the three-bonding G–C pair. Enzymes that exchange an amine group on adenosine with an oxygen, generating inosine, can switch between 2-bond and 3-bond pairs.



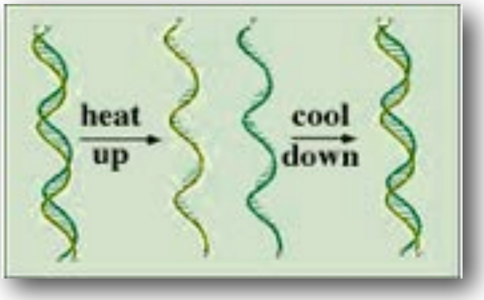
The ‘binding site,’ so to speak, of an RNA chain is another RNA chain in which the sequence of bases is complementary going in the opposite direction. Like a zipper, the complementary bases bind and align the two chains, the G-C triple bond being stronger than the A-U double bond.

In either case, the distance across the complementary is a constant three rings.

In a DNA double helix, there are two zippered chains that cling tightly together. In other varieties of RNA, the chain folds back on itself, as in the small tRNAs where a single chain creates loops as complementary sections zipper together.



The folding of an RNA/DNA chain is exactly like that of proteins, except that to the internal complementing of chemical activities is now added the complementing of digital information on the pattern of nucleotide H-bonds. It has already been noted that there is an inadequacy of the lock-and-key concept to explain the rapid fashion by which nucleic acids find and unite with their exact complements. In DNA, all the internal structure is base-pairs.



If DNA is heated above a certain temperature, the thermal energy becomes sufficient to disrupt the double helix and the two strands separate. When cooled below that temperature, the DNA ‘anneals’ and the two strands very rapidly align and bind back together again as a double helix. This is exactly the same process as in the reversible denaturation of enzymes by heating and cooling.

In unified science, the double helix is the ground state, while the two denatured strands of DNA are in an excited state of the extensive wavefunction. In unified biochemistry, the rapid annealing of RNA and DNA is to be expected; it is not a puzzle.

Terminology

Modern technology has accumulated a lot of wisdom about the manipulation of digital information. We would like to apply this wisdom in unraveling the way that RNA manipulates digital information in living systems.

In modern technology, digital information can be stored and disseminated in a wide variety of physical forms. Magnetic domains, electric charge, electric current, reflective pits and radio waves are a brief sample. Digital information is readily transformed from one physical form onto another many times, but the digital information always remains unchanged.

Whatever the physical form,—N or S magnetism, reflective or non-reflective, etc.—the digital information is notated in the same way, as a string of zeros and ones, i.e., in the binary code. All that wonderful stuff that digital computers, phones, routers, TVs, etc. do is a highly-sophisticated manipulation of 0s and 1s responding to input from the environment.

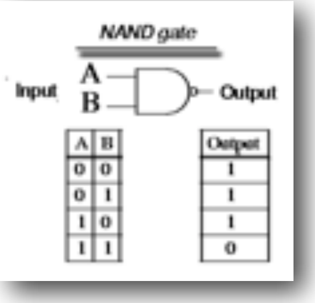
The problem is that manipulation of digital 0s and 1s is highly arithmetical, and A, U(T), G and C are not suitable symbols for these mathematical operations. It will make the application of binary-code wisdom to living systems much easier if we use numerical, not alphabetical, symbols for digital information. Binary code will not do because it cannot handle the relations between the four bases.

We will use the four integers, 0, 1, 2 and 3 instead of letters to name the four bases in RNA. The chemical difference between uracil and thymine is irrelevant to the digital information and need not be noted.

	1 RING	2 RINGS
2 H-BONDS	2	1
3 H-BONDS	3	0

Logic operations

The mathematical manipulation of digital information is also a systematic hierarchy, where simple operations are concatenated into more sophisticated operations. At the very lowest level are the simple logic gates. They are physical structures that take a digital signal input and generate a digital output. The simplest NOT gate turns an input of 1 into an output of 0, and an input of 0 into an output of 1. It simply inverts the binary digits, and a simple circuit in a transistor easily does the binary inversion.



More sophisticated logic gates take two inputs and, depending, have a single output. Examples are gates AND, NOR or XOR that take two inputs that result in a single output. The NAND gate, for instance, always outputs a 1, unless both inputs are 1 and then it outputs a 0. A transistor with a few connected AND and NOT gates on it will do this.

TC	
•N	•|N-3|
0•	•3
1•	•2
2•	•1
3•	•0

The logic operation that a gate performs on two inputs of binary information is shown in a ‘truth’ table in which 1 is true, 0 is false. While it seems an unpromising manipulation of two digits, sets of connected NAND gates can do every kind of logical manipulation possible to a digital input. Everything that a computer does can be done by sets of NAND gates alone.

Using the numerical notation, the manipulation of digital information at the base of the systematic hierarchy can also be expressed as a truth table. As a reminder that direction is important, we will use • to signify the free hydroxyl at the 3’ (*three-prime*) end of the chain.

An example is the logical operation of threes-complementing, TC, a number in which the output is the size of the number after 3 is subtracted, TC(N•) = |•N–3|, and the TC of this returns the original, TC(TC(N•)) = N•.

This logical operation can be applied to a string of bases, N_1 N_2 N_3… N_n• = **N**• and performing the operation twice, TC^2, duplicates the original string **N**• + TC^2(**N**•) = 2 **N**•. To make a copy of digital information, the TC logical manipulation is performed twice on the original, creating two identical copies.

Barring a few exceptions, such when a poly-adenosine primer is assembled, all RNA and DNA is generated by the TC logical operation—the enzyme *transcriptase* transfers digital information from DNA to RNA, while the enzyme *reverse transcriptase* copies it from RNA to DNA and, in one of the set of analog operations that RNA ‘rybozymes’ are capable of, information on RNA is copied onto RNA. These are the physical structures that perform the logical operation and these enzymes are equivalent to the circuits on a transistor that perform the NAND operation.

The digital information on DNA is duplicated by performing a TC on both strands of the double helix, which are pried apart for the operation. The enzyme helicase separates the strands and two DNA polymerase enzymes assemble the complementary strand. As nucleotides are only added to the 3’ end of a growing polymer, the leading template strand is simple to assemble, while the lagging template is complemented in sections which are then linked together by a ligase. The end result is two identical DNA helixes.

1**N**• 2•**N** + TC(1**N**•) TC(2•**N**) = 1**N**• 2•**N** + 1**N**• 2•**N**

This gives two copies of the digital information. After n repetitions of this there will be 2^n duplicates of the original digital information. After 100 duplications, the number of copies would be 2^{100} or about a billion, trillion trillion.

Another example of a logical operation on digital information in living systems is the transformation of an adenosine to inosine.

The truth table of the operation is simple but, as shown, performing a TC twice changes a 1 in a digital string to a 0. The logic operation is the exclusive subtraction of 1 from the number, XSB(1) = 0, while leaving the other numbers unchanged. This is an example of performing this sequence on a string of bases 0321•

XAD(TC^2(0321•)) = 0320•

N	XSB	TC	TC
0•	0•	•3	0•
1•	0•	•3	0•
2•	2•	•1	2•
3•	3•	•0	3•

We can simplify the notation. As we have made clear, the digital information on codon and anticodon is the same except for it being in complementary form. We can signify this identity of DL by simplifying the notation and just signify the DI and the direction it is going by a •.

So the complement of 0123• is •0123; the numbers remain unchanged, and just the dot moves. The threes complement of a number is generated by moving the dot from one end to the other. This is in deference to the tradition that mRNA is the codon while DNA and tRNA are anticodons (though the reverse, like electricity, would make more sense).

So the passing along of DI in protein synthesis entails that the numbers do not change, just the location of the dot. At the end, it signifies the codon, so the numbers equal the usual bases. At the start, it signifies the anticodon, so the numbers signify the threes-complement base. Flipping from T on DNA to A on mRNA to U on tRNA is cumbersome and adds no new digital information, just the chemical nature of the particular media it is on which is quite irrelevant.

Media	DI	AW
DNA	•0123	
mRNA	0123•	
tRNA	•0123	
aminoacid		*Bezier generator*

While the exploration of the systematic hierarchy of sophisticated operations founded on the NAND logic has given us the iPhone, the mathematical exploration of the systematic hierarchy of operations founded on the TC and XSB logic operations is minimal, and there are probably more such basic operations that have yet to be discovered.

What is well-known, however, is the connection between digital information, DI, on RNAs and the digital information in proteins, their primary structure. As discussed, this is the sequence of aminoacids in a linear polymer, and it is this DI that determines the automatic folding of the chain into the active form of the protein. This folded form, in turn, determines the analog wave, AW, that the protein generates to add to the harmony in a vital unit, the sequence being represented as:

DI-RNA → DI-protein → AW-generated.

To make this connection, we first have to describe a few of the many RNA varieties.

An RNA World

It is becoming clear that DNA, which has heretofore played the central starring role in biological theory, has only a supporting—if essential—role comparable to that of the somewhat passive role of a hard drive in a PC computer. All the really important action—including getting life started in the first place—is performed by RNA with a role comparable to the central processing unit (CPU) of a computer that reads and writes digital information to the hard drive as well as manipulating it, combining it with input from the environment (the User) before outputting it as analog information to a screen or loudspeaker.

We will now briefly summarize the varieties of RNA that are well-understood and then just mention those that have been so recently discovered that their function is still being deciphered.

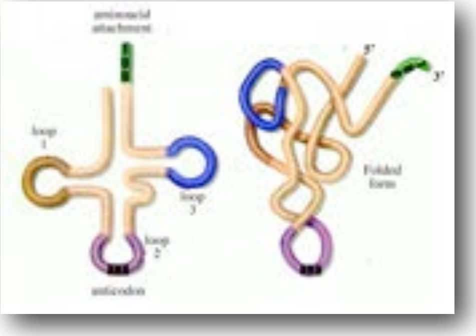
Messenger-RNA

One of the simplest is an RNA whose sole function is similar to that of digital film cassette that carries digital information from one location to a distant location. Digital information stored on a DNA strand is threes-complemented as a strand of mRNA is assembled.

Each section of DNA that is transcribed into a particular stretch of RNA is called a gene. Some genes create mRNA, others create all the other types of RNA. The mRNA is conveyed to a ribosome which then uses the digital information to assemble proteins.

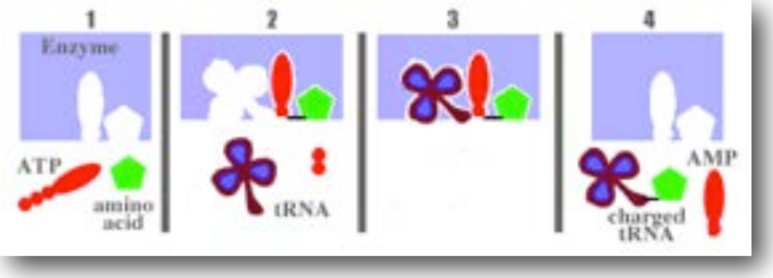
In the monomer-bacteria, the mRNA is now ready for its role in protein synthesis. In all eukaryotes—animals, plants and fungi—the mRNA is processed by another variety of RNA that excises specific, long stretches of bases, called *introns*, and only the remaining *exons* get used to assemble a protein.

Transfer RNA



The small transfer RNAs are generated by threes-complementing DNA onto RNA in the same way, except that now the strand is chopped up into the 61 varieties of tRNA. “However, many cells contain fewer than 61 types of tRNAs… A minimum of 31 tRNAs are required.”[18]

Each tRNA folds into a particular, if similar cloverleaf form, two of which we saw earlier, with three loops separated by paired-base stem sequences. Every tRNA has an identical 3’ ending sequence of 001• (cytosine, cytosine and adenine with its free hydroxyl) and each tRNA has an unpaired triplet of bases, NNN•, exposed to water called the anticodon. An adenine in the third ‘wobble’ place in the anticodon is often XSBed to an inosine, so its complement is cytosine, not uracil, XSB(NN1) = NN0. This reduces the number of essential tRNAs that must be assembled.



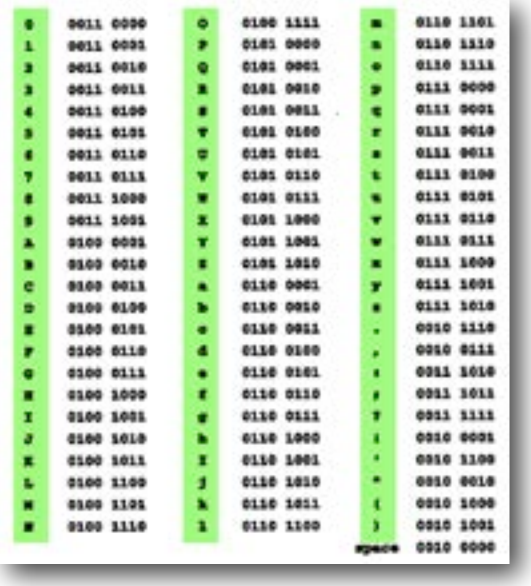
There are 20 enzymes in all living systems, one for each of the natural aminoacids, with two binding sites, one for its particular aminoacid, the other for an ATP. When both are present, the active site splits the ATP and adds AMP to the carboxyl end of an amino/imino acid. This activated aminoacid remains bound, and the protein undergoes a conformal change, creating a third binding site. The substrate that fits this site is the shape, and sometimes the anticodon as well, of a particular tRNA. Some enzymes have a binding site that can accommodate six different tRNAs. In this way, just 20 enzymes can process up to 61 different tRNAs.

When the appropriate tRNA is bound, another active site swings into action transferring the aminoacid from the AMP to the free 3'-hydroxyl on the terminal adenine of the tRNA. The tRNA is now 'charged' with an aminoacid. This linking of RNA and aminoacid is the basis for transferring DI on an RNA form to DI on a protein primary structure. This is akin to a computer transferring DI from magnetic domains on a hard drive to DI in the CPU as electric potentials in silicon gates.

Every single one of the natural aminoacids is now associated with at least one anticodon on a tRNA, serine being the champ with six different tRNAs it can be attached to. There are 64 different triplet anticodons. Three of them are are not expressed on a tRNA; they are reserved for simple commands such as *Start* and *Stop*. The other 61 are assigned an aminoacid in a 'translation table' called the Universal Triplet Code. All extant living systems use the same assignments, some with a few very minor variations.

Translation Tables

In the systematic hierarchy, the universal triplet code plays the same role in living systems as the universal ASCII code plays in computer systems. Even the earliest computers did not deal with single bits, they dealt in constant-sized blocks of multiple bits. Four bits were used at first and the block was called a nibble. This was limited in scope, and the industry quickly settled for blocks of eight bits, called a byte, as it could comfortably encode the roman alphabet. This is the '8-bit' level of sophistication in the computer systematic hierarchy.



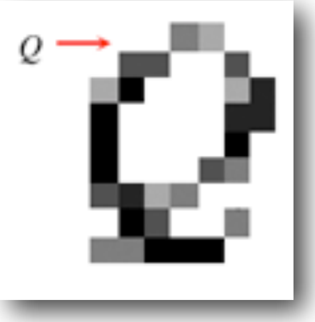
0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	i	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

Bytes and Codons

There are 2^8 different bytes, and these 256 suffice to encode the symbols on a keyboard in what is called the ASCII code. The initial 128 of these (0-127, 00000000-01111111 binary) encode a few simple commands (such as *carriage return*) and the common numbers and letters. The latter 128 bytes (128-255, 10000000-11111111 binary) encode more exotic symbols as in the illustration.

For example, when shift-A is pressed on the keyboard, the byte 1000001 (65) is sent to the computer which looks it up in a table of analog shapes. In the early days, these shapes were all 12-Courier, `which looked like this.` The analog shape A is sent to the graphic processor which displays this shape on the screen.

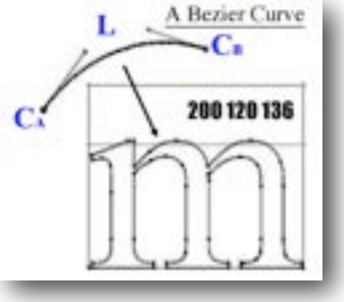
In a similar way, the digital information in living systems is manipulated in sets of three bases called a codon. There are $4^3 = 64$ different codons from 000 to 333. The codon on tRNA provides a lookup table for the elements of analog form, the aminoacids in a protein. The array of tRNAs is a translation table from digital triplets to the elemental generators of analog form, the aminoacids.



Elements of form

The simple 8-bit computers used a table of bitmapped shapes. It was useless to try to alter their size since the curves would all come out lumpy, not smooth at all.

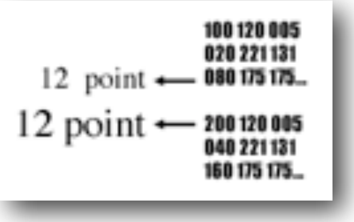
Nowadays, sophisticated systems generate the analog form of a font in any size for screen or printer by storing shape information as a set of Bezier curves; a simple mathematical length, L, plus a curvature, C, at either end.



Each relative length and two curves contributes to the overall analog shape of the letter. The letter ‘m’ in the illustration involves over 30 Bezier points separating the 30-odd curves it takes to create the analog form of a Times New Roman ‘m.’ As it takes 3 bytes to describe each curve, the letter ‘m‘ takes about 100 bytes of storage. Simple letters, like ‘c’ and ‘s’ require less information, while complex letters, such as Q and E, require more.

As each component of each curve in this scheme can have 256 different values, there are ~65,000 different Bezier curves.

If I select a block of 12-point text in the document, and tell the computer to make it 24-point, all the computer has to do is multiply the L value of each letter by 2 to generate the requested change, just the first byte is altered and 24-point type is displayed.



Amino acids are like Bezier curves in multidimensions. Each adds its contribution of curve to the final shape of the system form when folded. This is the curve to the internal wave aspect.

While there are only 20 different Bezier-amino acids, the description now involves thousands of different points, not just dozens, each contributing to the final form of the active folded protein. In the computer system, the curves are variable in length, while in the primary sequence, each amino Bezier takes up a fixed space.

The computer system takes the opposite tack to that of a living system in distribution of numbers, but the end result is the same in that a huge number of forms can be accurately described. Again, they take opposite tacks in that the Bezier curve description of the letter ‘m’ describes the form of the letter, while the aminoacid description of a glucose-binding enzyme describes the resonant complement to the glucose form and the required surrounding water structure.

	Element	Curves	Points	Length	Describes
COMPUTER SYSTEM A letter	**Bezier**	**Many**	**Few**	**Variable**	**Form**
LIVING SYSTEM A protein	**Amino acid**	**Few**	**Many**	**Fixed**	**Complement**

The Triplet Code

Each digital anticodon on a tRNA is thus linked to an aminoacid-Bezier, a tiny generator of form. All these aminoacid-Beziers, when linked in a chain, contribute to the final folded form of the protein and the wavefunction it generates to structure water and metabolism. The role of tRNA is a set of adaptors with DI-carrying nucleotides at one end and AW-generating aminoacids at the other

For historical reasons, the triplet on the tRNA is labelled an anticodon but the lookup table linking RNA and aminoacid is always given as the codon. As the digital information on a codon is the same as that on an anticodon, it does not really matter.

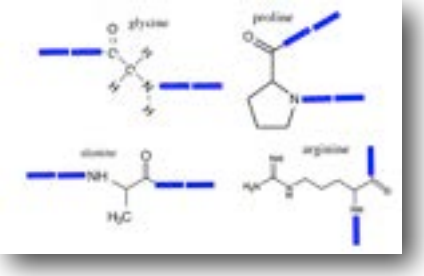
The table has the 1st-position in the codon as rows, the 2nd-position as columns, and the 3rd-‘wobble’ position at the 3’-end added to complete the 64 possible codons. Three of the codons are reserved for *Stop* command to mark the end of a chain. A methionine codon always marks the start of a chain (and is often later removed before folding).

		2ND			
		0	1	2	3
1ST	0	**000•** GLY 001• 002• 003•	010• GLU 011• 012• ASP 013•	020• VAL 021• 022• 023•	030• ALA 031• 032• 033•
	1	100• ARG 101• 102• SER 103•	110• LYS 111• 112• ASN 113•	120• MET 121• ILE 122• 123•	130• THR 131• 132• 133•
	2	200• TRP **201•** [end] 202• CYS 203•	**210•** [end] **211•** 212• TYR 213•	220• LEU 221• 222• PHE 223•	230• SER 231• 232• 233•
	3	300• ARG 301• 302• 303•	310• GLN 311• 312• HIS 313•	320• LEU 321• 322• 323•	330• PRO 331• 332• 333•

The other 61 are distributed among the 20 aminoacids. The code is mathematically *degenerate* since multiple codons are assigned the same aminoacid. There are patterns to this assignment table, one being that the 3rd position is often irrelevant, eight aminoacids have a box all to themselves, while six split a box in exactly the same way, serine doing both at once.

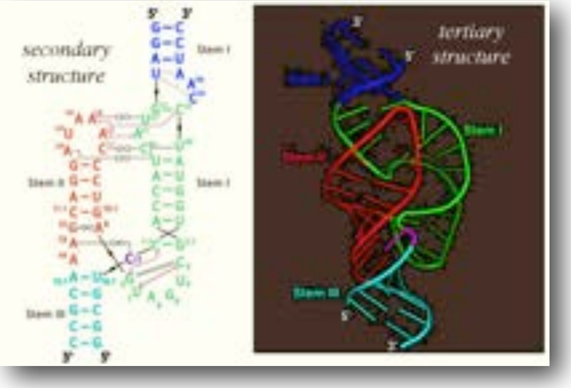
Another pattern is that when only the stronger, 3-bonded guanine and cytosine pair are in the 1st and 2nd positions, they code for two pairs of complementary 'contributions' to the analog form of a protein:

- **00N•** codes for glycine, which is a small simple amino acid with a strong tendency to participate in structures such as coils and sheets.
- **33N•** codes for its complement, proline, which is a large ring 'imino' acid that adds a distinct bend to an amino acid chain and strongly disrupts structures such as coils and sheets. Glycine and proline are a complementary pair.
- **03N•** codes for arginine, a large polar molecule with multiple H-bonding capacity.
- **30N•** codes for its complement, alanine, a small nonpolar molecule with zero H-bonding capacity.



It is such patterns of codons and properties that have convinced many that, like the 4-bit nibble that preceded the 8-bit byte in computer technology, the very earliest versions of the RNA to aminoacid was a 2-bit binary codon that preceded the 3-bit triplet codon in the sequence of steps that occurred during the origin of life.

We have now discussed two types of RNA: the mRNA is a long molecule complemented from DNA, and a set of tRNA charged with an aminoacid and marked with an anticodon triplet of exposed bases. The final RNA we need to complete the picture is the ribosomal RNA, rRNA, that brings the two together in a ribosome. This is a major example of RNA manipulating analog forms just as protein enzymes do.



Ribozymes

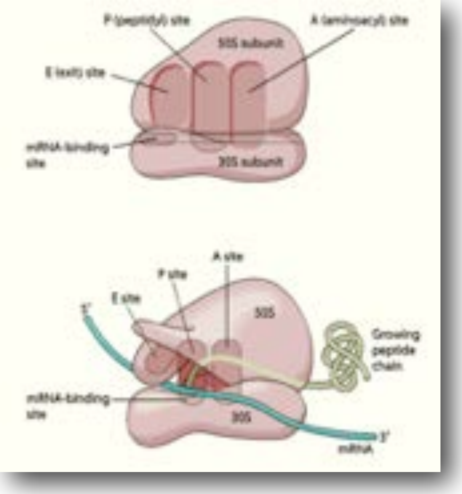
One of the reasons why it is thought that the RNA world preceded that of protein and DNA is that RNA, like protein, can generate waves that can perform many simple metabolic steps. In particular, it excels at manipulating nucleotides and nucleic acids. Unlike the specialized DNA and protein, RNA is capable of both analog and digital manipulations.

A ribozyme (from ribonucleic acid enzyme, also called RNA enzyme or catalytic RNA) is an RNA molecule possessing a well-defined tertiary structure that enables it to catalyze a chemical reaction. They can comprise one or more chains of RNA.

While this is an emerging field, it has already been established that ribozymes can: Catalyze the hydrolysis of one of their own phosphodiester bonds (self-cleaving ribozymes); Catalyze the hydrolysis of bonds in other RNAs; Catalyze the amino-transferase activity of linking aminoacids on tRNA into protein; Catalyze their own duplication and synthesis out of nucleotides.

As in a protein, the primary structure of a ribosome is the linear sequence of ribonucleotides, the secondary structure is how the chains loop and connect by complementary binding, while the tertiary structure is the final active form with its shell of water and compensating ions, usually magnesium.

Every living system has complexes of ribozymes that, with a suit of proteins as assistants, are the sites of protein synthesis. All prokaryote bacteria use the same basic ribosome for assembling proteins, while all eukaryote plants, animals and fungi use larger and more sophisticated ribosomes (except in their organelles, the mitochondria and chloroplasts, where the simpler, bacterial ribosomes are still in use. These organelles are self-contained and their duplication is kept quite separate from that of the rest of the eukaryote cell.

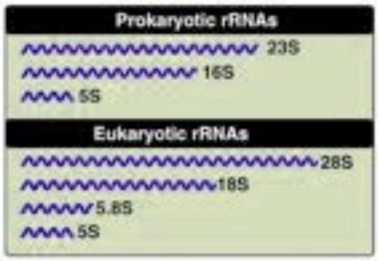


Ribosome

The ribosome is a complex of ribozymes that do all the chemical manipulations that turn the digital instructions on mRNA into the primary structure of proteins. The ribozymes are assisted by a dozen or so proteins that tune the ribozyme activity.

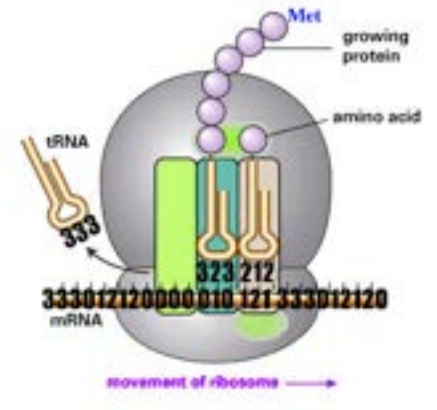
The rRNA is complemented from DNA, processed, and assembled into two complexes of different sizes. These two unite around a mRNA at the starting methionine codon.

The rRNAs in prokaryote vital units and eukaryote vital molecules are similar in size, with the latter augmented with an extra RNA.



The larger subunit has three active sites: the A site binds loaded-tRNA, The P site binds the previous tRNA with the attached growing peptide, and the E site where the now-unloaded tRNA ends up and is ejected for reloading. The smaller subunit has one site where mRNA is bound.

The subunits bind and unite at the required methionine codon at the 5’-end of an mRNA. The ribosome then behaves as a complicated machine that has a repetitive clockwork-like mechanism. The mRNA is ratcheted through one triplet codon at a time, the mechanism being powered by GTP, rather than the more usual ATP. A t-RNA with an anticodon that matches the newly-exposed codon is bound. The aminoacid chain is split from its tRNA and linked to the new aminoacid. The old tRNA is released to be recharged by its enzyme.

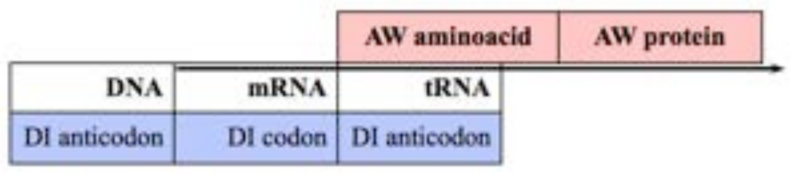


Stripped of its time element, the ribosome aligns the codons on the mRNA with anticodons on the loaded-tRNA and then links the aminoacid chain together. This is basically how the digital information on RNA is transformed to digital information as the primary sequence of aminoacid-Bezier wave generators.

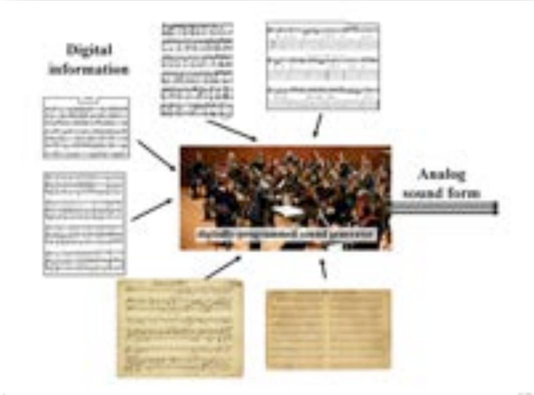
The ribosomal RNA links all the aminoacid-Bezier AW generators into an aminoacid chain. The linear chain of aminoacids is liberated when one of the *End* codons is encountered. While the analog form of the *Start* Met-codon is necessary for the assembling of the two rRNA subunits together on the mRNA, the analog form of the *End* codons is antithetical and the two subunits dissociate and go their separate ways.

The linear combination of all the aminoacid-Beziers gives a specific form to the wavefunction of the ground state. The chain shakes off energy and folds, as discussed, into the final active form specified by the ground state.

This is the manipulation of DI by RNA reading it from memory on DNA and converting it into an AW to join the harmony prevailing in the vital unit. From DNA to mRNA to an array of tRNAs, the flow is DI that switches from codon to anticodon at each step. The array of adaptor tRNAs is also an array of Bezier AW simple generators. These are linked into a primary structure which folds into a protein AW generator that structures water and substrates.

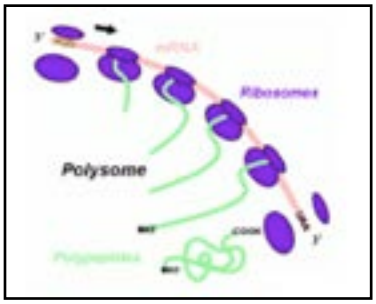


		AW aminoacid	AW protein
DNA	mRNA	tRNA	
DI anticodon	DI codon	DI anticodon	

The digital score has become analog music. Other than requiring the initial Met-codon, the ribosome is indifferent to the sequence on the mRNA or what protein it is making. A human ribosome will freely translate mRNA from a bacteria, a radish, or an extinct dinosaur, into bacterial, radish, or dinosaur protein.

Programmed Generator

In a symphony orchestra, an instrument such as a piano can produce any music at all. A piano is a universal analog wave generator, and the actual waves it generates are digitally-programmed depending on what musical score it is supplied with.

In living systems, the analogue to the musical instrument is the ribosome that does all the manipulations to turn a digital mRNA into a protein, a ‘note.’ It is a universal generator and will turn any stretch of mRNA into protein. This structure was also inherited from the Logos before the basic living system emerged and has changed little over 3 billion year



Many ribosomes can be at work on the same mRNA, following each other at a short distance, in what is called a polysome. In this way, thousands of a particular protein can be made from just one mRNA. The mRNA has a set lifetime, however, as enzymes that hydrolyze mRNA patrol the cell and are constantly reducing the mRNA population. The turnover of mRNA is such that the ‘score’ being played can be changed in minutes.

A single mRNA molecule can give rise to over 100 identical proteins, all of them generating the same wave. This number of proteins is quite sufficient, recalling the abilities of gelatin, to completely alter the wave in a vital unit.

This is exemplified by the bacteriophages, the viruses that need bacteria to multiply in. When a single molecule of virus RNA is injected into a bacterium, within minutes all the resources of the vital unit are redirected into constructing new virus particles. A single molecule of viral RNA can control the symphony being played in a vital unit, and this applies to the natural state as well as pathological states.

In summary, this is the way that digital information as DNA is transformed into analog waves structuring a vital unit, and so determines the interactions that it is capable of. This is exactly what happens when a CD player reads digital information as a series of reflective pits on the CD (the DNA) and outputs a DC current that is either on or off, read as a sequence of bytes of binary information (the mRNA). The adaptor is a DC/AC transformer (the tRNA) that takes a binary number and converts its value into a voltage, Vt, at that moment (the amino acid) that drives the amplifier for the loudspeaker (the protein) that generates the analog sound wave. The sampling rate determines how long each Vt lasts—a 1/1,000th of a second is not unusual—and this gritty voltage that drives the loudspeaker is blurred into a smooth-sounding wave by the inertia of the loudspeaker membrane.

This flow of DI to AW is called the ‘reading’ of stored digital information.

$$\boxed{\begin{array}{l} DI_{DNA} \xrightarrow{READING} DI_{codon\ \ mRNA} \longrightarrow DI_{tRNA} \longrightarrow AW_{aa} \longrightarrow AW_{protein} \\ DI_{CD} \xrightarrow{READING} DI_{DC\ \ byte} \longrightarrow DI_{DC/AC} \longrightarrow AW_{Vt} \longrightarrow AW_{\mathrm{loudspeaker}} \end{array}}$$

The reading direction, from DNA to protein, is reasonably well understood and is foundation for the next level of sophistication in the hierarchy of life, the level that is the object of study in genetics.

UNIFIED GENETICS

I live in a society where the question, “Did you back it up?” is usually a portent of disaster. Our whole digital technology is based not only on the reading of DI but also on the writing of DI in the reverse direction. Analog form is converted into digital information and stored. This is the writing direction from analog form to digital information.

The process of turning the glorious analog form of a Beethoven symphony into the linear pits that give CDs their particular rainbow shine is basically just the reverse of of the reading process.

Analog waves have a property that is utterly absent in digital information. Analog waves are holographic, the structure of the wave is nonlocal, and a small sample is all that is needed to comprehend the entire wave. This is obviously not the case for digital.

The structured air in a symphony hall is immense compared to the area of an eardrum, yet this tiny sample of the wave is all that is required to appreciate the performance. Just like the eardrum, the sensor in a microphone takes a tiny sample of the wave and turns the analog pressure-wave in time into an analog electric current which is input to an AC/DC converter.

The AC/DC converter measures the amplitude of this wave, which can be plus or minus, each moment at the sampling rate. This measure is output as a binary number byte. The linear stream of binary bytes is written onto the master CD as a stream of linear pits in the surface.

$$\boxed{\begin{array}{l} DI_{CD} \xleftarrow{WRITING} DI_{DC\ \ byte} \longleftarrow DI_{AC/DC} \longleftarrow AW_{Vt} \longleftarrow AW_{\mathrm{microphone}} \\ DI_{CD} \xrightarrow{READING} DI_{DC\ \ byte} \longrightarrow DI_{DC/AC} \longrightarrow AW_{Vt} \longrightarrow AW_{\mathrm{loudspeaker}} \end{array}}$$

The master CD can then be duplicated for distribution. The writing operation is not just for long-term, unchanging DI; it is also used for short-term, changeable DI manipulation. An example is the writing of the manuscript on a MacBook Pro.

As you will have probably noticed, I revel in illustrations, diagrams, graphs, etc. These are created on a small suite of programs: *Safari* for googling, *Adobe Elements* for diagrams, *Grapher* for graphs, *Magic Number* for calculations, and *MathType* for equations. When I am working, these programs with their multiple windows, plus Mail and WiFi, are all running at the same time, creating a digital structure that is many gigabytes in size. I use Apple *Pages* to assemble all these disparate elements together, and it remembers what I have done so I can backtrack at any time. This enormous structure of digital information is written to the hard drive as a temporary file, as short-term memory.

I can jump easily from one part of the digital structure to another. The CPU just calls up that section of DI from active memory on the hard drive into its working memory on its silicon registers, replacing what was there. If I switch from *Pages* to *Elements*, the appropriate part of the DI structure is read into active memory. I now draw a circle filled with the red. The changes I make are sent to the graphic processor for display, and also written to the hard drive, updating the virtual image on the disk. Everything I alter is displayed and written to active memory.

In the old days, a dog knocking the electric plug out of its socket, plunging the screen to blankness, would be a disaster. But not for a modern Mac. It restarts, and one by one, starting with the *Finder*, all the programs reload with all their windows just as they were before the crash.

Other examples could be given, but the main point is that the Writing operation—AW to DI—is just as important as is the Reading operation—DI to AW—in our sophisticated manipulation of digital information in this computer/Web world.

FUNDAMENTAL DOGMA

Knowing what we know about how digital information and analog wave are bi-directional in modern technology, it is surprising that the foundations of classical genetics *embrace the Reading direction but totally reject the Writing direction*. This rejection is known as the Fundamental Dogma of Genetics, which states that information only flows from genotype (DI on DNA) to phenotype protein (AW as bodily form), never from phenotype to genotype.

In this view, where ‘writing to disk’ is not allowed, the only way that DI in the DNA can ever change is by random, accidental mutations—alterations in the physical DNA that randomly alter the DI. Such mutations can be as simple as a single base being changed by a copying error (the probability of which is very low, but not zero) or a radioactive carbon detonating or as complex as whole sections of DNA being duplicated, flipped, or moving from one location to another.

These random changes in the physical DNA—like running a magnet over a hard drive—can radically alter the DI in the genotype. This is reflected in alterations in the analog wave, alteration in the phenotype. These new phenotypes are sorted out by ‘natural selection’, i.e., those that fit well in the world around them get to flourish and multiply, while those that do not fit well simply perish and disappear.

This foundation of read-only classical genetics is called the modern synthesis of Darwinism and molecular biology. I know it sounds weird in our digital age, but that is the nub of modern evolutionary thinking.

Reading and Writing

As any programmer working on the iPhone will affirm, this is not an efficient way to work with digital information. You need to have the writing direction down first, then the reading direction. A unified genetics will have a biochemistry that links the analog wave of life, in all its diversity of forms recalled from the digital information on the DNA, with a Write direction as well as the Read direction, and the Write coming before the read.

Taking a lesson from CD technology, we would expect that, if there was a writing direction, then it would look similar to the reading direction in reverse.

One such reverse section of the reading process in living systems is already well-established. The enzyme *transcriptase* complements a DNA strand to assemble an RNA strand, while the aptly-named enzyme *reverse transcriptase* complements a strand of RNA to assemble a strand of DNA (which can be complemented to form a double-helix).

$$DI_{DNA} \xleftarrow{\text{reverse transcriptase}} DI_{RNA} \longleftarrow DI_{tRNA} \longleftarrow AW_{aa} \longleftarrow AW_{\text{protein}}$$

$$DI_{DNA} \xrightarrow{\text{transcriptase}} DI_{RNA} \longrightarrow DI_{tRNA} \longrightarrow AW_{aa} \longrightarrow AW_{protein}$$

Transcription:

In transcription, under the control of an enzyme complex, a double helix stretch of DNA is unwound and one strand is used to assemble a complementary strand. The only difference to DNA copying being that ribo-, not deoxyribo-, nucleotides are linked together in the sugar-phosphate backbone. Only one of the strands, the *reading strand*, is transcribed by the enzyme.

This 'messenger RNA' (mRNA) then departs from the DNA and the helix reforms.

Reverse Transcription:

In transcription, DNA is used to make RNA. In reverse transcription, under the control of a *reverse transcriptase* enzyme, a stretch of RNA is used to make a complementary strand of DNA. This DNA is then complemented, as in duplication, and a DNA double helix is formed. The study of this process is still in its infancy, as is an understanding of the function of the ~60,000 *reverse transcriptase-like* genes found in the human genome.

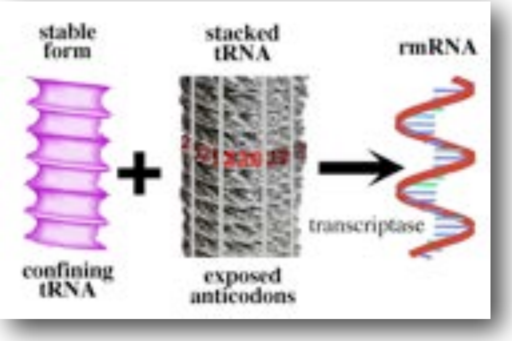
Once in DNA, the DI can be passed on down a lineage (with a little tweaking) through deep time. The illustration, for instance, is the primary structure of the same core housekeeping protein found in all contemporary living systems whose lineages diverged billions of years ago. Yet, the DI for the primary sequence on DNA has hardly altered in all that time. This is an example of cellular long term memory; i.e., once something is truly learned, it is never forgotten.

HUMAN	DAPGHRDFIKNMITGTSQADCAVLIV
TOMATO	DAPGHRDFIKNMITGTSQADCAVLII
YEAST	DAPGHRDFIKNMITGTSQADCAILII
ARCHAEA	DAPGHRDIVKNMITGASQADAAILVV
BACTERIA	DCPGHADYVKNMITGAAQMDGAILVV

THE CONSERVED AMINO ACIDS HAVE NOT CHANGED IN 3 BILLION YEARS

Reverse mRNA?

What is not known is whether a stable linear array of tRNA anticodons can be used to assemble a linear sequence of codons on a single RNA.



A stable array of tRNAs in a straight line is obviously impractical, but how about the possibility of spiraling around in a stacked helix of tRNAs with ends pointing to the central axis and the anticodons exposed on the outside in a linear spiral?

Starting at one end, a transcriptase can move along the spiral assembling a single reverse-mRNA that is the complement of the tRNA spiral.

Information about the analog form that is confining the tRNA into the helix is now converted to linear digital information on an rmRNA.

Such a situation would add a second section to the Write operation that is also a reverse of the Read operation.

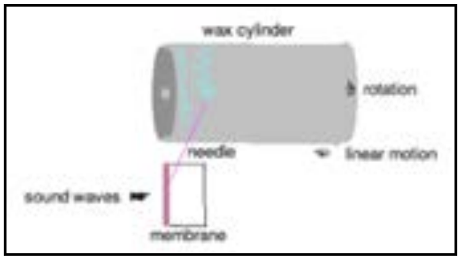
$$\begin{tikzcd}
DI_{DNA} & DI_{RNA} \arrow[l, "write"'] & DI_{tRNA} \arrow[l] & AW_{?} \arrow[l] & AW_{?} \arrow[l] \\
DI_{DNA} \arrow[r, "read"] & DI_{RNA} \arrow[r] & DI_{tRNA} \arrow[r] & AW_{aa} \arrow[r] & AW_{protein}
\end{tikzcd}$$

If this is so, we need an analog form that provides the stable confinement of tRNA while being complemented.

Sampling the wave

In the example we used from technology, it was not an entire wave that was involved, just a sample. Due to the holographic nature of waves, this sample reflected the entire wave.

The great American inventor, Edison, was the first to exploit this aspect of waves and put it to practical use when he invented the first method of sound recording. The method involved a thin membrane that moved back a forth with the change in air pressure. This vibration of the membrane was the sample of the wave in the air. Attached to this membrane was a light needle that made a scratch on a wax-coated cylinder.



This cylinder was put into two motions. It rotated at a moderate, constant speed, and it also moved slowly from left to right. In quiet air, the needle inscribed a smooth helix about the cylinder. Placed in the room with a resonating tuning fork, the needle scratched out a sine wave in the wax.

The wave on wax was transformed into a wave on metal and the system was then run in reverse. The wavy scratch on the metal drum was rotated and a needle was placed at the start of the wave. The needle was attached to a membrane that vibrated as the metal wave passed under the needle. A sound wave was generated.

In this purely analog-analog situation, the writing process samples a wave in 3-D air changing with time, into a 1-D wave in wax changing with distance along a line. The reading process just reverses the steps, converting the wave in wax into a wave in air.

The waves in a vital unit are not structuring pressure but the spatial structure of water and metabolites. The most important of these is the water structure standing wave followed a close second by the structuring of ATP and other core metabolites.

What we require for an AW to DI converter is a structure that can sample these important waves and convert them into DI about the wave. This requires an adaptor RNA that has both analog and digital ‘ends,’ the reverse of the Read direction, where a loaded tRNA has an analog end in the attached aminoacid. As aminoacids are not involved, to make the scenario plausible, we will need to examine some of the less well-known types of RNA to see if any have an analog side to them.

Types of RNA

Almost every week a new type of RNA is discovered with a new set of properties to add to the dozens of RNA types already uncovered. This is a list of some of the recently established varieties of RNA. Only the first three (unshaded) are included in the classical 'read-only' worldview of read-only Darwinism, as eloquently propagated by Richard Dawkins *et al*.

mRNA	Codes for protein	srpRNA	Membrane integration
rRNA	Translates mRNA	snoRNA	Base modification
tRNA	Link to aminoacids	smyRNA	mRNA splicing
miRNA	Gene regulation	teloRNA	Telomeres on DNA
piRNA	Chromosome stability	siRNA	Gene regulation
gRNA	mRNA modification	xistRNA	Chromosome inactivation
rnpRNA	tRNA maturation	aRNA	mRNA translation
yRNA	DNA replication	lncRNA	various

For some time, it has been known that RNA information is easily written into DNA information by the activity of *reverse transcriptase* enzyme (RT), but this was thought to be significant only for RNA 'retroviruses' such as HIV. This insignificant role for RT in living systems made it difficult to account for the 500,000 or so different variants of RT found in the human genome. Richard Dawkins discounted this as yet more Junk DNA—affirming this at a time when it is now known that this DNA, which is never translated into protein structure, is transcribed into RNA at low, but significant rates unnoticeable by earlier, cruder methods.

If Writing of digital information has a role in unified molecular genetics, we can expect that these 500,000 versions of RT have 500,000 different roles and are also transcribed at a rate currently below detection.

One variety of RNA called *small interfering* RNA (siRNA) is double stranded—two RNA chains locked together as in DNA—and is used by genetic engineers to silence genes..

Yet another variety of RNA that is only now being explored is *long noncoding* RNA (lncRNA), which must be a contender for the RNA CPU manipulating digital information since it has such a wide gamut of activities:

> Evidence has accumulated showing that (lncRNA) play a significant role in a wide variety of important biological processes, including transcription, splicing, translation, protein localization, cellular structure integrity, imprinting, cell cycle and apoptosis, stem cell pluripotency and reprogramming, and heat shock response.[19]

Riboswitches

To conclude, one new type of RNA activity has only recently been documented that fits the requirements for an AW to DI connector, i.e., the *riboswitch* RNA.

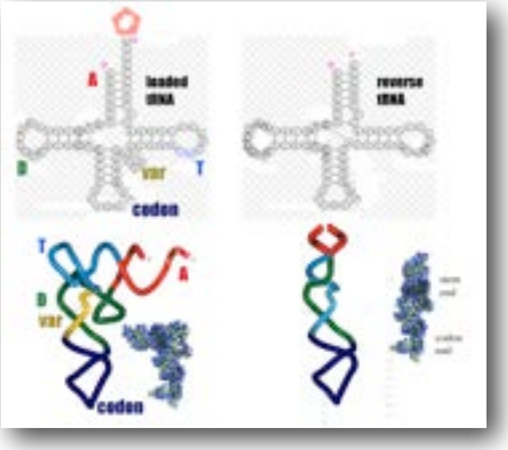
This is a type of RNA that structures water and has a binding site for a substrate. This RNA generates a wave that attracts and binds its substrate in a nonlocal way just as a protein enzyme does. Just like an enzyme, a riboswitch flips its form when the substrate is bound, causing a conformal change in anything it is attached to:

> Riboswitches bind cellular metabolites and control gene expression: Segments of RNA, typically embedded within the 5'-untranslated region of a vast number of mRNA molecules, have a profound effect on gene expression through a previously-undiscovered mechanism that does not involve the participation of proteins. In many cases, riboswitches change their folded structure in response to environmental conditions (e.g. ambient temperature or concentrations of specific metabolites), and the structural change controls the translation or stability of the mRNA in which the riboswitch is embedded. In this way, gene expression can be dramatically regulated at the post-transcriptional level.[20]

This riboswitch ‘sampling’ of the wave in vital units is an area of research that has opened a door to a heretofore unexpected field of study connecting analog form with digital information. Much has been established about what happens, much is yet to be learned about how it happens:

> Riboswitches are structures that form in mRNA and regulate gene expression in bacteria. Unlike other known RNA regulatory structures, they are directly bound by small ligands. The mechanism by which gene expression is regulated involves the formation of alternative structures that, in the repressing conformation, cause premature termination of transcription or inhibition of translation initiation. Riboswitches regulate several metabolic pathways including the biosynthesis of vitamins (e.g. riboflavin, thiamin and cobalamin) and the metabolism of methionine, lysine and purines. Candidate riboswitches have also been observed in archaea and eukaryotes. The taxonomic diversity of genomes containing riboswitches and the diversity of molecular mechanisms of regulation, in addition to the fact that direct interaction of riboswitches with their effectors does not require additional factors, suggest that riboswitches represent one of the oldest regulatory systems.[21]

This generation of precisely folded forms in water solution is exactly like those generated by Bezier-aminoacids in a protein, except now there is Bezier-RNA generating the wave. So, an assemblage of RNAs resonating in the wave of the vital unit is not at all impossible.



My candidate for such an RNA, seeing that aminoacids are not involved, is a variant of the tRNAs, a variant that preceded the familiar ones. All tRNAs have the same basic form, a perfectly symmetrical cloverleaf tuning fork that is just what might be expected of a good resonator except for the variable section, a kink that spoils the symmetry about the codon and stem.

Before the tRNAs appeared, they could have been preceded by a set of RNAs without the kink. The 3’-triplet for adding an amino acid could be absent but a new internal adenine-uracil bond could be added, straightening the final shape, which is estimated in the illustration. This symmetrical shape is just what a good resonator should look like, a tuning fork. Such a molecule of reverse transfer-RNA (rtRNA), would resonate with analog waves as well as carrying a digital byte of information and could well stack into a form with the codons linearly arranged on the outside for a transcriptase to move along.

Unfortunately, I do not find such an RNA with google, and do not have a well-equipped laboratory. The number of such rt-RNA molecules would be expected to be small, just a few of each kind in an aggregate.

There may be a few of such aggregates, for as we know from our technological transition from mono to stereo, just two sensors taking their samples collects another level of analog information, such as phase difference. Two microphones are used to sample the analog air wave, one left of center, the other to the right. The analog wave from the left is converted into a binary stream, as is that from the right, at the sampling rate. The two streams of binary digits is merged into a single stream—a computer has no problem separating them if the first digit and subsequent odd bits are the left channel, the second and all even bits the right channel.

When the separated channels are converted into analog current that drives a loudspeaker on the left and one on the right, the recreated sound wave in the lounge is a lot more like the original sound in the concert hall. So we can expect at least two stacks of r/tRNA sampling the wave in a vital unit, perhaps even more channels for 3-D wave samples. Even so, the numbers of reverse transfer RNA molecules can be expected to be small. I shall try to keep up with RNA and see what emerges in the literature. Leaving this to basic research, we turn to looking at what use such an AW to DI adaptor-RNA could be put to.

State Sensor

In our picture of a vital unit, a minimal living system, we have a large number of water molecules that are resonating to the unified standing wave generated by the small number of proteins. In terms used in physics, there is a ‘water field’ with a value for the local ‘ice-like’ structure of the water molecules.

Almost all vital units are in thermal equilibrium with the physical environment and are subject to change in temperature with the weather. The ice-like structuring of water is sensitive to temperature, and the water-wave of a vital unit is sensitive to temperature. A sensor that provided a digital readout of this would be a most useful input to the RNA for digital output that determines the state of the vital unit. In those animal vital units that are kept at a constant temperature, the water-wave would not change with temperature, a drone note that anchors every chord like that of a bagpipe.

Every protein generates its particular water ‘note’ to contribute to the symphony. Many proteins also generate from a binding site a wave for ATP to resonate with and bind with. All these harmonize in a standing wave that resonates with ATP, and there is a constant ATP-field as well as a water field. In the symphony analogy, the water wave is like the percussion section setting the basic beat, while the string section is the ATP wave that dominates the melody. A sensor that generated a digital output about the state of this ATP standing wave would also be a useful input to the digital processing that controls the state of the vital unit.

It is estimated that in a bacteria growing and multiplying in an abundant environment, there are ~1,000 different metabolites being processed in the vital cell.[22] Each and every one of these 1,000 metabolites has its own field—i.e., the orchestra is composed of 1,000 different types of instruments. The state of some is more significant than others; they dominate the melody, so to speak. The water and ATP standing waves are examples of such major fields. The NAD and pyruvate fields are also major fields, as are others.

Sensors that generated a digital output about the state of all these major fields would also be useful in managing the state of the cell.

In our discussion so far we have dealt with the water in living systems as if it was plain. It is not. The water in each and every vital unit has a concentration of ions in it—simple atoms or molecules with an electric charge. The pH is a measure of the ratio of OH^- / H^+ concentrations, and the pH of the water is strictly maintained. In eukaryotes this is 7.4, a small preponderance of hydroxyl and slightly alkaline. The concentration of the other ions is always strictly controlled and, as in the case of calcium ions, is sometimes altered as a global signal for change in the state of the vital unit. In an animal, for instance, the concentration inside the cell is lower than that outside, except for potassium which is the reverse. Note that calcium is rigorously excluded from animal cells.

Ion	Inside	Outside
K^+	139	4
Na^+	12	145
Cl^-	4	116
HCO_3^-	12	29
Mg^+	0.8	1.5
Ca^+	0.0001	1.8
PO_4	1	0.9

Proteins not only structure water with the wave they generate, they also structure the ions. There is a field for each ion, and the phosphate level is known to be a major one: “Cellular metabolism depends on the appropriate concentration of intracellular inorganic phosphate (Pi). Pi starvation-responsive genes appear to be involved in multiple metabolic pathways, implying a complex Pi regulation system in microorganisms and plants.”[23] A digital sensor for this can be added to the list.

On a personal note, after studying biochemistry at Sussex University, I was a scientist with Eli Lilly looking into the antihistamine-resistant side of asthma. As this was basic research, I delved into the second-messenger role of cyclic adenosine monophosphate (cAMP) and its guanosine-analogue, cGMP. They seemed to have complementary actions, in many situations where cAMP did something when raised in concentration, then cGMP did the same when lowered in concentration, and vice versa.

These two small molecules have a global effect on metabolism that is as drastic as an influx calcium. RNA is known to be sensitive to them both, and a digital sensor for cAMP and cGMP can also be added to the list of major fields that are monitored by digital sensors.

Analysis of wave

The human ear converts an analog sound wave into a digital stream, but it does so in quite a different way than our technology. We have seen how simple waves, sines and cosines, can be combined to form every other wave, even a sharp sawtooth.

It was Fourier who made this mathematically-sound by proving that this equation could describe any wave to an accuracy, limited only by the number of included terms.

$$AW = a\sin 1x + b\sin 2x + c\sin 3x \ldots + q\sin 100x + \ldots$$

Each sensor in the ear is tuned to resonate with only one of these component waves, say sin(100x), and the strength of its resonance is a measure of the amount of the sin(100) wave, the coefficient, Q.

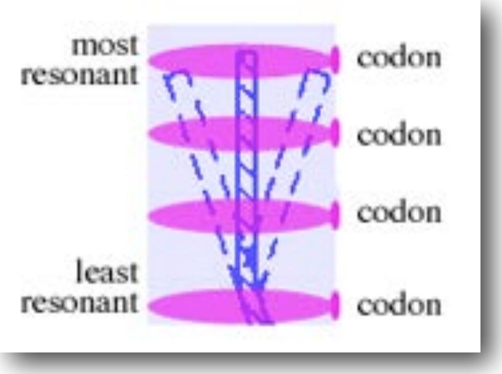
The sensor has a dedicated line to the brain along which only information about the sin(100) is ever transmitted. The digital representation of the number Q is sent down the line to be received as digital information about sin(100x).

Each sensor is tuned to a different component, so the brain receives in massively-parallel form a current Fourier Transform of the current analog sound wave. The brain puts the sines back together and we hear the music, not a lot of sine waves.

$$a\sin 1x + b\sin 2x + c\sin 3x \ldots + q\sin 100x + \ldots \ = \text{Music}$$

The slightly different folded forms of the putative r/tRNAs are tuned so that they also perform the equivalent of a Fourier Transform on the sampled wave of a vital unit. One is responsive to the water-field, others to all the major fields, ATP, NAD, phosphate, etc.

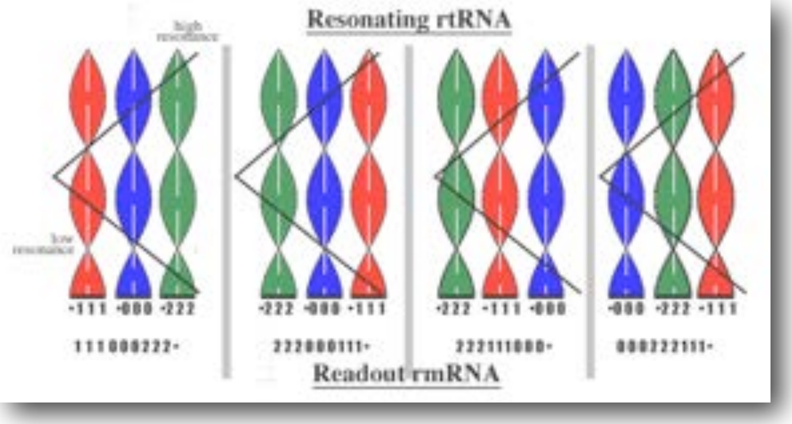
The amount of resonance each sensor has in its field determines its position in the resonating stack of r/tRNA, most resonant at one end, least at the other.



A reverse mRNA transcribed from this would be a digital report about the state of the vital unit that is perfect for input to an IF/ELSE digital processing decision. This aspect of RNA is only now beginning to be explored, so we will need to fall back on an illustration of how such a digital sensor could influence a vital unit.

Recalling memory

To illustrate the possibilities of digital sensors, we shall use a system of just three sensors, colored according to the wave they resonate with. The blue RNA sensor with anticodon •000 resonates with the fundamental water field and provides the basic reference point. The red sensor with •111 resonates with the cAMP field, while the green sensor with •222 resonates with the cGMP field.



The three sensors resonating with their fields in a vital unit will arrange themselves in order from least resonant to most resonant, and the transcriptase will then create a rmRNA with the anticodons as templates.

There are four possibilities we will consider in relation to the water sensor:

1. Red cAMP is less and green cGMP is greater than the water resonance.

The rmRNA is 111000222•

2. Red cAMP is greater and green cGMP is less than the water resonance.

The rmRNA is 222000111•

3. Both are less than the water resonance.

The rmRNA is 222111000•

4. Both are greater than the water resonance.

The rmRNA is 000222111•

a. 111000222•
b. 222000111•
c. 222111000•
d. 000222111•

There are four different outputs (ignoring the other possible two for the moment) that the digital output can be.

The digital sensors have an output of DI on ‘readout’ RNA that reflects the state of the wave in the vital unit. This DI can then be an input to IF/ELSE digital computing.

In a simple computer before the days of point-and-click, a crude calculator program would display a screen of choices and wait for an input from the keyboard, a port into the computer, which is assigned to the variable X.

The CPU of the computer runs a simple MS Basic routine that calls upon four different subroutines depending on the value of the variable. The computer ignores any key that is not 1, 2, 3, or 4 and just waits as it constantly scans the digital input for

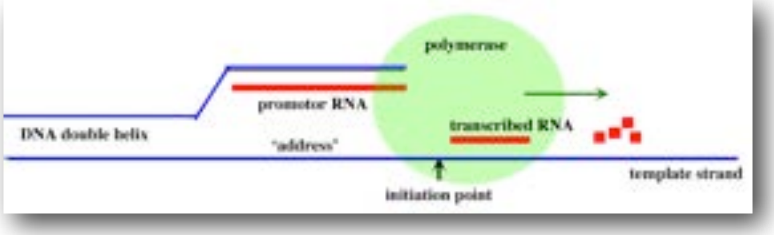
```
Press
1 to add
2 to subtract
3 to multiply
4 to divide
```

a match. If there is one, the CPU looks up the physical address of the DI on the hard drive and reads it into active memory.

Each segment on a hard drive is numbered, and this number is the physical address of the DI stored in that segment. The RUN command in the above program is an instruction to look up in a table the physical address of the named programs, copy the DI stored at that location on the hard drive into active memory, and then follow its instructions.

```
IF     X = 1 RUN ADD
ELSEIF X = 2 RUN SUB
ELSEIF X = 2 RUN MUL
ELSEIF X = 3 RUN DIV
RETURN
```

Naturally enough, living systems do not use MS Basic for such IF/ELSE processing but RNA does use a similar set of addresses for processing. The DI on DNA has a digital address in the promoter region that precedes each segment of DNA that is to be transcribed into RNA. The RNA polymerase binds to this *promoter* region with a strand of RNA that is complementary to that promotor region. With this complementary strand, the polymerase binds to the promoter and then initiates the assembly of RNA at the initiation site.



This complementary strand binds to the promoter sequence on the nontemplate strand, so the ‘address’ on the template DNA is the same as on the strand.

In our simple vital unit there are four stretches of DNA storage, each with a digital address. In the vital unit, each of these four stretches codes for a single mRNA that can profoundly alter the state of the vital unit. We have already seen in the viruses, that a single RNA molecule can suborn the mechanism of the vital unit into making more viruses.

The DI is only read from the DNA onto RNA, however, when the readout rmRNA binds to the promoter address—they are threes-complements of each other.

1. In times of abundance, both the cAMP and cGMP sensors are less resonant than the water and the readout RNA is 222111000•. This binds to the address •222111000 and the polymerase binds and the mRNA transcribed. This is the program *GrowMultiply* that generates the analog wave of growing and multiplying.
2. Bacteria excrete a small amount of cAMP. When they are close together, the external cAMP level soars and this alters the internal cAMP. The cAMP resonator is now greater than the water. The readout RNA is 222000111• and the address it binds to is •222000111. The mRNA transcribed is the program *Colony* that generates the analog wave of uniting as a characteristic colony.

•111000222 --- Search
•222000111 --- Colony
•222111000 --- GrowMultiply
•000222111 --- Spore

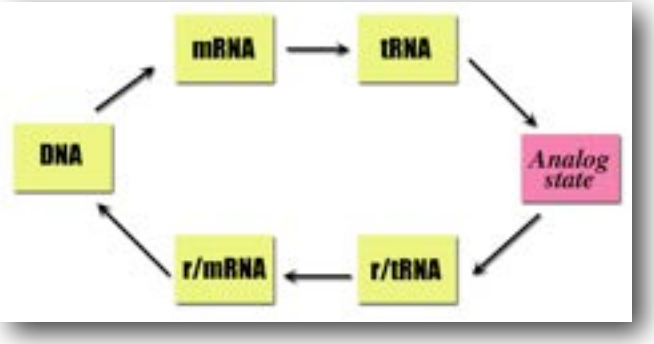
3. When food is getting scarce, the cGMP alters and the sensor is greater than water. The readout is 111000222• and the called address is •111000222. The mRNA transcribed is the program *Search* that generates an analog

wave that channels resources into motility.

4. When there is famine, both the cAMP and cGMP fields cause more resonance than water in the sensor. The readout is 000222111• and this binds with address • 000222111, and the transcribed mRNA is the *Spore* program; the vital unit shuts down.

Feedback loop

Earlier, we described how the digital output of DI in the Read direction as mRNA determined the overall standing wave of the vital unit, its state. To this we can add a suggested feedback in digital form of the state of the vital unit. Digital information about the cell moves in the Write direction, from r/tRNA to rmRNA to DNA to determine what is transcribed as mRNA.



We can refer to all DNA that has such an address as the digital ‘repertoire’ of a vital unit. Only DNA that has an address can be transcribed into RNA, although the address itself is not transcribed into RNA. Very complex systems, such as eukaryote cell, have a great deal of DNA involved in these addresses that is not transcribed, and is probably part of what used to be called ‘junk’ DNA.

The repertoire includes all the DNA that is called on to make protein as well as DNA that is called on to assemble all the other types of RNA involved in calling up subroutines and the like.

Challenge and response

In our simple illustration using a triple sensor, there were two possible digital readouts that we did not assign a match on the DNA. What happens if these unassigned rmRNAs are the digital readout. Here we encounter the basic level in the systematic hierarchy of learning and memory.

a. 111222000•
b. 000111222•

If a readout rmRNA does not find a match, it is copied by RT into a blank address to store the result of the learning process that follows. The vital unit now calls up, in order, on its digital repertoire to see if it is a useful response to the input.

In the case where both cAMP and cGMA were less than the water but their order is reversed, copying the *GrowMultiply* program into the blank address and transcribing the DNA works just fine, so the *GrowMultiply* program is now called up when the cAMP and cGMP are both less than the water sensor.

In the final unassigned readout, both cAMP and cGMP sensors are greater than water. This rmRNA is copied into DNA and the orderly exploration of the repertoire begins as the overall state falls below optimum. The *GrowMultiply* program fails, as does *Search* because the bacterium is caught in a matrix and cannot move. Before the last resort of *Spore* is called upon, the vital unit can start mixing and matching some of its subroutines, the protein modules it has available.

Proteins are modular assemblies. The same module is found in many different proteins and performs the same way. Many proteins, for instance, have a module that binds ATP with very similar primary sequences. This ATP module is in a string with other modules on the mRNA for the entire protein. When the module splits an ATP, its conformal change is transmitted to another module to drive an energy-absorbing catalytic change to the substrate of another module.

This ATP module appears in many other enzymes driving a host of very different reactions. New proteins can be generated by mixing modules, and simply requires tacking their mRNA together and copying it back to DNA.

Let us return to our stressed-out vital unit with its blank address. The vital unit now assembles new combinations of modules to see if it can bring things back to normal. The mRNA for the modules is copied into the DNA at the blank address, and its single mRNA transcribed and translated into protein.

One of the proteins it generates by mixing modules raises the normally low rate of digestive enzyme export. These convert the large molecules of the restraining matrix into small food monomers and the vital unit springs back to health, the cyclic nucleotides fall, and the *GrowMultiply* program restarts.

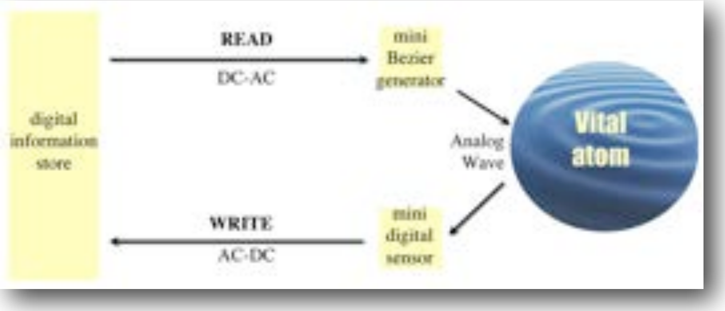
The vital unit has now learned a lesson. It has gained a bit of wisdom about how to handle this situation when it occurs. The sequence of modules that did the trick is now the program *Digest* with an address on the DNA that matches the readout RNA when both cyclic nucleotides sensors resonate more than the water sensor.

The repertoire of responses with a three-field RNA sensor has now expanded. This is basically how the store of digital wisdom is expanded.

a. •111000222 --- Search
b. •222000111 --- Colony
c. •222111000 --- GrowMultiply
d. •000222111 --- Spore
e. •111222000 --- GrowMultiply
f. •000111222 --- Digest

Unified Genetics

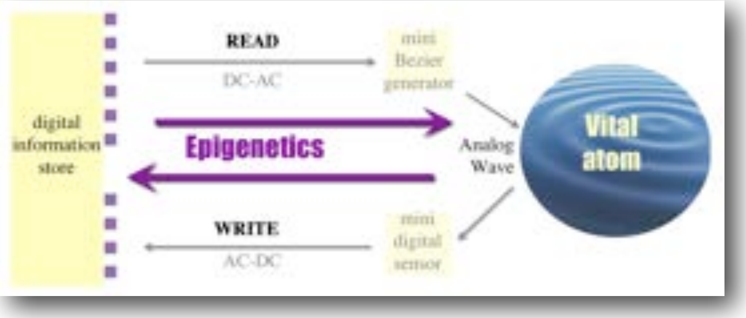
This diagram summarizes the discussion of a unified genetics that includes the internal wave aspect in the picture. All the digital information in this feedback loop is in the pattern of base-pairs on DNA.



Living systems also have another level of digital information that is not stored in base-pair patterns but the pattern of methyl groups added onto bases along the DNA molecule.

The only analogy I can draw from computer technology is pressing the little language button in my menu bar. The keyboard input—Richard—is the same, but the analog shapes on the screen are utterly different. If I choose Greek, it is Ριψηαρδ, if I choose Arabic, it is زيصحارد, while if I choose Hebrew, it is ןבישרג and it types from right to left. The same input but a very different output.

The computer does this by changing lookup tables. RNA would do it another way. It would block all the addresses of all the other languages by dabbing a spot of paint to make them unreadable. Now, only the addresses of the chosen language are available for calling as output. Difficult on a hard drive, but the result is the same: an input can have a different output depending on this second level of writing. Methylation of the bases along the DNA strand makes it even more hydrophobic and coil up even tighter, thereby making it less unavailable than usual. (The transition from RNA-only to DNA+RNA probably involved a similar mechanism.) Since this level of digital information is written using the genetic level as substrate, this feedback loop is called Epigenetics.



In the Great Debate over a designed or a random universe, classical genetics with its read-only concept of digital information has been the scientific support for randomness with its Fundamental Dogma. This ‘foundation of sand’ is inevitably shifting. A sign of this is to be found in *Nature*, the preeminent science journal, and reprinted in *Scientific American*, purveyor of mainstream science to the general public:

> A student referring to textbook discussions of genetics and evolution could be forgiven for thinking that the 'central dogma' devised by Crick and others in the 1960s — in which information flows in a linear, traceable fashion from DNA sequence to messenger RNA to protein, to manifest finally as phenotype — remains the solid foundation of the genomic revolution. In fact, it is beginning to look more like a casualty of it…

The review also went on to debunk another concept propounded by Richard Dawkins, a major promoter of random-chance-and-accident Darwinism, that of Junk DNA. This considered that the 95% of human DNA that was not read into mRNA, rRNA and tRNA to be meaningless ‘selfish’ DNA that was just useless baggage:

> …Starting in 2003, ENCODE researchers set out to map which parts of human chromosomes are transcribed… Last year, the group revealed that there is much more to genome function than is encompassed in the roughly 1% of our DNA that contains some 20,000 protein-coding genes — challenging the old idea that much of the genome is junk. At least 80% of the genome is transcribed into RNA.[24]

It is already known that, just like a single RNA virus that suborns a cell, some human DNA is only briefly transcribed into RNA and then shuts down for the rest of a lifetime. The most astonishing example of this is the SDR on the human male Y-chromosome. This is only transcribed into RNA for a few hours in a 6-week old embryo. It then shuts down and is never transcribed again. Yet the RNA generated in that brief burst is sufficient to divert the default female path of development into that of the male. An embryo with a Y-chromosome lacking this comparatively short stretch of DNA will develop into a female, a genetic glitch that has troubled sex-divided sports testing.

As the sensitivity of the methodology improves, it will probably turn out that almost 100% of DNA is transcribed into RNA at some point in a person's lifetime.

As our technological example of virtual memory suggests, it is quite possible that the DNA of somatic cells is used for long-term memory. This possibility cannot be explored until DNA sequencing is applied to various tissues of the same individual, the glia cells of the brain being the most likely to need DNA for long-term storage of digitally-encoded memories.

Epigenetics

Unlike most major advances, epigenetics as a field of study had its origins not in observation of simple systems, but in the observation of the most complex systemof all, human beings. It was found that the grandsons of grandmothers who had survived the famine during the siege of Stalingrad had significantly lower life expectancy than the control group. This was true even though the postwar experience of the parents and children in America were very similar.

The only known biological thing that grandsons inherit only from their grandmothers is their sole X-chromosome with its DNA of base-pairs. If the fundamental axiom of classical genetics were true, that reading but not writing only ever happens, then all these hundreds of disparate X-chromosomes must have undergone the exact same random change in the DNA to be passed on to the grandchildren.

However, this is exactly the opposite of what is expected of randomness when tossing 100 coins that all came up heads would cause extreme suspicion of the coins' fairness. But something was definitely being passed down the generations on the X-chromosome. The fundamental axiom of classical genetics trembled as it became clear it was incorrect: writing digital information happens alongside the reading of digital information.

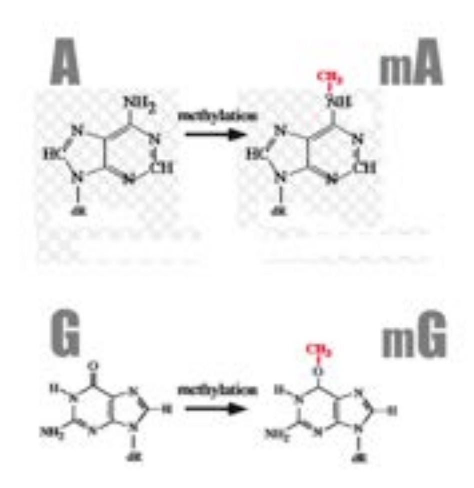
Thus, in the last decade, this is how the science of *epigenetics* got its start, and it promises to be at least as significant as genetics, probably more so. While the science is still in its infancy, it will come as no great surprise, seeing what we have already discussed, that RNA has a role to play in epigenetics as well as in genetics:

> [Epigenetics] could be mediated by the effect of small RNAs. The recent discovery and characterization of a vast array of small, non-coding RNAs suggests that there is an RNA component, possibly involved in epigenetic gene regulation. Small interfering RNAs can modulate transcriptional gene expression via epigenetic modulation of targeted promoters.[25]

While most research into epigenetics is currently in the animal realm because of its implications for aging and disease, it has also been established as a major player in the prokaryotes, the bacteria and simplest of vital units:

> Like many eukaryotes, bacteria make widespread use of post-replicative DNA methylation for the epigenetic control of DNA-protein interactions. Unlike eukaryotes, however, bacteria use DNA adenine methylation (rather than DNA cytosine methylation) as an epigenetic signal…regulates the cell cycle and couples gene transcription to DNA replication… Switching between alternative DNA methylation patterns can

> split clonal bacterial populations into epigenetic lineages in a manner reminiscent of eukaryotic cell differentiation… DNA methylation plays important roles in the biology of bacteria: phenomena such as timing of DNA replication, partitioning nascent chromosomes to daughter cells, repair of DNA, and… regulate cell functions involved in RNA stability, mRNA translation, or protein turnover. However, the underlying molecular mechanisms remain to be identified.[26]



Bacterial DNA is turned off by adding a methyl to all the adenines in a stretch of DNA while eukaryotes do it to the guanine. The transition is probably a clue to what happened during the prokaryote-eukaryote leap in sophistication.

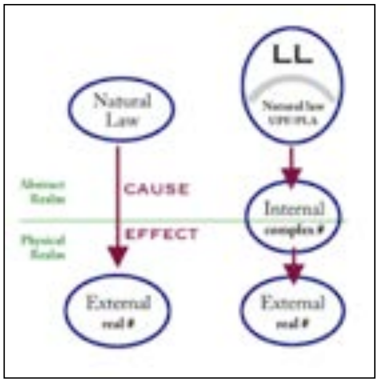
While epigenetics has a great future, it is still in its early days and most of the work has been done with eukaryotes. We will be discussing them in a later chapter.

We earlier outlined the history of the physical realm, starting with the Big Bang and ending with the formation of the planets. Our historical narrative now continues with that of the planet Earth. The 4-billion-year history of the earth is divided into Eons, and the first was the Hadean when the Earth was molten and subject to a tremendous bombardment of comets and the like, which raked the surface. There was no liquid water and there were certainly no living systems. The Hadean Eon was hellish and abiotic.

The Earth cooled, accumulated a liquid ocean and, within 100 million years, the fossil record shows clear signs of abundant bacterial life. The transition from an abiotic world to one teeming with life is the topic of the next chapter.

To summarize the view of evolution presented here. If the read-only, external-only, materialistic view of evolutionary development can be captured in the phrase, *Survival of the Fittest*; then this write and read, internal and external, theistic view of evolutionary development can be captured in the phrase, *Wisdom of the Ancestors.*

THE ORIGIN OF LIFE

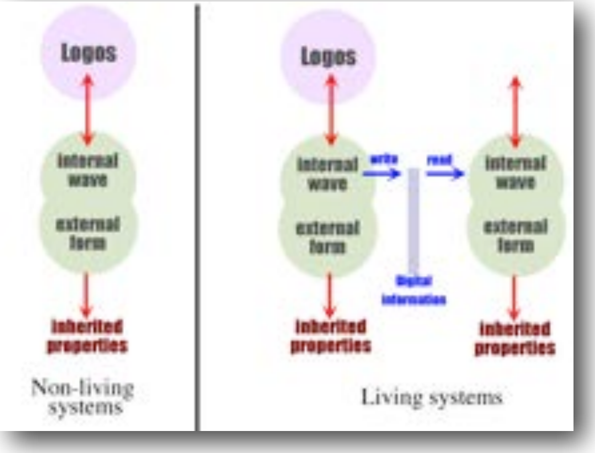


Biogenesis is the study of the origins of living systems. Classical biogenesis is based on the concept that natural law directly influences the external aspect of systems. A unified biogenesis is based on the more sophisticated view of modern science where natural law determines the internal aspect of systems which determines over time the external aspect of systems.

The Logos is an abstract systematic hierarchy that determines indirectly the structure and emergent properties as the physical hierarchy is constructed over time. The external form resonates with the Logos and the emergent properties are directly inherited from the Logos. If the system is disrupted, it no longer resonates with the Logos and the properties are lost. All the properties of the helium atom that we discussed are lost if the thermal energy disrupts it into independent electrons and nuclei.

We have also discussed how living systems can read digital information and convert it into analog waves. If these waves resonate with the structures in the Logos, then the emergent properties are expressed, even though the Logos was not involved.

We have also seen that there is writing of digital information in living systems, even if it is as yet poorly understood.



Putting all this together, we can say that the very first living system, the first vital unit was a system that resonated with the Logos and inherited a set of emergent properties that allowed it to sample its analog wave and write it to digital information. This was duplicated and used to recreate multiple copies of the analog wave that also resonated with the Logos and indirectly inherited the same set of emergent properties as the very first 'parent' system.

FIRST LIFE

To be a contender for first life, we need inanimate molecules that can: (1) Sample analog waves (2) Output and store digital information (3) Recreate the analog wave by reading the digital information (4) Duplicate the digital information.

It should be quite clear from what we have discussed why the consensus is that the only molecule with this set of emergent properties is RNA, and that it was an RNA world in the beginning.

Systematic edens

Living entities form a systematic hierarchy, just as the inanimate realm does, and the basic principles apply:

1. A system has an internal wave aspect that determines over time the confined forms of interacting subsystems that are coupling with their subsystems. This is the external form of the system.
2. If the confinement of subsystems is not perfect, the system can overlap its internal wave with that of another similar system so that they couple with their valence subsystems and interact. These are the external forms of the interactions of the system and gives it a set of characteristic properties not possessed by its individual subsystems.

Up until the advent of human beings, everything that happened during the history of the physical realm was a direct reflection of structure of the Logos. Each step in the expression of this abstract structure was, in turn, highly probable given that a few requirements were met:

1. Systems had emerged from a previous step.
2. Their circumstances are such that they can interact.
3. There is sufficient time for the Law of Large Numbers to make the external form of interaction be that of the internal form of interaction.

These requirements for system building are that there be sufficient time and circumstances for the interacting systems to stumble upon the probable form of a higher system that is waiting there but empty in the Logos.

Borrowing the concept of an Eden where everything was just right for the origin of man, we shall use the concept of an eden in describing system building. An eden for a system is where all the requirements are met, i.e., the subsystems are in an environment that is conducive to them and their interactions. The systematic development of the inanimate realm is a sequence of edens that is just right for the emergence of the next, higher level. The chart lists the sequence of inanimate edens.

We can expect to find a similar sequence emerging in the system building in living systems. So, the first step towards understanding the system building of life is the emergence of an RNA eden in which all its subsystems are in an environment suitable for interaction.

The unfolding of the Logos that led to the environment in which RNA emerged is only poorly understood at present. The only difference between the classical and the unified view is that the sequence of steps is inherent in the Logos in the unified view while it is random in the classical. Both views necessitate a sequence of steps and an environment in which RNA subunits can naturally occur.

One recent development is the possibility that the first RNA subunit did not emerge by linking base, ribose and phosphate together, but by the assembly of quite different fragments:

> [One ring bases] and their respective nucleotides have been prebiotically synthesized by a sequence of reactions that by-pass free sugars and assemble in a stepwise fashion by going against the dogma that nitrogenous and oxygenous chemistries should be avoided. In a series of publications, The Sutherland Group at the School of Chemistry, University of Manchester have demonstrated high yielding routes to cytidine and uridine ribonucleotides built from small 2 and 3 carbon fragments such as… glyceraldehyde-3-phosphate, cyanamide and cyanoacetylene. [27]

History of Earth

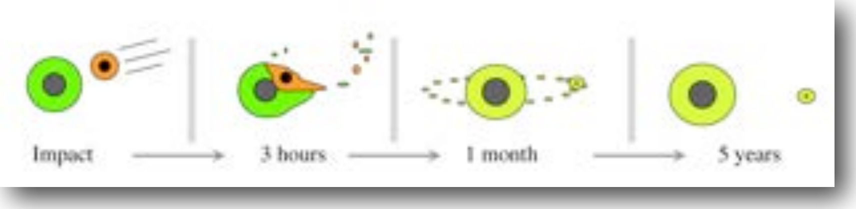
In our discussion of the unfolding of the Logos over time, we got as far as the third generation of stars that formed from collapsing clouds of interstellar H and He that also contained 1% of all the other elements as a dust. The dynamics of the formation of our Sun and planets have yet to be fully understood but 99% of the material ended up in the sun (or was ejected when the sun ignited) and 99% of the angular momentum ended up in the planets.

The inner rocky planets—Mercury, Venus, Earth and Mars—are mainly dust, while the gas giants—Jupiter, Saturn, Neptune and Uranus—are mainly H and He. To my mind, even though it was written over 60 years ago, the answer that George Gamow supplies to his question, summarized in his diagram, resonates with a unified perspective of standing waves in the dynamics of the collapse:

> It is clear that, in such heavy traffic, numerous collisions must have taken place between the individual particles, and that, as the result of such collisions, the motion of the entire swarm must have become to a certain extent organized. In fact, it is not difficult to understand that such collisions served either to pulverize the "traffic violators" or to force them to "detour" into less crowded "traffic lanes." What are the laws that would govern such "organized" or at least partially organized "traffic"?[28]

The Moon

One thing that is firmly established about the final step in the aggregation of the proto-Earth is that it involved a collision with a Mars-sized planetesimal, their combined splash coalescing in a few years into the Moon, then at only half the distance it is today.



This presence of our large satellite Moon is of great importance in making the Earth an eden for life for (at least) the following reasons:

1. The Earth's axis was tilted by 23° from the normal and most of the angular momentum of the Earth-Moon system ended up in the rotation of the Moon. This made the system very stable and the axis of the Earth, unlike that of Mars, has kept a constant orientation.

2. The crust of the Earth was shattered into fragments allowing the heat of the Earth's interior, stoked by radioactive decay, to drive the motion of tectonic plates with the gradual release of internal energy as ongoing volcanic activity. Venus, of similar size but without a moon-fractured crust, had no such gradual release and the buildup of internal heat eventually escaped as global eruption that remelted the entire surface.
3. The Earth cooled and water from vulcanism and icy comets condensed into the oceans. The Moon raised tides in these oceans that were enormous compared to those seen these days. The tidal effect is directly proportional to the cube of the distance. When the Moon was at only half the distance, the tides it raised on the Earth were $2^3 = 8$-times as great in amplitude as those today. As noted earlier, the energy of a wave is the square of the amplitude, so the primordial tidal waves had 64 times the energy of those today and coastal erosion was 64 times as efficient. Huge amounts of sediment were deposited in the oceans, creating the great China-clay beds we mine today for our pottery and industry. The photo is a remnant of one atop a mountain after centuries of mining.[29]

The Moon-contributed stability, volcanic tectonic plates, and great beds of clay gave the Earth-Moon system the Logos-inherited properties that, as we shall see, were just-right to be the eden for life to emerge and flourish.

THE EDEN FOR LIFE

While there is no current consensus as to how life actually emerged, a lot is known about aspects of the early earth that probably contributed to the momentous advent of life. I shall mention just a few of the emergent properties on the early earth that are most likely contributors to the origin of life.

Following the pattern prescribed by the Logos, three great systems interacted together as the subsystems of the eden for first life to emerge, two of which are indirectly attributable to the Moon:

1. Surface of the Earth; the oceans and atmosphere illuminated by the young Sun
2. Tectonic vulcanism
3. Sedimentation of great beds of clay minerals

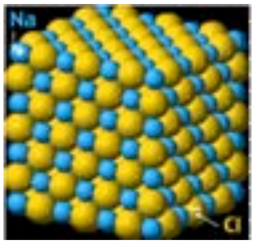
We will deal with each in turn, then see how they interacted together as the eden for first life.

Earth's Surface

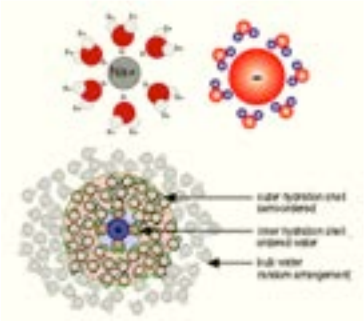
Water in its liquid state is the most important ingredient for life. In all living systems, water molecules are the main resonator subsystems that take up the form of the internal waves created by the generator subsystems. Just as an orchestra playing in the absence of gaseous air molecules cannot create a symphony, the generators cannot create a living system in the absence of water molecules.

The Earth is in what astronomers call the *Goldilocks zone* about the Sun. It is not too close to the Sun that would otherwise result in a surface temperature above the boiling point of water; it is not too distant from the sun, otherwise resulting in a surface temperature below the freezing point of water. It is just the right distance for liquid water to exist alongside solid water and atmospheric water. Neither closer-in Venus at +900°F nor further-out Mars at –110°F is in the Goldilocks zone and consequently do not have oceans.

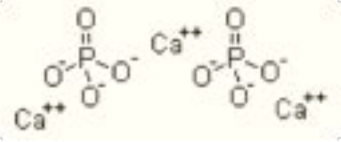
A very important property of water is that it is an excellent solvent. We can use common salt, sodium chloride, to exemplify this.



An ionic solid like sodium chloride is not really composed of NaCl molecules. There is no sharing of electrons; the sodium loses an electron completely to a chlorine atom. The result is two charged spheres since both have their outer electrons in the noble gas configuration. The spheres stack as closely as they can to minimize their repulsion and maximize their attraction. For sodium chloride, this a cubic array, and salt crystals composed of zillions of atoms exhibit this shape. These ionic bonds are very strong and it takes a temperature of 1,074°K (801°C; 1,474°F) before salt will melt, and only at 1,686°K will the ions be liberated as a free gas of ions, a plasma.



If a crystal of salt is dropped into water at room temperature, however, the ions dissolve into free ions surrounded by water molecules. There is less free energy in solvated ions than in the crystal, so sodium chloride is quite soluble and 36 grams of it will dissolve in 100 grams of water.



At the other extreme is dicalcium triphosphate, $Ca_3(PO_4)_2$, where the free energy of the tightly bound ions is much less than when they are surrounded by water, and this ionic compound is quite insoluble in water as only 0.002 gram of it will dissolve in 100 grams of water. Living systems often use the powerful interaction of calcium with phosphorous as a signal coordinating the generator subsystems within a cell.

At the time of the origin of life, the newly formed oceans were not pure water. The great tides raised by the Moon had dissolved various salts in the water. It was in this milieu that living systems emerged. The 'symphony of life' has as its resonating subsystems the water molecule and a small number of ions. Ignoring the rare ions, this solution is approximated by mixing four salts together, as listed in the chart.

SALT	%
NaCl	0.8
KCl	0.02
Na_2HPO_4	0.14
KH_2PO_4	0.024
pH	7.4

It is this solution that life emerged in, and it is roughly the ionic concentration in the cytoplasm of all living systems to this day. All cells go to a good deal of trouble to maintain this concentration of ions.

Small Organics

The atmosphere of the very early earth would have reflected the gas cloud out of which the earth accreted, composed mainly of hydrogen and helium. We have already noted that the speed at which the molecules of a gas are moving at a given temperature goes down as the molecular eight increases. Both the hydrogen molecule and the helium atom are small, at 2 and 4, so they were moving fastest of all. Since their speed was greater than the escape velocity, over time almost all of these two gases escaped from the atmosphere.

This is called the Hadean era of the earth’s history. It started at Earth's formation about 4.6 billion years ago, and ended roughly 3.8 billion years ago. This was a period of heavy bombardment, including the impact that created the Moon, and intense volcanic activity.

Based on today's volcanic evidence, the resultant atmosphere would have contained 80% water, 10% carbon dioxide, 7% hydrogen sulfide, and smaller amounts of ammonia, nitrogen, carbon monoxide, methane and inert gases. Free oxygen would be entirely absent.

Atmosphere

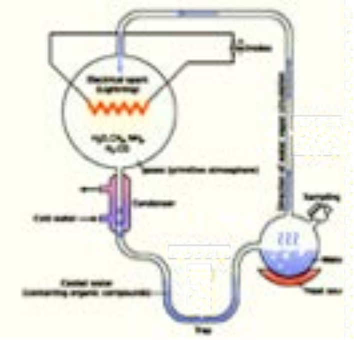
The tremendous tides raised by the early Moon ensured that the ocean and atmosphere were in equilibrium. There was no free oxygen, and hence no ozone layer, so the UV from the sun could penetrate into the lower levels of the atmosphere. Lightning was also commonplace as the weather back then was awful.

The cataclysmic formation of the Moon probably stripped away most of the earliest atmosphere, but the rain of comets brought with them water and a great number of small organic molecules.

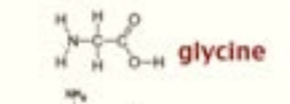
The energy input by lightning and UV fragmented the molecules in the atmosphere by knocking out hydrogen atoms, creating free radicals with unbalanced electrons. These free radicals then combined with each other, creating more complex molecules.

$$\boxed{\begin{array}{l} H_2O \rightarrow HO- \\ NH_3 \rightarrow H_2N- \\ CH_4 \rightarrow H_3C- \end{array}}$$

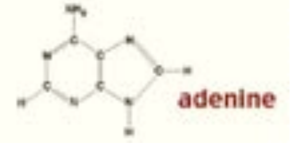
The classic Miller-Urey experiment, as illustrated, recreated the primordial atmosphere and conditions, and subjected it to an electric discharge.



At the end of one week of continuous operation, Miller and Urey observed, by analyzing the cooled water, that as much as 10-15% of the carbon within the system was now in the form of organic compounds. Two percent of the carbon had formed aminoacids, including 13 of the 22 that are used to make proteins in living cells, with glycine as the most abundant.



glycine



adenine

The Miller-Urey experiment inspired many experiments in a similar vein. It was found that aminoacids could be made from hydrogen cyanide (HCN) and ammonia in a water solution, and significant amounts were formed of the nucleotide adenine which is one of the four bases in RNA and

DNA.

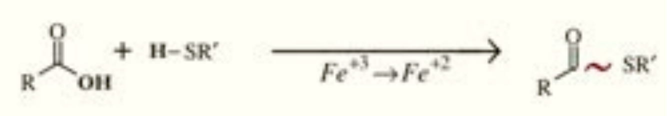
Ocean

The primordial ocean was saturated with iron in its reduced, ferrous state Fe^{+2}, which is soluble in water. The ferrous ion can easily give and receive electrons as it reversibly changes into the ferric state Fe^{+3}. In this way, it can transfer electrons (each accompanied by a H^+ ion) and act as a simple reversible mediator between chemical interactions.

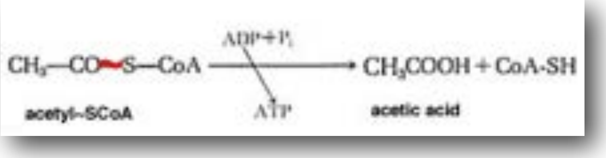
The intense UV light striking the oceans was absorbed by ferrous ions, which changed into ferric ions. The liberated electron unites with a H^+ to create a very reactive hydrogen atom that can participate in a host of chemical reactions and even drive chemical reactions 'uphill.' The generation of excited electrons provided the primitive Earth with reducing potential and the abiotic synthesis of reduced raw materials such as H_2 and HCN.

$$Fe^{++} + UV \rightarrow Fe^{+++} + e^{-}$$

This was a crude echo of the photosynthetic splitting of water, and the liberated oxygen precipitated out as an insoluble ferric/ferrous mixed oxide called magnetite. This is how the *banded iron* strata were deposited—the main source of iron ore today, $[FeO][Fe_2O_3]$.



One reaction that many think played a central role is the condensation of a sulfhydryl, the sulphur analog of an alcohol, e.g., CH_3SH, with a carboxylic acid, e.g., CH_3COOH, to form a thioester. The thioester linkage formed is "energy rich," releasing between 7.5 and 8.5 kcal/mol upon hydrolysis. The significance of this is that this is sufficient energy to form pyrophosphate from two inorganic phosphates, and pyrophosphate is the energy store used to drive many chemical reactions in an uphill direction.



Thioesters still play a key role in the *house-keeping* metabolism common to all life, and drive the formation of ATP directly in *substrate-level* phosphorylation.

Tectonic Vulcanism

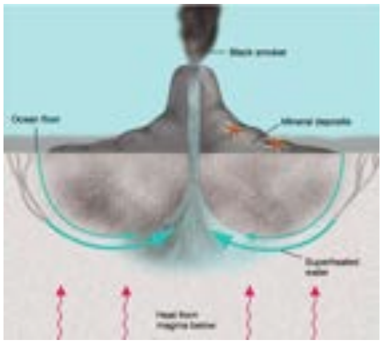
The crust at the bottom of the oceans is naturally saturated with seawater, and the heat escaping from the inner mantle heats this water and sets it into convection as the hot water rises and the cool

Subsystems	Environment	System
Matter/antimatter	Cooling Big Bang	Electrons, quarks
Electrons, quarks	Cool universe	H, He atoms
H, He	Aging stars	The *Metals*
The Elements	Gas clouds	Molecules, planets

water from the ocean sinks through the crust. The upwelling of heated water can be channeled into two types of outlets called *smokers*—one black, one white.

Black smokers

The faults between tectonic plates are sites where hot magma can come close to the surface. When these areas are underwater, the result is *black smokers*, where seawater percolating down is heated and returned to the surface acidified and saturated with minerals, particularly sulfides. When the superheated, mineral-rich water leaves a vent and mixes with the cold ocean-bottom water, it precipitates a variety of minerals as tiny particles that make the vent water appear black in color and, over time, this precipitation creates a chimney-like structure. This is why these sulfide chimney structures are called black smokers.



The sulfides are energy rich and can be used as a source of free energy to power chemical changes. To this day, black smokers host a prolific biota that is powered by high-energy sulfides, rather than the light of the Sun, as is the case for almost all other life.

White smokers

White smokers refer to vents that emit lighter-hued minerals, such as those containing barium, calcium, and silicon. These vents also tend to have lower temperature plumes. They are not powered by magma coming close to the surface as tectonic plates spread apart, but by the reaction of the newly-surfaced rock with seawater. The water chemically reacts with the rock, forming hydroxide minerals like serpentine. The reaction liberates heat, hydrogen, methane and ammonia. These break through the seafloor as the white smokers. Rather than the dense precipitate of iron sulphide, the minerals that precipitate out in white smokers form lacy and porous networks, the pores being of bacterial dimensions. The reaction of methane with hydrogen is catalyzed by iron sulphide crystals, and builds organic molecules while releasing energy. While carbon dioxide is very stable, it reacts with free radicals in the vents to form acetyl thioester, an activated form of carbon dioxide. Carbon dioxide will spontaneously react with this to form pyruvate, a simple CHO molecule that is at the center of core metabolism in all organisms

These alkaline hydrothermal vents also continuously generate acetyl thioesters, providing both the starting point for more complex organic molecules and the energy needed to produce them, since acetyl thioesters can incorporate phosphate, as acetyl phosphate, which can, like ATP, transfer its high-energy phosphate to other molecules. Microscopic structures in such alkaline vents show many interconnected compartments that are thought have possibly provided an ideal womb for the origin of life.

Lost City is a small forest of such white smokers in the mid-Atlantic ocean of about 30 chimneys made of calcium carbonate 90 to 180 feet high, with a number of smaller chimneys. The outflow from these white smokers contains a variety of hydrocarbon molecules:

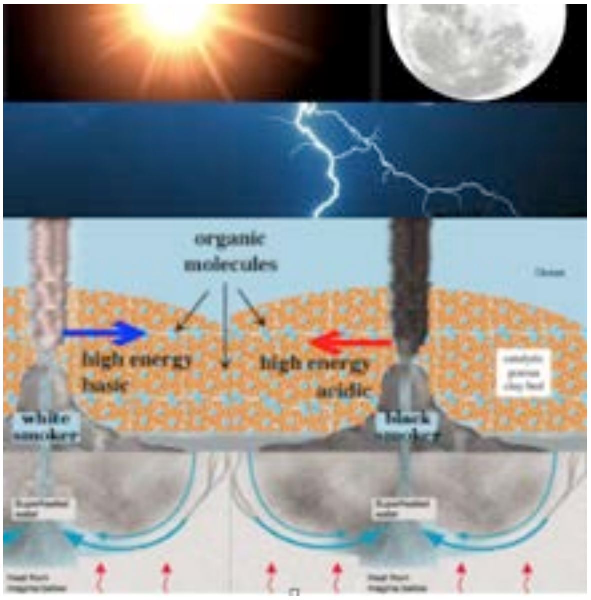
> Radiocarbon evidence rules out seawater bicarbonate as the carbon source for [hydrogen and carbon monoxide] reactions, suggesting that a mantle-derived inorganic carbon source is leached from the host rocks. Our findings illustrate that the abiotic synthesis of hydrocarbons in nature may occur in the presence of ultramafic rocks, water, and moderate amounts of heat.[30]

Sedimentary Clay Beds

There was intense weathering on the early earth and the sediment settled in the oceans as immense beds of clay. Clay has many interesting emergent properties, including a wide variety of catalytic properties that are exploited today in the chemical industries.

A typical clay particle is normally very small, <2µm, which results in the presence of very large surface areas. Clay minerals are composed of silicon, aluminum or magnesium ions or both, and water. Iron can be a substitute for aluminum and magnesium, and potassium, sodium, and calcium are often present in abundant quantities as well. Chemical solutions perfused through clay beds undergo many useful transformations. The catalytic properties of clays are still being explored, but a wide range of chemical ability has already been documented in a recent review:

> Clays exhibit specific features such as high versatility, wide range of preparation variables, use in catalytic amounts, ease of set-up and work-up, mild experimental conditions, gain in yield and/or selectivity, low cost, etc., which may be very useful tools in the move towards establishing environmentally friendly technologies. Furthermore, the possibility of upgrading these materials by the [separation of layers] opens new and interesting perspectives, also considering possible shape selective advantages. Recent catalytic applications of cationic and anionic clays in organic or fine chemistry (acid- or base-catalyzed reactions, Diels–Alder reactions, reactions using metallic nitrates, etc.), environmental catalysis ([sulphide and nitrate] oxidation) and energy exploitation (partial oxidation of methane) are discussed as very promising research subjects with a wide range of possible future developments.[31]



The primordial clay beds were, therefore, places where diverse chemical interactions between molecules could occur, and it has been proposed that the catalytic properties of clay were involved in creating life's precursors.

Womb of Life

The primordial earth, with all the properties just enumerated (and probably many more that are yet to be understood) that were inherited from the Logos, was an eden in which all the subsystems were present for the system-building interactions that led to the first living systems.

All of these emergent properties came together in what can only be called a womb in which this momentous event could occur.

This womb had three main components:

1. Ocean water saturated with iron and small organics is circulated through clay beds deposited on the crust driven by the heat exiting the mantle.
2. The bed has both black and white smokers that add high-energy organics to the perfusate and establish gradients of both temperature and pH in the clay bed.
3. The catalytic properties of the clay allow many transformations to occur and, where the conditions are just right as prescribed by the Logos, allow for nucleotides to emerge.

While there is no consensus as to the exact details, we can surmise that a bed of clay was deposited over a tectonic fault and that it was perfused by both black and white smokers. The small organic molecules that enriched the cold ocean water were drawn through this bed and, after being heated by the magma below, entered the clay as high-energy thioesters and phosphates.

This circulation of water through the catalytic pores in the clay (with the smokers playing the role of a heart) and the temperature and acidity gradients that were set up, allowed a multitude of chemical reactions to occur and a ‘chemical ecology’ to be established expressing a plethora of Logos-derived properties.

One aspect of this prebiotic chemistry in its clay bed eden is that the properties that it inherited from the Logos had a distinct chiral nature. This is similar to the very first eden of all, the eden for the emergence of matter—the Hot Big Bang of matter and antimatter in essentially equal amounts. The one-in-ten-billion deficit of antimatter fermions—a right ½-twist along the complex time axis—over matter fermions—a left ½-twist along the complex time axis—was sufficient when the universe cooled to form all the 100 billion galaxies in the visible universe (not to mention that the physical realm is probably magnitudes times greater, though not infinite).

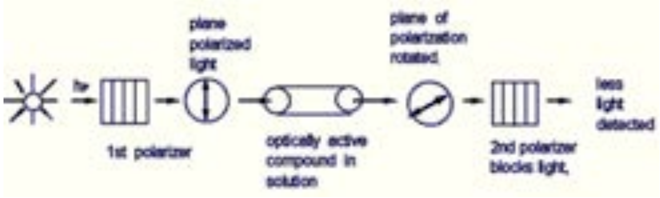
The eden for matter was chiral, with a fundamental preference for left over right on the internal, complex level.

The eden for first life was also chiral, with a fundamental preference for *right* sugars and *left* amino acids.

Left-right asymmetry

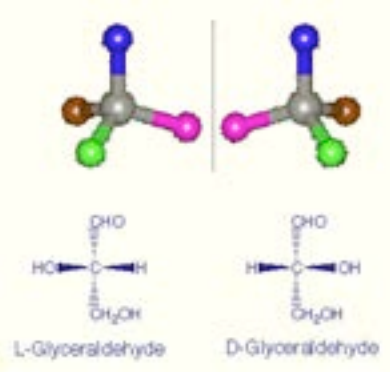
The light is a transverse wave—the axis of waviness is at right angles to the direction of travel (while sound is a longitudinal wave where the axis of waviness is parallel to the direction of travel). In unpolarized light, the axis is at any, and all directions, around the direction of travel. In *plane* polarized light, there is just a single axis of waviness.

If such polarized light is passed through water, the axis will be unchanged. If it is passed through a solution of an “optically active” compound, however, the axis is rotated. This does not involve any transfer of energy, just the configuration of the chemical compound. The rotation can be to the right (clockwise) or to the left (counterclockwise). This rotation can be measured using a simple experimental setup.

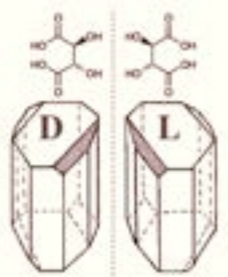


Molecules involving carbon atoms are optically active when there is an ‘asymmetric carbon’, i.e., a carbon atom in which all four of the tetrahedral bonds are connected to different sets of atoms. In this situation, it is possible to distinguish between two isomers that are identical except for being mirror images of each other. The asymmetric carbon is said to be ‘chiral.’

The glyceraldehyde (GAD) molecule that occurs in core carbohydrate metabolism has an asymmetric carbon with its two mirror-image isomers that are equally and oppositely optically active. The central carbon atom of GAD is attached to a hydrogen, a hydroxyl, a formaldehyde radical, and a methanol radical. As this is the simplest sugar, the isomer that rotates light to the right is called D- (*dextro-)* and to the left, L- (*-levo).* All molecules in metabolism can be sourced to this molecule, so it is used to define the chirality of organic molecules. All the aminoacids that reflect the L-form of GAD are assigned a chirality of L (even if they rotate light to the right) and those based on the D-form of GAD have a chirality of D (even if they are now left rotators). Similarly, all the many carbohydrates used by life can be classified as D or L sugars.



The crystals that these isomers form in the pure state are also mirror images of each other, as is illustrated by the two crystals of D- and L-tartaric acid, which played a key role in the exploration of optical activity.

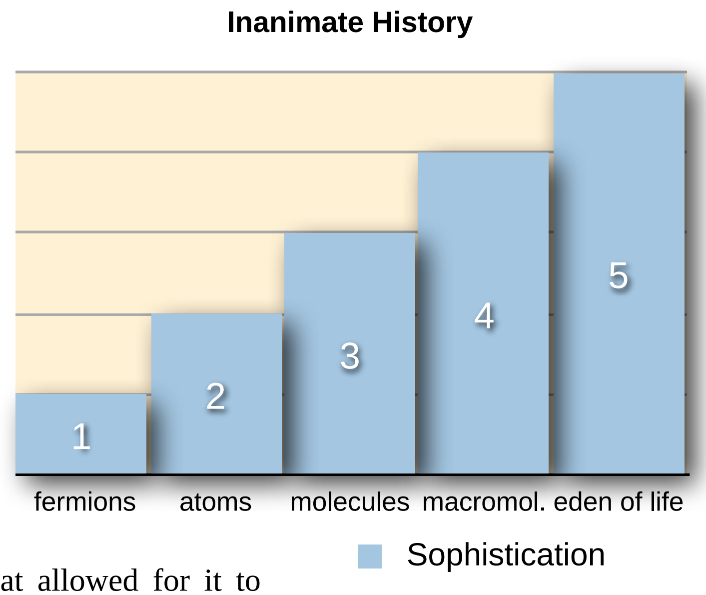


Currently, there is nothing that is known that would suggest that all of the sugars and aminoacids that could have entered into the womb of life were not balanced in their chiral forms. That there were an equal number of both the D and the L forms around.

Something happened during the gestation of life, however, and the universal ancestor of all life emerged constructed solely of L-aminoacids in all its proteins, and D-sugars in all its nucleic acids. As far as I am aware, there has been little work done on proteins constructed of D-aminoacids or L-sugar nucleic acids, so the underlying reason for this chirality is unknown.

If the properties are identical, then the first to emerge stole the show. If their properties are subtly different, as might be expected given the chirality of the Logos, it was because the proposed solution within the Logos to the challenge involved only the subsystems with a specific chirality.

Challenge and Response

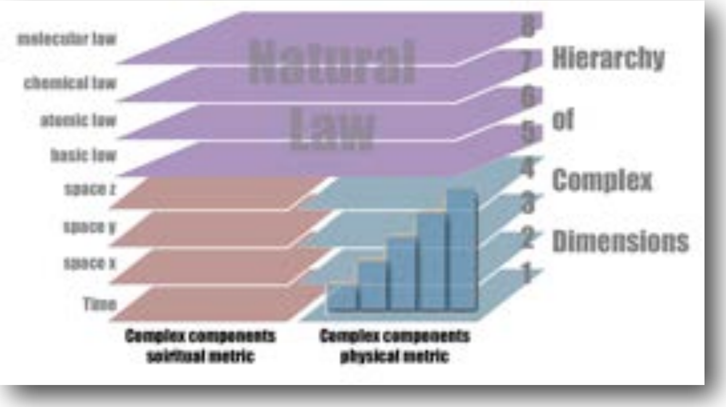


Moving back to the big picture, there is a subtle difference between the view of history based on the principles of a unified science and those of current classical science.

Our science is now confident that we have a pretty accurate description of the history of the physical realm from the Big Bang origin of matter fermions to the emergence of the eden for life on the planet Earth some nine billion years after.

In the classical picture, this development was a fortuitous accident in a universe that just happened to have the precise natural laws that allowed for it to happen. That one universe should be blessed with such a fortuitous set of natural laws is to be expected at random in a multiverse of a trillion {*forty* trillions} trillion other universes each with their random selection of natural laws.

That is the classical perspective. The unified perspective views the history of the physical realm—composed of twisted components of four complex dimensions—as being the stepwise expression of abstract structures in the Logos—composed of a hierarchy of complex dimensions.



A similar stepwise expression of the Logos occurs in living systems:

1. Prokaryotes. Vital Units with a wide variety of emergent properties that allow them to populate and thrive in almost every environment found in and around the surface of the Earth.
2. Eukaryote protists. Poly vital units, single plant, fungi and animal cells. A higher level in the sophistication of their emergent properties, such as the amoebas, yeasts and the denizens of ponds, such as euglena and paramecium. They are almost as ubiquitous as the bacteria.
3. Multicellular eukaryote plants. Wide variety of emergent properties, autotrophic so can live on sunlight, carbon dioxide and water plus a few minerals.

4. Multicellular eukaryote fungi. Heterotrophic recyclers of dead plants and animals.
5. Multicellular eukaryote animals. Active analog muscles and calculating digital nervous system.

This development over time is called evolution; living systems have developed over time into a systematic hierarchy of ever-increasing sophistication. The emergence of a new level of sophistication does not happen instantaneously; it is a process involving time. By its very nature, a process has a beginning, a middle and an end. Any process in system building can be divided into three stages:

1. *Formation*. All the necessary systems are gathered together in a suitable environment.
2. *Development*. The systems interact with each other and explore their possibilities.
3. *Completion*. The interaction of the systems resonates with a form in the Logos, and they become subsystems of a more sophisticated system, a step up in the systematic hierarchy.

An simple example is the system building step when atoms first emerged in the universe out of a plasma of free electrons and protons, which happened about one million years after the Big Bang.

The early universe was utterly hostile to any atom of hydrogen or helium at all. For every electron and proton, there were 100,000,000,000 high-energy gamma photons that instantly disrupted any liaison if they ever encountered each other. All that energy had a gravitational attraction that opposed the residual inflation of the universe, slowing the expansion of spacetime. This drained energy from the gamma photons and they became X photons, then UV photons, then visible light photons, then IR photons and, by our era, they became microwave photons, the CMB.

1. *Formation*. During the last stages in this cooling, the energy of the still-as-abundant photons became too small to disrupt helium and then hydrogen atoms.
2. *Development*. Opposite electric charges moved towards each other, while equal charges moved apart, still interacting with photons.
3. *Completion*. There were an equal number of positive and negative charges that emerged from the Hot Big Bang, and the electromagnetic force is so strong that all found a mate as subsystems of a hydrogen atom or a helium atom.

Each of these three stages is also a process in time, so each of the three also has a start, middle, and end. A process can be broken into a series of of subprocesses.

This also applies to the system-building in the hierarchy of living systems, and here the classical read-only view and unified write-read perspectives diverge.

Consider a vital unit that is multiplying in an environment rich in items A and B. The vital unit has the digital information to generate an analog wave to utilize A as food but not B. As the supply of A diminishes as multiplication proceeds, there is *selection pressure* to use B as food.

In the classical view, the response to this selection pressure is to wait until the random changes in the current DI come up with a digital sequence that happens to generate an analog wave for utilizing B.

In the unified view, the vital units shuffle their resources and test them out one by one, recording what works, discarding what does not.

For even simple systems, there are a large number of things that can happen, i.e., the things that are possible given the circumstances. To describe such large sets of possibilities, scientists have developed the concept of a *phase space* and the history of a set of interacting systems as having a *trajectory* in that phase space.

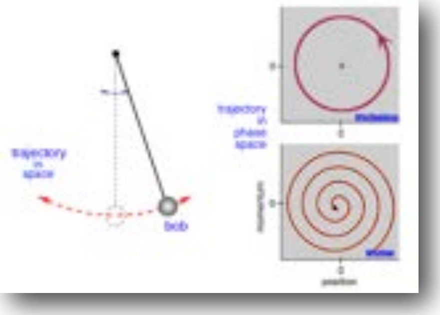
Phase space

Each system has a *degree of freedom* for each of the things it can do, e.g., moving in the three spatial dimensions. Expressing an interaction it is capable of is another simple example.

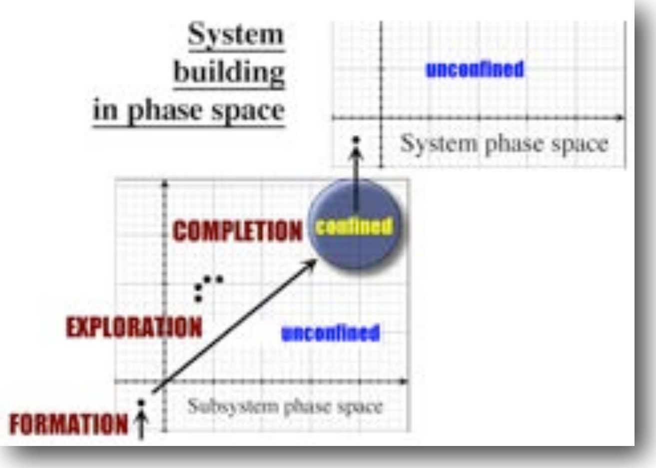
In a phase space, every degree of freedom of the system is represented as an axis of a multidimensional space. A phase space may contain a huge number of dimensions. For instance, a gas containing many molecules may require a separate dimension for each particle's x, y and z positions and momenta, as well as any number of other properties. For every possible state of the system, or allowed combination of values of the system's parameters, a point is plotted in the multidimensional space. This trajectory, which is a succession of points in phase space, is a representation of the system's state evolving over time.

In summary, the phase diagram represents all that the system can be and can do, and its shape can easily elucidate qualities of the system that might not be obvious otherwise.

An example is a pendulum bob swinging to and fro in an arc. The actual trajectory of the bob in actual space is variable, and it is momentarily motionless at either end while moving rapidly through the center of the arc. In a phase space where position and momentum are the degrees of freedom, however, the motion is a simple constant circle. If the pendulum is frictionless and swinging in a good vacuum, the circle is a constant. If energy is lost to friction, the trajectory is a spiral that winds slowly to a stop at the center.



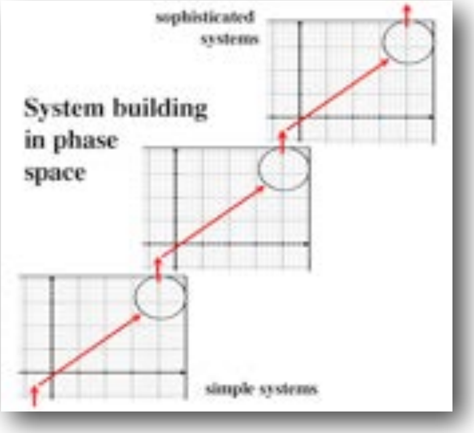
As it is technically impossible to illustrate thousands of orthogonal dimensions, we will restrict our diagrams to just two representative dimensions. Although this is a loss, there are still useful trajectories that can be illustrated in just two dimensions. For instance, in a system such as helium whose internal wavefunction firmly confines all of its subsystems, the trajectories of all of the subsystems in phase space are confined within a volume. The only degrees of freedom a helium atom has in everyday circumstances, i.e., excluding ultracold and ultrahot environments, is movement in the three spatial dimensions. The confined volume of subsystem phase space is moving as an entity in the helium atom phase space. System building involves a confined volume of subsystem phase space and the extension of a new set of dimensions to describe the system phase space.



The incomplete subsystem confinement of most system waves, other than perfect helium, are the coupling possibilities of the system, its valence couplers, and each extends a degree of freedom to the new phase space. The core subsystems, like helium, are firmly confined to a volume of phase space.

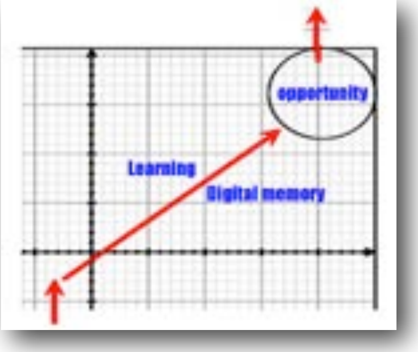
In the stepwise expression of the Logos over time, each step can be broken into the three stages:

1. *Formation*. Emergence of systems from previous levels into an eden provided by the Logos in which the systems thrive and explore their interactions
2. *Exploration*. The systems explore the possibilities of their interactions, contributing growth and development of the environmental eden they are in. They have a trajectory in phase space.
3. *Completion*. The interactions of the subsystems resonate with the Logos and the resultant internal wave confines the systems as subsystems of a higher system. Their partial confinement is the coupling ability of the higher system, which emerges as the confined form is established.



This emergent higher system is now ready to participate with others in the formation stage of the next step in system building as they explore the phase space of the degrees of freedom extended by the emergent interactions.

For inanimate systems, this does not add much to the picture of historical system building but, for living systems, we have the added aspect of learning and digital memory. The learning is about interactions with others and the environment, and the environment is an expression of the Logos. The living system is learning about the Logos and committing it to digital memory.



In the classical view, the trajectory through phase space in response to selection pressure is random and only a description. In the unified view, the trajectory through phase space already exists in the Logos and negative selection pressure can be viewed as a opportunity, a challenge with a prize.

There are no living systems that exist forever and, given a population of living systems that are unable to multiply, it will decline in numbers over time with a certain half-life. If the multiplication rate of the living system is greater than the average half-life, then the population will increase. So, the movement through phase space is a lineage moving through time, the leading edge increasing and the tail end fading out.

The trajectory through phase space is a lineage of living systems accumulating *wisdom*, knowledge about the Logos, along the way.

As long as the benign natal eden endures, the lineages that remain the same do just fine. If, however, the eden disappears as the Logos-guided development of the environment proceeds, then the opportunity is more of a challenge to be solved. Not so much later in the evolution of life, free oxygen was added to the environment and sufficiently entered into the clay beds to completely alter the possible chemistry, and the eden for life disappeared. Only those lineages that solved the challenges of life outside of the clay bed eden survived to leave descendants. This is akin to the classical concept of selection pressure: a lineage adapts or it becomes extinct. The only difference is that learning and writing digital information is a lot faster than waiting for random errors to generate the requisite information in the modern synthesis of genetics and evolution.

In the clay-smoker womb of life, the challenge is not to get swept away by the water flow—selection pressure for water confinement and control—and how to synthesize the molecules of life independently of the abiotic sources—selection pressure for metabolic control.

Kerogen

As any organic chemist will testify, it is all too easy for molecules to link up into a disorganized tangle of connected atoms that coats the experimental glassware. Such amorphous *kerogen* probably coated and filmed the channels in the backwaters of the clay-bed wombs. It could have been such films that the first vital units used to confine water and an environment in which phospholipids could be assembled.

The transition from a chemical ecology to the emergence of the first living systems took a few hundred million years, and much remains to be understood. What is most remarkable is that all the evidence is that one, and only one, lineage solved the challenge of independent life and emerged as the ancestor of all life on Earth. This lineage is the *Last Universal Common Ancestor* (LUCA) from which all known living systems are descended.

LAST COMMON UNIVERSAL ANCESTOR

LUCA

The subsystems that entered the womb of life were an inanimate heterogeneous mix of activated small molecules. What emerged, a hundred million or so years later was the Last Universal Common Ancestor (LUCA) of all life on earth. LUCA was a living system with all the properties necessary for life independent of the clay-bed womb.

The properties of the LUCA lineage is the set of properties that all living things have in common plus some that were lost along the way. These include:

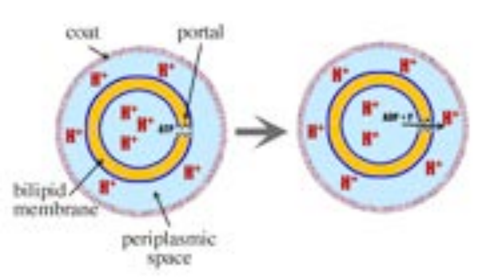
1. An outer coat very similar to a kerogen of cross-linked polymers, i.e., something like a coat of mail. All prokaryotes have one but the lineage that led to eukaryotes discarded it along its trajectory in phase spaces.
2. A bi-lipid membrane that confined the vital unit of water within the protective coat
3. The core carbohydrate metabolism of small molecules
4. The set of nucleotide-related prosthetic assistants in metabolism—ATP, NADP, etc.
5. DNA for deep-time storage of digital information down a lineage
6. The universal triplet code for converting digital information into analog waveforms
7. The large and small RNA subunits of the ribosome for assembling proteins
8. Using hydrogen ion gradients, *proton-motive force*, to recharge ATP

We have already discussed these properties except the last. This is the basis for many sophisticated processes that also use proton-motive force to link ADP and phosphate together with the high-energy bond of ATP.

PROTON-MOTIVE FORCE

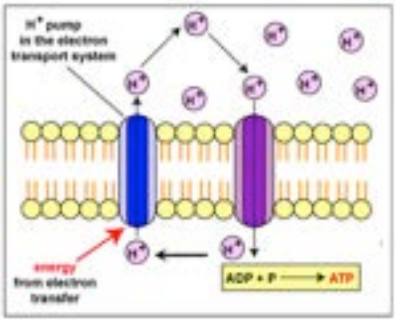
One of the challenges facing early life was the control of acidity, the concentration of hydrogen ions, the pH of the vital unit of water. The molecules of life work well only at or near a neutral pH—if too high or too low, all sorts of unpleasant things start to happen.

In order to thrive in an acid environment, energy must be expended to drive the H-ions against the concentration gradient. This energy is provided by a portal protein breaking ATP down to ADP



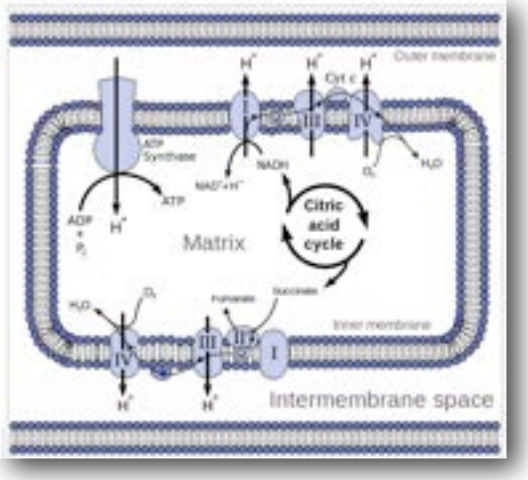
and P and ejecting an H-ion. This ability to control pH must have been discovered early on in living systems.

This is a reversible process. If excess H-ions outside are allowed to flow inwards, ADP and P are united into an ATP. If H-ions are pumped out through the membrane by some alternative route, then they can be allowed to flow back inwards through the portal with the generation of ATP. The H-ions can be pumped out again to repeat the process.



The LUCA lineage had discovered how to create such a current of protons and use it to generate ATP by using the electrons released by the stepwise breakdown of carbohydrates to pump H-ions out through a membrane, using a sequence of electron carriers and an electron acceptor, such as ferrous and/or sulphide ions.

Photosynthesis and Respiration



This proton-motive or *chemiosmotic* force was later adapted for trapping the energy of light. The energy of absorbed photons is used to drive the electron transport of H-ions into the periplasmic space. A water molecule is the electron acceptor with the liberation of free oxygen.

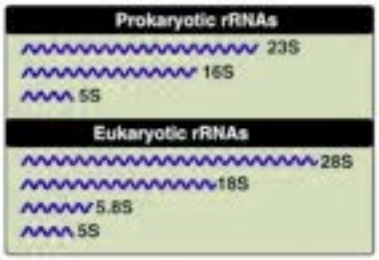
This free oxygen, in turn, became the electron acceptor in respiration, mastered by the ancestor lineage of the mitochondria as summarized in the Wikipedia diagram.[32]

The cyclical breakdown of pyruvate to carbon dioxide releases energetic electrons that fall down a chain to oxygen and drive H-ions into the periplasmic space. The return flow of these H-ions is used to generate ATP.

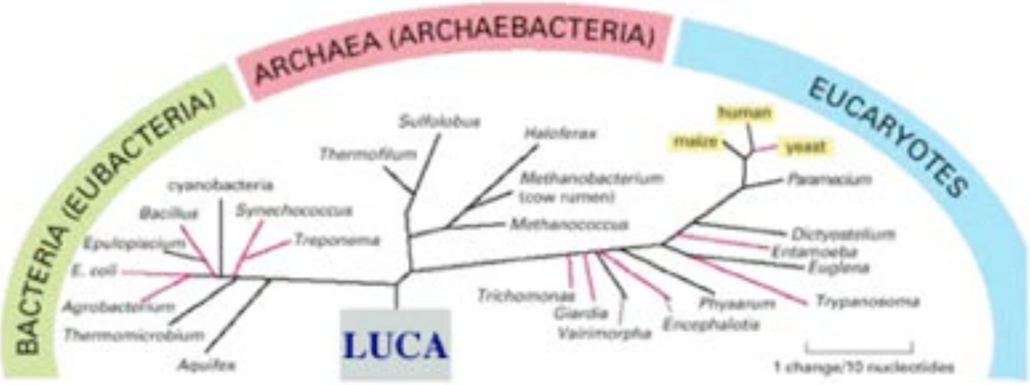
LUCA RIBOSOME

The ribosome on which digital information was turned into analog waveforms was central to the ability of the LUCA lineage to use proteins to control water and metabolism. The ribosome was so central to the process that it has altered surprisingly little over the 3 billion years it has been passed on down the three great lineages that radiated into phase space from the LUCA as the eubacteria, the archaebacteria and the eukaryotes.

The ribosome subunits in the two prokaryote lineages are the same size, but the RNA sequences are different. The eukaryote ribosome is similar tobut larger than the archaebacterial ribosome. In contrast, the eukaryote lipid membrane is eubacterial, which complicates unraveling the lineage that led to the eukaryotes. Other than this, the little-changing ribosome is very useful for outlining the basic family tree of living organisms.



The illustration below shows the similarities among small subunit ribozymes for cellular life forms (bacteria, archaea, and eukaryotes). Each branch is labeled with the name of a representative member of that group, and the length of the branches corresponds to the degree of difference in the rRNA sequence. The changes down all these lineages have been minimal over the billions of years since the LUCA emerged.

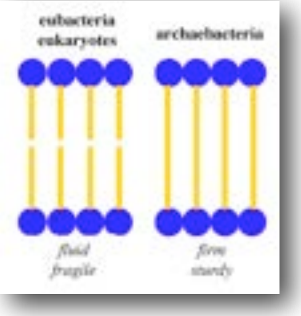


On this scale, plants, and fungi—here represented by maize and yeast—are our close cousins ,while E. coli is not.

The eden in which the lineage that led to the LUCA had all the ingredients for RNA to thrive in. But this eden in which life emerged was only a small locality in a much larger abiotic earth, and it is quite possible that only one locality, a womb in the eden, had the mix of conditions that were just right for RNA to flourish and explore its phase space as RNA mastered the use of amino acids to manipulate analog waveforms.

While the womb had everything necessary, the rest of the eden was supportive but lacking in one or another of the essential subunits needed for RNA.

The challenge was to explore the vast phase space opened up by proteins and, one by one learn how to create these essential subsystems from other substances in the environment. The core metabolism in current use by all living systems contains relics of the course of this exploration. We have already mentioned that the early ocean was saturated with iron and it seems that electron transfer to ferrous ions from the abundant hydrogen sulphide was first harnessed to drive the proton-motive force of generating ATP. Many of the archaebacteria use this method to this day, and many



enzymes important in electron transfer have an iron-sulphur cluster at their active site.

As the clay-bed eden involved extremes, it is thought probable that the bi-lipid membrane of LUCA was of the archaebacterial type, inasmuch as they thrive in the most extreme environments. Unlike the bi-lipid membrane enclosing eubacteria and eukaryotes in which the two layers are free to slide over each other, the archae-lipids are cross-linked, and the membrane is much sturdier as a consequence, but stiff at low temperatures.

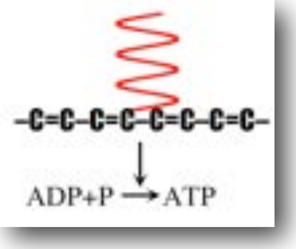
While it was suitable for clay-bed temperatures, it was unsuitable for ocean temperatures, so it was a lineage that discovered a more fluid membrane that graduated from the clay eden with the resources to thrive and explore this new phase space in the ocean. At least one archae-lineage also learned how to make fluid lipids—perhaps by horizontal gene transfer of the necessary digital information from the eubacteria—and joined them in exploring the world ocean.

The LUCA was a vital unit that used digital information to generate analog waves to control water and metabolism in a way akin to how a music score is transformed into the symphonic control of the air pressure in a concert hall.

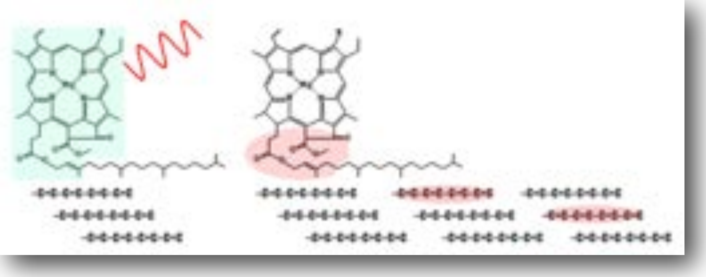
The LUCA was probably more akin to the archaea because they survive in environments similar to those found on the young earth—hot springs, sea vents releasing sulfide-rich gases, boiling muds around volcanos, etc. They use mineral energy to drive their metabolism, i,e., sulfides, etc.

Procaryote Radiation

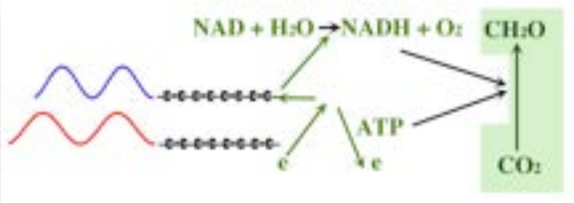
The fluid membrane opens up a whole new phase space to explore and learn about. The iron and hydrogen sulphide in the ocean activated by UV light provided a source of energy at first, but the exploration soon discovered *pigment* molecules that absorbed light and elevated electrons to levels that could drive the proton-motive ATP cycle with hydrogen sulphide as electron acceptor. These pigment molecules had conjugated double bonds whose delocalized electrons resonated with photons, just as in an antenna, and absorbed their energy. These excited electrons were then passed down a cascade to drive the proton-motive force.



Eventually, such exploration led to the discovery of chlorophyll as perfect for an antenna. The magnesium’s electrons are delocalized over the entire body of the molecule. These delocalized electrons absorb a photon and jump into the excited state. The shape of this excited wave is localized near the long hydrocarbon chain by which the body is embedded in the phospholipid membrane. This tail is adjacent to other, simpler conjugated molecules, and the excited electron is passed on down a cascade to drive proton-motive force.

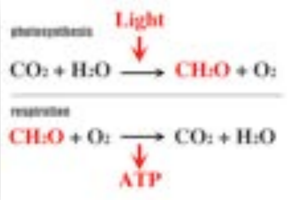


When a hydrogen atom in the body of chlorophyll-A is replaced by a methyl group, as in chlorophyll-B, the resonant frequency is altered and a different color of light is absorbed. It was soon discovered that if an excited electron from A was passed to B and another photon absorbed, then the electron had sufficient energy to strip hydrogen from a water molecule and attach it to NAD, with the liberation of free oxygen. The activated hydrogen of NADH could then be used to reduce the plentiful carbon dioxide to carbohydrate.



This photosynthetic double activation by light totally liberated living systems from any abiotic molecules for food, and was perfected in the green photosynthetic eubacteria that flourished.

The oxygen released was at first absorbed by *sinks*. These oxygen sinks included the ferrous iron that saturated the ocean, which was oxidized into insoluble ferric oxide that precipitated out as the great iron ore beds we mine today. Hydrogen sulphide and ammonia were oxidized in the UV irradiated atmosphere.

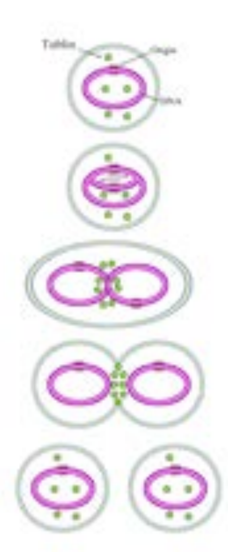


Eventually all the sinks were full and free oxygen appeared in the atmosphere, a major change in the environment over a few million years. Adjustment to free oxygen was a major challenge, and exploration of phase space eventually established a successful lineage that could thrive in the nighttime by reversing the photosynthetic cascades to use oxygen to convert carbohydrate into ATP, carbon dioxide, and water. This is *oxidative respiration* and is the great cycle of carbon dioxide and water in life powered by light photons.

The LUCA is estimated to have lived some 3.5 to 3.8 billion years ago when the atmosphere contained no free oxygen, and all metabolism was anaerobic. There is evidence that living systems emerged in the period of 500 million years after the earth was formed, the LUCA some time after that, and the prokaryotes diversified after that for the next 1.5 billion years.

Prokaryote Division

The asexual division of a prokaryote into two independent vital units is relatively simple. The unified internal wave changes as the protein AC generators change in number through a series of steps. The DNA double helix is in a single loop attached to the membrane at the *origin* stretch of DNA.

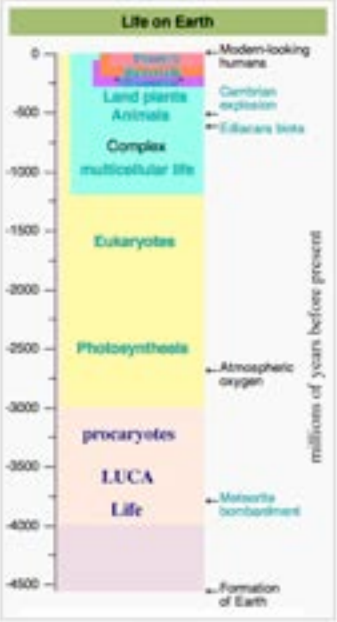


The DNA replicase enzyme-complex unwinds the origin DNA and duplicates it in both directions. As the two copies of DNA elongate, the tubulin proteins (ancestral to the tubulin of the eukaryotic cytoskeleton) collect in a ring about their connecting point, pinch in the membrane and cell wall, and complete the membrane and cell wall that separate the two daughter cells.

The next eden

Cyanobacteria use water, carbon dioxide, and sunlight to create their food, the byproduct of this process being free oxygen. At first, this oxygen was rapidly reduced by the omnipresent ferrous ions in the seawater, but as the ferric iron precipitated out, free oxygen started to linger around. This was a major challenge, as oxygen is reactive and disruptive to an orderly metabolism.

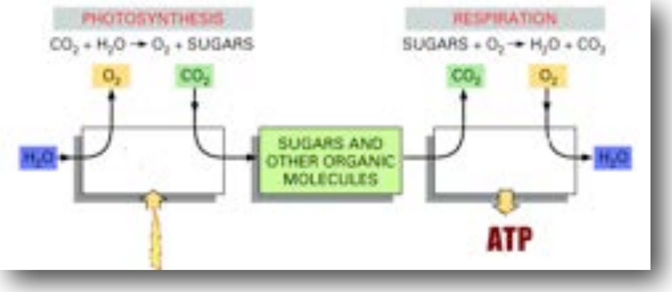
At least one lineage learned the solution to this challenge presented by the Logos in the current state of the environment. The lineage explored phase space by using a duplicate of the electron cascade from photosynthesis and running it in reverse, letting the electrons released by carbohydrate breakdown fall down the cascade, generating ATP by proton-motive force, and ending up on oxygen. Two hydrogen ions then add themselves, generating a molecule of water.



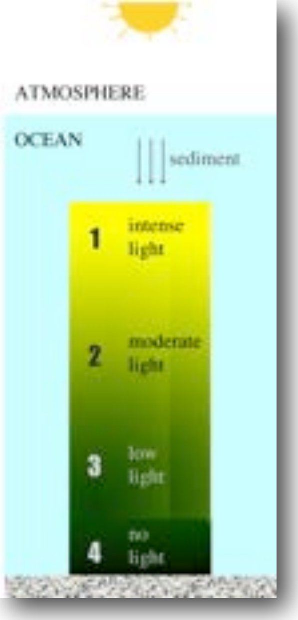
This lineage could thrive in the light of day, splitting water to liberate the oxygen and adding the hydrogen to carbon dioxide as carbohydrate. The lineage could equally thrive in the dark of night when carbohydrate could be split into carbon dioxide and the hydrogens added to oxygen regenerating water. This was the origin that developed into the oxidative respiration used in most eukaryotes.

A layer of mucus often forms over mats of cyanobacteria. In modern microbial mats, debris from the surrounding habitat can become trapped within the mucus, which can be cemented together by calcium carbonate to grow thin laminations of limestone. These laminations can accrete over time, resulting in the banded pattern common to stromatolites. The dome-shaped morphology of stromatolites is the result of the vertical growth necessary for the continued infiltration of sunlight to the organisms for photosynthesis.

Stromatolites were abundant on the planet by three and a half billion years, a billion years after the formation of the Earth. The earliest stromatolite of confirmed microbial origin dates to 2.72 billion years ago, while a recent discovery provides strong evidence of microbial stromatolites extend-



ing as far back as 3.4 billion years ago. In the primordial ocean, the photosynthetic and respiring bacteria thrived and utterly changed the Earth as the concentration of oxygen in the atmosphere and seawater inexorably increased over millions of years. Colonies of these bacteria grew below the lethal UV depth in the shallows and, as sediment slowly settled onto them, they grew towards the light. As these *stromatolites* slowly extended upwards, a mix of sand and organisms, the light intensity in the interior fell and exploration allowed growth to continue, albeit slowly, in dim light.



Deep in the interior of a stromatolite where the light was absent was the eden in which the next level of sophistication emerged in a lineage of archaebacteria with fluid membranes. They abandoned the now useless photosynthesis and turned to a lifestyle as a recycler, as a heterotrophic scavenger. All a lineage had to do, really, to respond to this lightless challenge was to learn to feast by exporting its degradative enzymes to the exterior. These secreted enzymes would dissemble the dead and dying photosynthetic bacteria drifting down from the sunlight far above.

This lineage open up, and radiated into, a phase space in this stromatolite eden and explored and learned the system-building steps that led to the sophisticated multi-vital-unit eukaryotes.

THE EUKARYOTES

Stromatolites only form these days in shallow sea water unsuitable for most other life. In other locations they would be grazed away before they had a chance to form.

In the early ocean, stromatolites were by far the most sophisticated type of system around. They lasted tens of millions of years and provided the eden in which prokaryote lineages could explore their interactions and the system building that led to the eukaryotes.

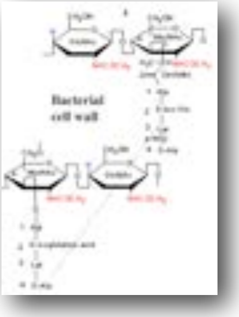
The mix of founder bacteria that initiated the stromatolite diverged into different varieties, simple races, that specialized as they explored and learned how to thrive in the different zones within the stromatolite.

1. At the surface, especially the top, the useful light and disruptive UV are intense. Here, races specialize in handling RNA damage and membrane oxidation.
2. Below is a zone of moderate light and low UV, and these races do well in moderate conditions.
3. In the low-light zone, the challenge is efficiency and making the most of every photon.
4. The response to the challenge of darkness is to abandon photosynthesis and rely on respiration alone and the recycling of debris drifting down from above.

LOGOS DERIVED, EMERGENT PROPERTIES

All bacteria secrete a cell coat to protect the delicate lipid bilayer. The cell coat is commonly made of murein, a rigid complex of linked sugars and amino-acids that surrounds and protects the delicate outer bi-lipid membrane like a coat of chain mail.

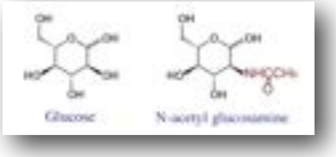
In prokaryotes, the primary function of the cell wall is to protect the cell from internal turgor pressure caused by the much higher concentrations of proteins and other molecules inside the cell compared to its external environment. The simple bacterial cell wall seems to be a relic of much earlier metabolic diversity in that instead of the usual L-amino acids it incorporates D-amino acids. The wall is located immediately outside of the cytoplasmic membrane. Peptidoglycan is responsible for the rigidity of the bacterial cell wall and for the determination of cell shape. It is relatively porous and is not considered to be a permeability barrier for small substrates.



Loss of cell wall

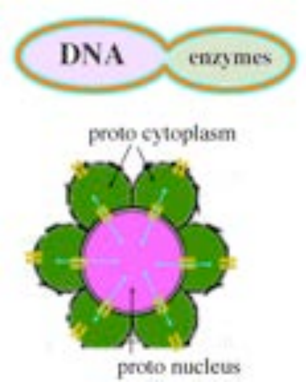
One of the first steps along the pathway to eukaryotes was a lineage abandoning this confining wall and learning how to manage without it.

Much much later, the lineage divided as one line developed a protective wall of cellulose, a branched mega-polymer of glucose, which led



eventually to the plants. Later still, the wall-less lineage divided yet again as one line developed a protective coat of chitin, a branched mega-polymer of N-acetyl-glucosamine, a derivative of glucose. In terms of structure, chitin may be compared to the polysaccharide cellulose. It is the main component of the cell walls of fungi. The lineage that did not readopt a protective exoskeleton that defined its shape developed instead a sophisticated internal cytoskeleton to define its shape and was the ancestral lineage that founded the animal kingdom.

But for many ages in the protective stromatolite eden, the ancestral lineage of all eukaryotes did without an external cell wall. Exploration of the scavenger phase space that opened up in the stable darkness found that the sturdy outer coat could be abandoned without harm. This allowed the digestive enzymes that were secreted to freely hydrolyze the surroundings and generate monomers that could be absorbed.

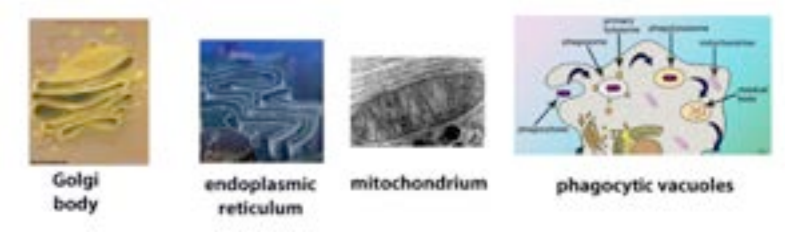


Powerful digestive enzymes, however, are dangerous to have around, especially in proximity to the digital store on DNA. At least one lineage learned the advantages of dividing but not duplicating DNA, so only one compartment had DNA in it. The extra DNA-free compartments could contain all the heavy industry, so to speak, with one compartment reserved for the delicate computer systems, the RNA CPU and DNA data stores.

All that would be needed is cell division, without DNA duplication, and incomplete separation. This was the beginnings of the nucleus in which the DNA is strictly segregated from the rest of cell metabolism.

Exploration of the advantages of many, diverse compartments continued. The path through phase space involved learning how to control the transfer of material between compartments. These discoveries included protein rails, the precursors of filaments as guides, and protein motors with loads to ratchet along these filaments. The filaments could transfer in both directions, so information on the state of the industry could flow back to the computer area. These were the simple beginnings of the cytoskeleton.

Further exploration learned the advantages of further specialization and, before the eukaryotes diverged, dozens of specialized compartments had been added as the basic eukaryote structure. The diagram illustrates are just a few examples of some of the compartments found in all plant, fungal, and animal cells.

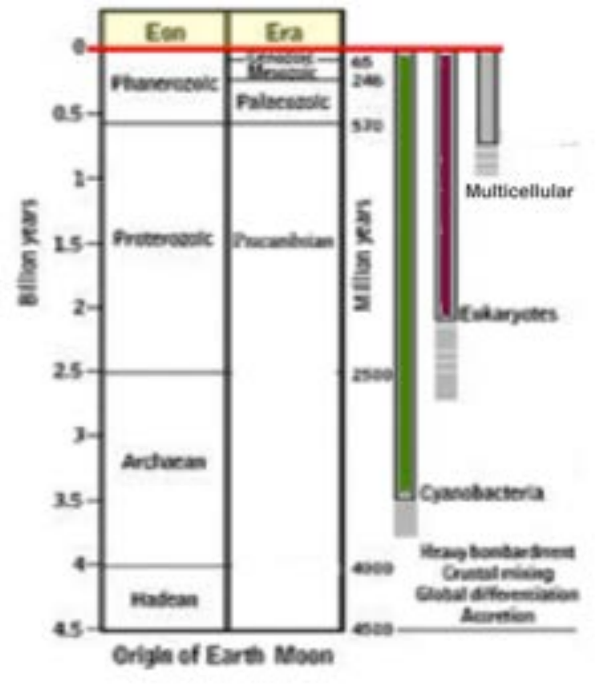


Emergent properties

At least one lineage eventually made the leap in sophistication from prokaryote to eukaryote. This involved learning how to assemble a number of interrelated subsystems that differentiate the sophisticated eukaryotes from the simpler prokaryotes.

Very few of the transitional forms were able to survive outside the stromatolite eden and there are only a few *primitive* eukaryotes still around today. The list of levels of sophistication that emerged in the lineage that left the womb and radiated into the wider world is extensive and, not surprisingly, it took a long stretch of time to learn it all and a lot of extra DNA to store all the digital information accumulated down the lineage that was needed to generated all the different analog forms that were required.

Much is still to be elucidated regarding the details of this development, but it seems that only one lineage accomplished all of the steps with the ability to leave the stromatolite eden and explore and populate the larger world. It did not take the descendants long to learn that stromatolites were an excellent food supply, and the stromatolite were grazed almost to extinction. Stromatolites now only survive in waters almost all other life forms find too hostile to bother with.

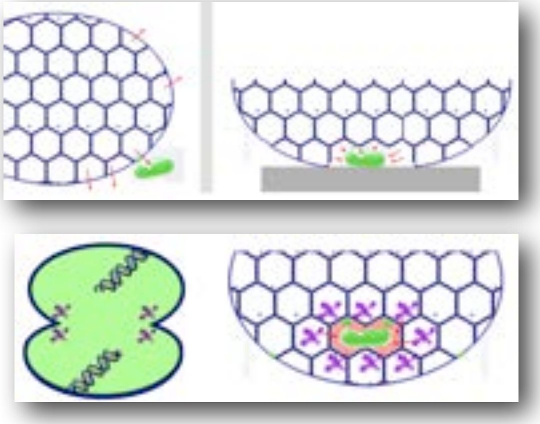


The list of developments along the line to the eukaryotes that left the stromatolite womb includes:

1. Phagocytosis
2. Cytoskeleton
3. Centrosome
4. The assembly line
5. Chromosomes
6. Nucleus and Nucleolus
7. Sophisticated digital processing
8. Domestication of prokaryotes
9. Mitosis
10. Sexual reproduction

We will now discuss each of these developments separately, although they are often intermixed with each other.

PHAGOCYTOSIS



In any other environment, being without a protective wall was a lethal experiment but, in the stromatolite eden, it had a great advantage that the scavenger was in intimate contact with the dead cells drifting down into darkness from the light above. The cell could grow without being limited by its surface area that could be irregular. It could learn how to envelope fragments of dying cyanobacteria against a surface and digest them in a pocket, rather than just wastefully secreting digestive enzymes into the environment as bacteria do.

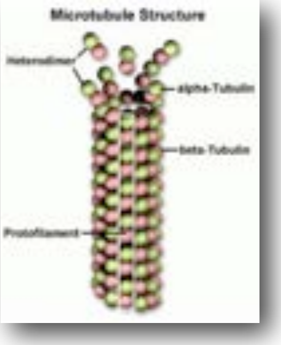
Experimenting with the proteins used to divide a prokaryote into two, variants were developed that closed off the pocket so that the prey was in a *vacuole* into which the enzymes were poured to digest the prey into its monomers.

The lineage learned about phagocytosis from the Logos and flourished. It was safe and protected. The lineage further explored the phase-space possibilities provided by the Logos.

Cytoskeleton

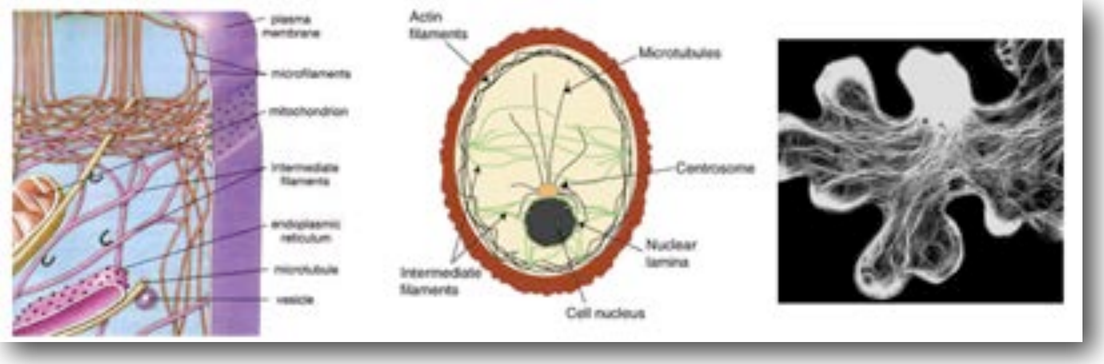
Rather than control its shape and form with an external cell wall, the eukaryote lineage controlled its shape with an internal cytoskeleton. As the number and variety of vital units increased, so did the cytoskeleton become more elaborate. Each vital unit, like a prokaryote, could be in a number of states. The cytoskeleton controlled the state of each vital atom, switching them about according to the digital information patterns stored on DNA that were expressed in the cytoskeleton. All eukaryotes have this structure:

> The apparently formless background of the cytoplasm of the cell… has been shown to have an internal structure when examined by high-voltage electron microscopy…. A microtravecular lattice, an irregular 3-D lattice of very slender protein threads…. A 3-D spider web in which are suspended the … organelles …enclosed by membranes which effectively partition the cytoplasm into specific compartments.… The contents within a compartment may be quite different from the environment in the general cytoplasm or inside other [compartments].[33]



The details of the development of the cytoskeleton common to all eukaryotes are currently unknown, but the lineage must have explored the phase space of possibilities opened up by structural proteins, such as the microtubules. These are mega-structures in which the system wave embraces large proteins as subsystems.

During this period, a lineage developed the three main kinds of cytoskeletal filaments found universally in eukaryotes: the microfilaments, intermediate filaments, and microtubules. The cytoskeleton provides the cell with structure and shape. Cytoskeletal elements interact extensively and intimately with cellular membranes at attachment points.

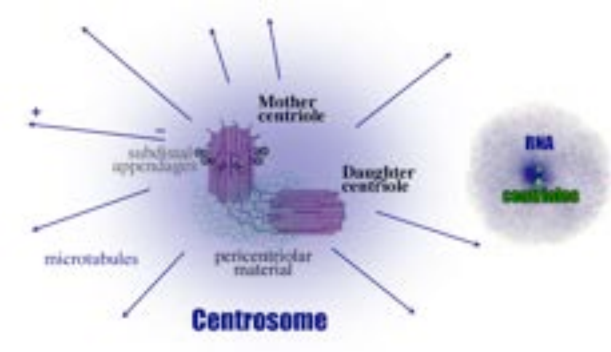


The filaments can be thought of as the ropes that pull and the posts that push in the erection of a circus tent. The structural elements can also transmit and receive images from one end to the other; they are both sensory and motor.

It is the interplay of these that gives shape to the wall-less ancestors and allows them to develop phagocytosis. The fibers of the cytoskeleton control the state of the vital unit they are attached to.

The Centrosome

The state of the cytoskeleton controls the states of the vital atoms, and the control of the cytoskeleton is centralized in the centrosome.



All of the cytoskeletal fibers have an *output* plus end attached to a vital unit, while all the *input* negative ends converge at the centrosome.

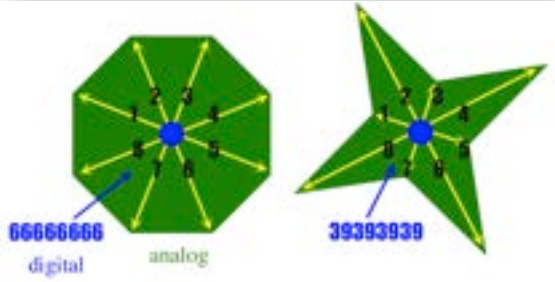
The bulk of the centrosome is a halo of RNA and attendant proteins, the pericentriole, and at the center are the *mother* and *daughter* centrioles.

In the period of the cycle called *interphase,* the cell is not preparing to divide, and it is the mother centriole that is in charge while the daughter just tags along.

The mother centriole converts the digital information on the RNA into the activity of the microtubules that control the states of their attached vital units. Digital information is converted into the analog form of the many vital units of which the cell is composed. The centriole translates digital information into analog form—it is a DC/AC converter. This is the role of the ribosome at a higher level of sophistication.

> A novel RNA was detected in the centrosomes…. This RNA was named centrosomal RNA (cnRNA); five different cnRNAs were described. During the sequencing of the first… it was discovered that the transcript contained a conserved structure—a reverse transcriptase domain. In a 2005 study, we speculated about several possible mechanisms for determining the most important functions of centrosomal structures and referred to one of them as an "RNA-dependent mechanism"…. The presence of a reverse transcriptase domain in this type of RNA, together with its uniqueness and specificity, makes the centrosome a place of information storage and reproduction.[34]

As the workings of the centrosome are still currently a topic of investigation, we can only suggest an analogy for the connection between the digital information in RNA and the state of the cytoskeleton and, hence, the state of the attached vital units.

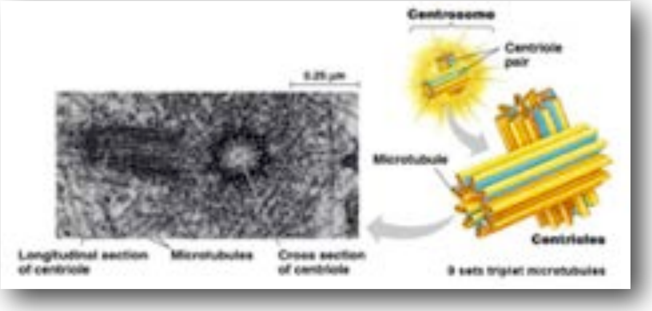


Consider a kite with eight struts radiating from a core that adjusts the length of each strut as indicated by a sequence of eight digital numbers sent up the kite's cord from a handset. Each sequence of digital numbers results in a different analog form to the kite, just two of which are illustrated.

This is an example of digital information being translated into specific analog forms, another DC/AC converter.

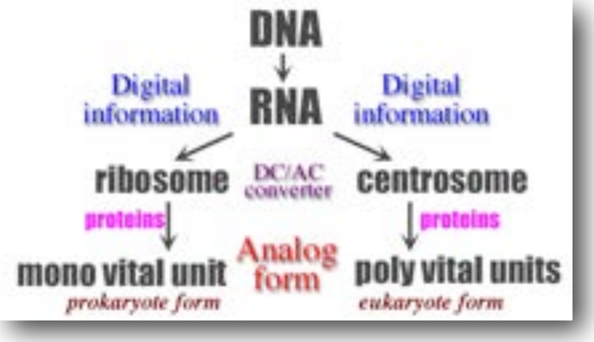
In the lineage leading to the eukaryotes, this type of digital control was perfected. The fibers of the cytoskeleton not only control the state of the many vital units, they can also bodily transport whole units about within the cell and perform many other functions that are only now being explored.

The centrosome is the microtubule organizing center of the cell as well as a regulator of cell-cycle progression. The centrosome we have described is thought to have evolved only in the animal lineage of eukaryotic cells. Fungi and plants use other similar structures to organize their microtubules.



A centrosome is composed of two centrioles, barrel-like structures made mostly of tubulin. They are at right-angles to each other and surrounded by a star-shaped ‘aster’ of RNA and many proteins. The proteins are responsible for microtubule nucleation and anchoring. Each centriole of the centrosome is based on a nine triplet microtubule assembled in a cartwheel structure.

Eukaryote form

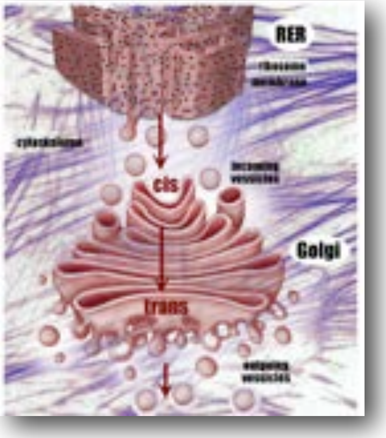


The primary cilium, a long skinny cellular extension found in most cells, grows off one of the centrosomes. This primary cilium is probably involved in some sensing mechanism. In fact, in some cells (such as the rod and cone cells of the eye), the primary cilium is where most of the cellular sensory apparatus is located.

The centrosome receives RNA from the nucleus and adjusts the cytoskeleton to the requested form. As eukaryotes can change form quite rapidly, we can assume that a constant stream of RNA arrives at the centrosome from the nucleus to balance the breakdown of old messages. This is the way that ribosome output on the mono unit level is regulated. The ribosome and centrosome are the DC/AC converters on their respective levels of sophistication.

The pattern is, as always, systems of organized interacting subsystems. Ribosomes organize aminoacid polymers to generate the internal AC wave of a prokaryote-level mono vital unit. Centrosomes organize vital units to generate the internal AC wave of a eukaryote-level poly vital unit.

THE GOLGI ASSEMBLY LINE



The exploration of the phase space in the Logos resulted in the specialization of vital subunits for centralizing the bulk manufacture of proteins. They developed into a set of vital units that acted as an assembly line.

Those at the start of the assembly line are called the rough endoplasmic reticulum (RER). The walls of the RER are studded with ribosomes that are busy translating mRNA into proteins—the mRNA originating from the nucleus. The proteins that accumulated inside the walls are regularly budded off as vesicles which the cytoskeleton conveys to the Golgi Body.

The Golgi is a set of stacked, flattened vital units that, like an assembly line, has a starting point—the *cis face*—and an ending point—the *trans face*. A vesicle arriving from the RER merges with the cis face of the Golgi. Its contents are passed from compartment to compartment being specifically modified along the way. Finally reaching the trans face, the products are sorted and packed into vesicles, an address label affixed and the vesicle budded off for the cytoskeleton to deliver to its intended destination.

Cells synthesize a large number of different proteins in the RER. The Golgi is integral in modifying the proteins from the RER—such as attaching a carbohydrate to specific places on the primary structure, thus adjusting its folding and properties. The Golgi is also involved in the transport of lipids around the cell, as well as the generation of lysosomes—recycling units filled with digestive enzymes to which the cytoskeleton can transport worn out organelles or ingested prey for breakdown and reuse.

The Golgi sort, package, and address the vesicles for transport by the cytoskeleton to the many different destinations within the cell. This last function is similar to that a post office; it packages and labels items which it then ships to different parts of the cell.

The efficiency of such an assembly line with its linear sequence of specific actions is to be seen today in the computerized manufacture of a car, where each robot performs its function in turn.

As the number of sophisticated analog forms learned and accumulated down a lineage increased, the digital information needed to store and manipulate these analog forms also increased. Two major innovations in digital technology occurred in the ancestral eukaryote lineage. The innovations were probably interwoven, but we will deal with them separately.

The first innovation was librarian-like, it involved the compact storage of huge amounts of digital information and an efficient way of reading a required piece of information. This is the chromosome with DNA stored on reels of histones.

The second innovation was akin to the computer leap in digital sophistication from the 8-bit world of ASCII and MS-DOS to that of the 16-bit computer of Windows, in which ASCII is only a subset of the information manipulated. This advance involves *post-translation* manipulation of mRNA before it is translated into proteins. The triplet-code *exon* sequences are embedded in not-triplet code *intron* sequences. They are copied together from DNA store to RNA and the introns are then stripped out. The remaining exons are linked together as an mRNA for transport to the ribosomes for translation into protein.

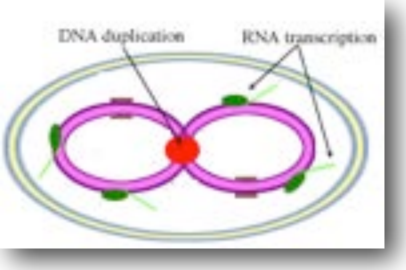
A similar stripping of higher-level code to create a simple ASCII text file happens in modern computers. While this manuscript is full of high-level information—inset graphics, multiple variations on fonts, etc.—if I choose to save my document as a *Text Only* file, all this high-level information will be stripped away and a simple ASCII file saved to disk; a file identical to those of the 8-bit era of technology.

CHROMOSOMES AND HISTONES

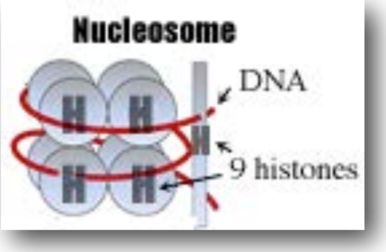
While both prokaryotes and eukaryotes use DNA for deep-time storage of their inheritance of digital information, they manage their DNA store in very different ways.

We have already mentioned that the defining difference is that eukaryotes have multiple compartments, with the DNA stored in one compartment, the nucleus, and metabolism occurring in all the other compartments.

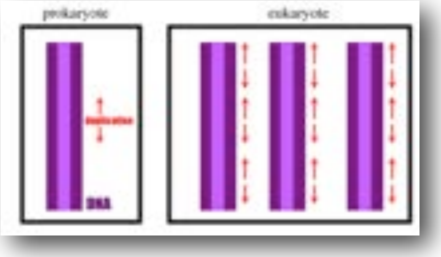
In the prokaryote vital unit, the DNA is a single loop attached to a protein anchor embedded in the cell membrane at a specific location called the nucleoid at about the midpoint of the cell. Close to this anchor is the unique origin for the initiation of DNA replication. Starting at this origin, the DNA is duplicated in both directions to generate two copies.



The DNA is loosely confined to the nucleoid by *packing proteins* which, when the state switches to spore, effect the condensation and dehydration of the DNA for stability over deep time. Other than this, the prokaryote DNA is always in the same state, and bacteria in the abundant state duplicate the DNA and transcribe RNA all at the same time.



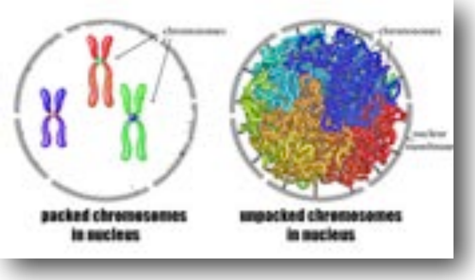
The much larger amount of DNA in a eukaryote nucleus is divided into a number of highly-structured chromosomes. The DNA double-helix is wrapped twice about a nucleosome, a reel composed of eight histone proteins, and locked in place with a ninth histone. These histones are among the most conserved of all proteins, and they have only slightly diverged down countless lineages since their discovery by the ancestor of plants, fungi, and animals.



The DNA is unwrapped from its nucleosomes for RNA transcription and then rewound when no longer required. The DNA is also unwrapped from the nucleosomes for duplication at multiple bidirectional sites along the chromosome and the fragments are then joined together. Unlike prokaryotes, duplication and transcription of DNA do not occur at the same time. There are three basic states that eukaryote DNA can be in:

1. *Growth*. The DNA is partially condensed and attached to the nucleus membrane. The unwound stretches are free to be transcribed into RNA. Each chromosome has its own volume inside the nucleus.
2. DNA *Duplication*. There is no transcription of RNA and all the DNA is unwound from the nucleosomes for copying.
3. *Cell Division.* The DNA is entirely wrapped on nucleosomes, and the spools are stacked and compacted into the condensed chromosomes. These have caps of repetitive DNA, called telomeres, and a somewhat central place specialized for cytoskeleton attachment called the centromere.

The DNA in each human cell is about 6 feet long— this is by no means a record—and this entire length is condensed on scaffolding proteins into a ~3 trillionths of an inch. As this condensation usually happens after DNA duplication, there are two identical *chromatids* attached at their centromeres ready for cell division (yet to be discussed). When the eukaryote cell is not preparing to divide, the DNA strands each have their own volume in the nucleus in which the DNA is strung from attachments and is in a partially open and partially packed state.



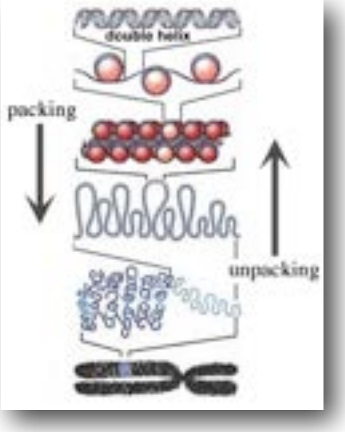
In certain situations, the DNA of a chromosome remains condensed and inactive. A mammalian example of inactivation of an entire chromosome is the X *dosage* difference between a male and female.

A male has one X chromosome in every cell that was received from his mother. All the cells of a female start with two X chromosomes, a maternal and a paternal. About 6 weeks into gestation, however, every cell in the embryo condenses one of its X chromosomes—apparently at random—and it becomes a Barr Body that gets duplicated but remains condensed down its lineage.

This mosaic of maternal and paternal active chromosomes is visible in the tortoiseshell cat which is always female. One color coming from mom's X and the other from dad’s.

Prior to cell division, the DNA is duplicated and packed neatly into two chromatids—the two DNAs—attached together at the centromere.

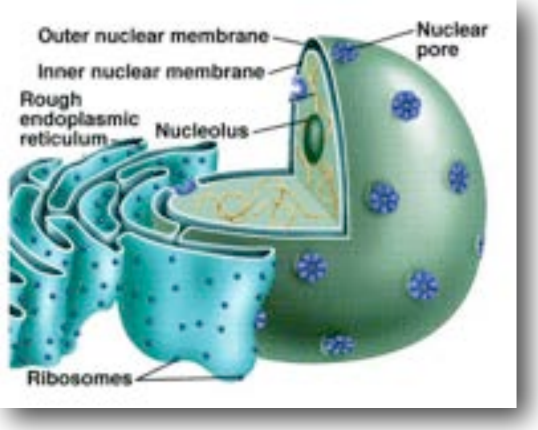
In the next steps, the reels are tightly stacked together, the stacks folded, and folded again, to form the condensed chromatids attached at the centromere. The proteins that participate in this condensation are descendants of the packing proteins that herd the DNA in the prokaryote nucleoid. In the *interphase* state of the cell (i.e., when the cell is not preparing for division), most of the DNA is kept wrapped on stacked nucleosomes except when sections are unwound for RNA transcription.



The Nucleus and Nucleolus

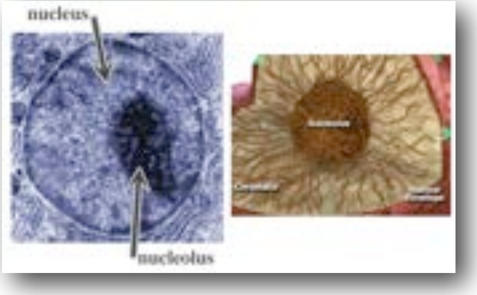
All the DNA digital store of a eukaryote is contained in the membrane-bound nucleus, and much of its content of RNA is concentrated in the nucleolus. The nuclear membrane consists of two lipid bilayers—the inner nuclear membrane and the outer nuclear membrane. The outer nuclear membrane is contiguous with the membrane of the endoplasmic reticulum, and the space between the two membranes is contiguous with the contents of the endoplasmic reticulum.

The inner nuclear membrane encloses the nucleoplasm, and is covered by the nuclear lamina, a mesh of *nucleoskeleton* proteins (similar to the cytoskeleton outside the nucleus) which stabilizes the nuclear membrane, as well as being involved in chromosome function and gene expression. The inner and outer membranes are connected by nuclear pores that penetrate the membranes. The nuclear membrane is punctured by thousands of these nuclear pore complexes—large hollow proteins with an inner channel.



The main structures making up the nucleus are the nuclear envelope, and the nucleoskeleton (which includes nuclear lamina), a meshwork within the nucleus in charge of transportation within the nucleus. The interior of the nucleus does not contain any lipid membrane-bound subcompartments, but the contents are not uniform, and a number of subnuclear bodies exist, made up of unique proteins, RNA molecules, and specific parts of the chromosomes. The largest of these is the nucleolus that takes up to about 25% of the nuclear volume.

In the prokaryote, almost all the RNA transcribed from DNA is translated into protein primary structure. The opposite is true in eukaryotes, where the majority of the RNA transcribed from DNA never makes it out of the nucleus to instruct a ribosome. The majority of RNA remains in the nucleus and is involved in the manipulation of digital information. This is akin to the central processing unit (CPU) of a modern computer where masses of digital information are manipulated and only the re-



sults are sent to the output ports of the CPU. The output ports of the nucleus are the nuclear pores through which the results of the digital manipulations are exported via skeletal proteins: the flood of rRNA , tRNA and mRNA all creating the protein activity directing each vital unit, and the sporadic centro-RNA to program the centrosome and the overall state of the cell.

Chromatin is DNA not in the highly compacted form of the chromosome. The nucleolus is a knot of chromatin. The functions of the nucleolus are currently under investigation, but one thing that is established is that it controls the production of ribosomes for export out of the nucleus. It also has all the characteristics expected of a CPU involving RNA manipulations:

> The nucleolus also contains proteins and RNAs that are not related to ribosome assembly and a number of new functions for the nucleolus have been identified. These include assembly of signal recognition particles (SRP), sensing cellular stress and transport of HIV messenger RNA.[35]

The last item is very suggestive. The RNA that redirects the metabolism of a cell into making virus particles is managed by the nucleolus. This suggests that the nucleolus also manages the top level RNA, the current program called up to run the cell in nonpathological situations. It is becoming clearer in the literature that the nucleolus is in charge of determining the cell cycle and cell differentiation.[36]

The SRP are RNA/protein complexes that attach to proteins as they are coming off ribosomes and are the addresses used by the cytoskeleton to deliver the protein to its correct destination.

In some organisms, particularly plants, when two nuclei are combined into a single cell during hybridization, the nucleoli compete for control. The RNA genes of one nucleolus are suppressed and not generally transcribed, though reactivation of the suppressed RNA genes may occasionally occur. This selective preference of transcription of RNA genes is termed nucleolar dominance.

The connection between sensing stress in a prokaryote and the writing or reading of digital information of DNA in response was discussed earlier. As the nucleolus has been established as a sensor of stress in the eukaryote cell[37], we can expect that a similar dynamic will be discovered in the nucleolus.

I suggest that all this is very CPU-like manipulation of digital information generating the output of the nucleus and thus the state of the cell. The exact location and functioning, however, of the digital CPU in the nucleus will need to await more detailed elucidation.

SOPHISTICATED DIGITAL PROCESSING

It should be quite clear from all the above that the eukaryote system is a whole new level of sophistication in which the prokaryote system is but a subsystem. While the ASCII-like triplet code suffices admirably for the simple prokaryote, it is incapable of encoding the sophistication of the eukaryote cell.

We again have an illustrative example from the realm of computer technology. The first computers using the ASCII code were only capable of the very rudiments of word processing, the reading and writing the digital information of simple text. The screen and printer had only one font for output, the monospaced *Courier* font that mimicked the fixed space of the manual typewriter—`and looked like this.`

The document processing of my MacBook Pro is much more sophisticated, it can deal with so much more than plain Courier text—even unusual text such as this.

If, however, I choose from the menu the **Plain Text** command, all the extras are stripped away from the ASCII, and the display is, again, such as this.

This increase in sophistication of computers was due to the input of human ingenuity. The increase in sophistication from prokaryote to eukaryote was due to input from the higher levels of the Logos as the exploration of phase space stepwise learned to manipulate digital information in a systematic hierarchy of increasing sophistication.

Digital systematic hierarchy

In the computer world, there developed over decades a systematic hierarchy founded on the the byte of the ASCII code.

The first step in sophistication was to manipulate digital data two bytes at a time—the realm of 16-bit computing. The ASCII code of eight bits never changed, but now the second byte could be used to code for single character properties such as *italic*, ***bold italic,*** and ***<u>bold italic underlined</u>***. The next step was to a 32-bit system in which the ASCII was still embedded, as ever, but the third and forth bytes could be used to code for thousands of colors.

The Mac I am writing on can run in 64-bit mode but accommodates older software that runs in a 32-bit environment. This manuscript I am writing takes up 14,000,000 bytes when it is stored on the hard drive, but almost all of that is not in ASCII code but in instructions about what to do with that ASCII which encodes about 100,000 words in about 100,000 bytes of ASCII. Only about 5% of the digital information is in ASCII which is on the same order of the 1% of the digital information in human DNA that is in the triplet code and is translated into protein. Like early computers where almost 100% of the digital information is in ASCII code, almost all of bacterial DNA is in Triplet Code.

1ST BYTE	2ND BYTE	3RD BYTE	4TH BYTE
ASCCI	italic	🟧	
ASCCI	bold	🟩	
ASCCI	underline	🟪	
data	instructions		

If a disk utility is used to examine the bytes of information stored in the normal file, it will be found to consist of ASCII bytes separated by non-ASCII multibyte stretches of binary information. In the plain text file, it will look exactly like that in the earliest computers, a sequence of ASCII codes.

All computers have basic ‘housekeeping’ that runs all the basic functions, such as keyboard input, screen display and reading and writing to digital storage, the Disk Operating System, DOS or *System*.

Simple Computers

On the 4-bit machines, the system that became the standard was CPM, which could hardly handle wordprocessing. This was quite rapidly replaced by 8-bit systems that could handle one byte of eight bits at a time, and ASCII became the standard.

The standard emerged because of interaction, you could only read another file if the same coding was used. In living systems, the equivalent stage was the 2-bit codon.

Wordprocessing could now handle content well, but to indicate any kind of formatting you had to insert codes into the text marked off with reserved characters. A phrase such as “He *said* that E=mc^2 was bunk” had to be entered as “He {i}said{i} that E=mc{sp}2{sp} was bunk.” You could do it, but it wasn't easy. Forget about color. This was the world of MS-DOS, 400K disks for storage and plain text files.

The simple living systems called prokaryotes (bacteria) use a similar system on a single strand of DNA. Almost all of its inherited digital information is codons that code for amino acids, the equivalent of plain text files in MS-DOS.

Sophisticated Systems

For computers, the step-up to 16-bits soon settled on the standard called Windows. Now there was space to mingle data and simple instructions. No more insertion of a code, now *italic* could be turned on and off at the click of a button.

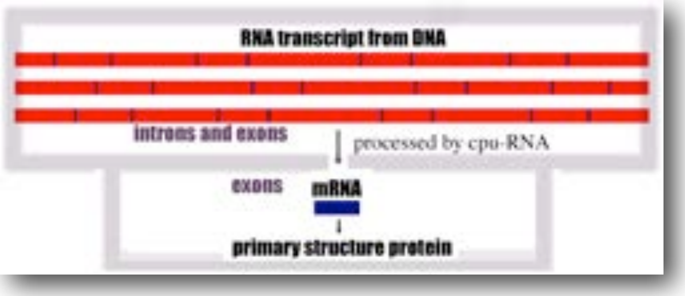
On my 64-bit computer, the ASCII code is still there taking up 1 byte with the other 7 bytes allowing millions of colors, scores of different fonts, and a plethora of different languages. With a few clicks I can now write ιν γρεεκ, ين ارابيص, んジャパネセ and יקנרןק’ (*in Greek, in Arabic, in Japanese and in Hebrew,* respectively), in colors and sizes as easily as in English.

While the 8-bit computers struggled as wordprocessors, my 64-bit Mac can play a plethora of roles with ease: publish books, play music, videos and TV, take photos, do international videoconferencing, Photoshop people out of photos, etc.

Introns and exons

All the more sophisticated eukaryotes—everything else except the bacteria—use the equivalent of Windows, although the method of mixing data and instructions is different. All the data in eukaryotes, the codons for amino acids, are broken into long strings of bases, called exons, separated by long stretches of codons that are not translated, the introns. These untranslated stretches contain instructions, such as how to splice out the introns and link up the exons correctly into an mRNA where the stored digital information is converted into the correct primary sequence for a protein. The spliced-out intron mixes with the RNA pool for a while, informing it, at the very least, that such and such an mRNA was recently generated.

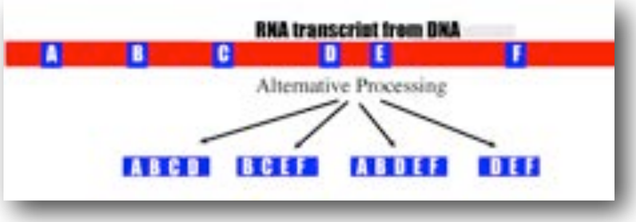
The human dystrophin gene is an extreme example of this preponderance of introns. The RNA transcript is the largest known to date, spanning 2,200,000 bases on the X chromosome that takes 16 hours to transcribe into 2,200,000 bases of RNA.



The gene size is mainly accounted for by huge intronic regions. After splicing out 2,186,000 bases of RNA introns, the 79 exons that remain are spliced into an mRNA of just 14,000 bases for translation by a ribosome. There it codes for a protein of 3,500 aminoacid residues that is essential to proper muscle functioning. Comparison of intron sequences of the human and mouse genes revealed that they are extremely conserved in size and that a similar fraction of total intron length is represented by repetitive elements. It seems like there is something that is important to protect from mutation—which suggests that cells control when and where changes occur in the DNA.

Boilerplate mixing

In recent years it has become apparent that most proteins have a modular structure, and the same module can appear in a large number of different proteins. Each module has a specialized function, such as binding ATP or sticking a zinc finger into DNA. A protein can have a dozen or so modules and unite all their disparate abilities into the precise ability of the protein. If correct, the modules would be the primary subsystems of proteins. The immune system does something similar when it permutates a set of modules to generate almost all the shapes a molecule can be before testing them to eliminate the self-shapes.



Sophisticated living systems can do even more with modules, they have the equivalent of ‘boilerplate’ text. Both prokaryotes and eukaryotes translate the codon-equivalent of a plain ASCII text recalled from disk into an analog output from the ribosome. The difference is that the mRNA that is read from the DNA is not processed before translation by the bacteria; in all other life, it is processed as the introns are excised before the RNA gets sent to the ribosome. Depending on the state of the RNA pool, a transcribed mRNA can be spliced into a variety of different mRNAs for translation.

This is akin to picking the first paragraph from boilerplate text:

1. *Dear Sir*
2. *Dear Madam*

Then picking the second paragraph:

3. *Thank you for your check…*
4. *We are concerned that we have not received your check…*

Just as in computers where 8-bit was simple and 64-bit is sophisticated, the prokaryotes running data-only ASCII never got very sophisticated, while all eukaryotes use the sophisticated method of mixing data and instructions.

DOMESTICATION OF PROKARYOTES

The control of life-units was so sophisticated at an early stage of the exploration of the phase space provided by the Logos that two very crucial events occurred in history—the domestication of the mitochondrion and, later, the chloroplast.

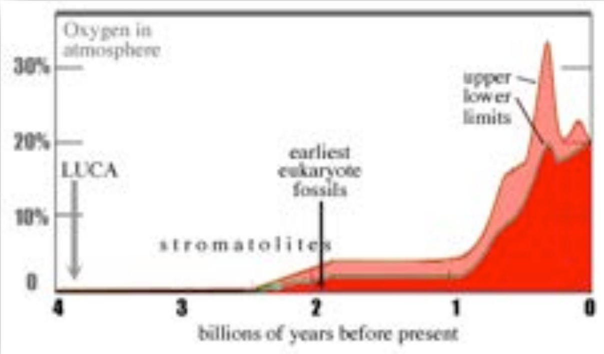
Phagocytosis has its dangers, e.g., a bacteria that is engulfed as food might resist being digested and, instead, infect the cell and kill it. In this way, the cell becomes food for bacterial multiplication.

An intermediate standoff situation can also occur. The bacteria enter the cell and end up in a digestive vacuole, but the bacteria is neither digested nor does it multiply. Such situations occur today, as with the tuberculosis bacterium. Most people who are exposed to TB never develop symptoms, since the bacteria can live in an inactive form in the digestive vacuoles of the lung cells. But they are constantly trying to escape control and spread from cell to cell. If the immune system weakens, such as in people with HIV or elderly adults, TB bacteria can become active. In their active state, TB bacteria cause death of tissue in the organs they infect. Active TB disease can be fatal if left untreated.

The oxygen generated by the photosynthetic bacteria in the stromatolites was not a problem at first because it quickly diffused away and was mopped up by the ferrous ions in the ocean. Some of the oldest known rock formations, formed over 3,700 million years ago, include banded iron layers. The formations are abundant around the time of the great oxygenation event, and become less common after 1,800 million years ago. The total amount of oxygen locked up in the banded iron beds is estimated to be perhaps twenty times the volume of oxygen present in the modern atmosphere. Banded iron beds are an important commercial source of iron ore.

Oxygen is an active gas, and it can cause many problems if it is more than a trace. It can form free radicals, such as oxygen and peroxide, that readily interact destructively with the molecules of life.

Something similar to the tubercle bacterium happened in one lineage of early eukaryotes. It ingested a bacterium that had perfected the process of aerobic respiration, the reverse operation of photo-



synthesis.

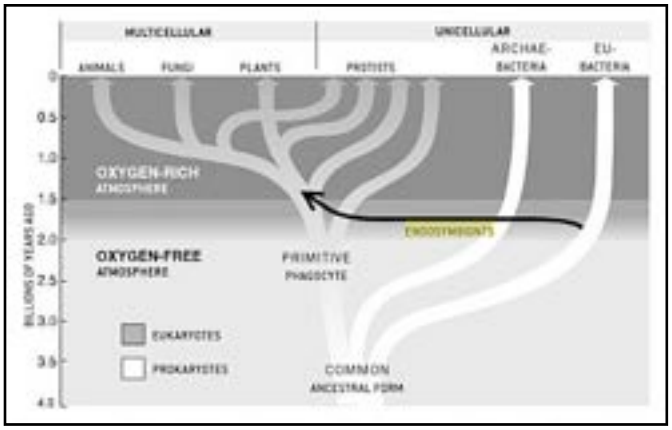
$CO_2 + H_2O$ + energy — photosynthesis ——> $CH_2O + O_2$
$CH_2O + O_2$ — respiration ——> $CO_2 + H_2O$ + energy

This bacterium was able to use the oxygen that was accumulating in the atmosphere and ocean to efficiently ‘burn’ food for ATP production instead of relying on the inefficient fermentation process used up until then by scavengers, which is what our ever-so-distant ancestors were in the stromatolite. The polite word is heterotrophs in contrast to the primary producers, the photosynthetic autotrophs.

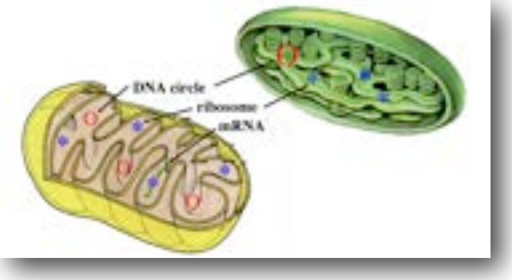
This latest-model bacterium, with its superior skills inherited from the Logos, ended up in a stalemate with the eukaryote ancestor. It could prevent itself from being digested, but it but could multiply unchecked.

It turned into a partnership as planned in the Logos. The eukaryote prospered: the bacterium soaked up all the otherwise toxic oxygen and excreted excess ATP. The bacterium prospered: the phagocyte proved a safe environment with an abundance of pyruvate to eat. It was a match made in heaven.

The phagocyte cautiously learned how to domesticate the bacterium, to let it grow and multiply, to attach it to the cytoskeleton, to govern its states. This was perfected in a lineage, the universal ancestor of eukaryotes-with-mitochondria (which is almost all of them) as the bacterium life unit was domesticated and became an integral, and essential, subsystem in sophisticated living systems.



Many of the mitochondrial genes we eventually transferred to the nucleus, with the proteins synthesized in the RER and transported to the mitochondria by the cytoskeleton. Presumably, long-distance control was inefficient for some crucial proteins and the mitochondrion retains a set of genes for the mRNA, rRNA and tRNA necessary to translate the few genes into protein. These are of the prokaryote varieties, and the mitochondrion divides just as a prokaryote does.

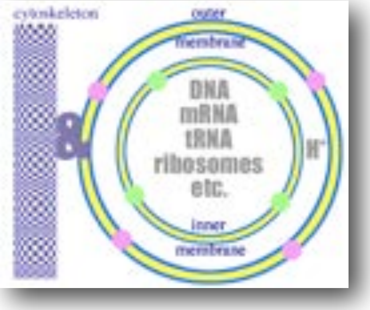


The mitochondria of all living things is descended from this lineage.

Later, a similar thing happened with a photosynthetic cyanobacteria. It was engulfed by a phagocyte with mitochondria, and it was also domesticated to became the ancestral chloroplast. Only a few of the genes were transferred to the nucleus, and the chloroplast has almost a full complement of prokaryote genetics.

This eukaryote lineage abandoned scavenging for a living and, following the plan in the Logos, became an autotroph that developed into the single-cell and multicellular plants.

These adopted bacteria are known generically as endosymbionts. Both the mitochondria and the chloroplasts, unlike most of the vital units, have a double bi-lipid membrane. All the DNA, ribosomes, tRNA and mRNA are within the inner membrane (as would have been the case for the ingested and tamed prokaryote). The inside of a chloroplast also has stacks of light-absorbing plates containing the chlorophyll.

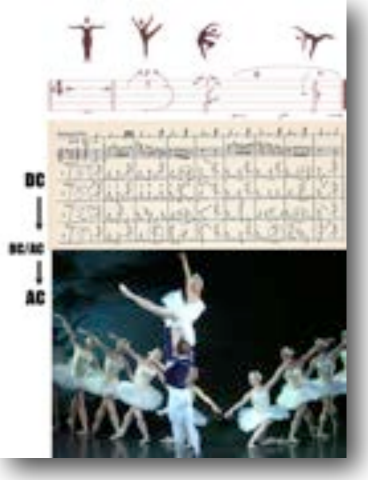


In both endosymbionts, the space between the inner and outer membrane is used for generating the proton-motive force. Both membranes have their specific portals that allow communication between the inner and outer space and the vital units surrounding it. The outer membrane is attached to the cytoskeleton so that endosymbionts can be moved as necessary.

The control of these endosymbionts is total. An example is the mammalian ovum, which has an abundance of mitochondria ready to power the development of the zygote. For decades, however, these mitochondria are all in the “off” state, as the dormant egg waits for release and possible fertilization.

During the mitotic division discussed in the next section, the centrosomes apportion the endosymbionts along with all the other organelles between the mother and daughter cells, and not always equally since it depends on what program they are running.

EUKARYOTE DIVISION

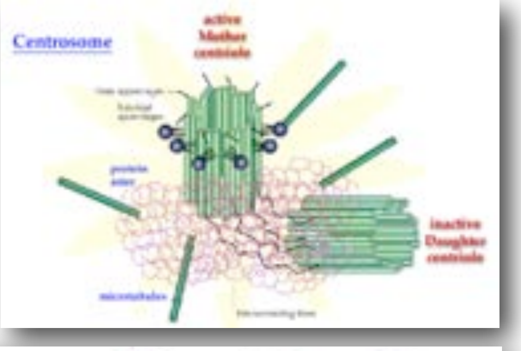
The structure of the eukaryote cell is complex, so dividing into two clones is not as simple as in the prokaryote. We have used the instructive analogy of a vital unit to a symphony. The process by which a eukaryote divides is *mitosis* and a useful analogy is a ballet.

The digital score for a ballet includes music and, in addition, a whole new set of instructions about arms, pirouettes, solos, duets, and corps behavior.

In an analogous way, the digital score stored on DNA is transformed by the DC/AC centrosomes in a beautiful choreography that has delighted and intrigued cytologists since mitosis was first observed.

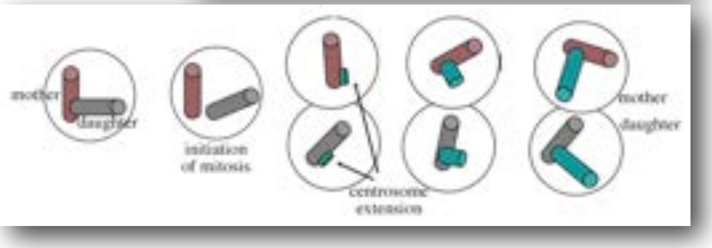
Mitosis occurs in a sequence of precisely organized steps, the very first being the duplication of the centrosome.

Centrosome duplication

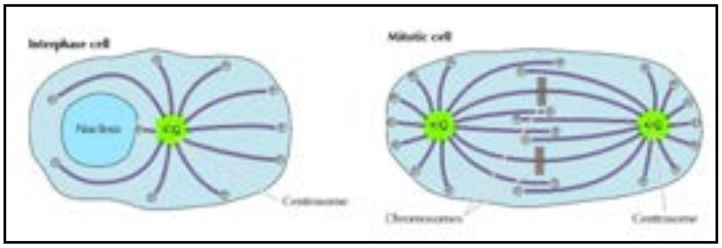
A eukaryote has just one centrosome in a cell. The two centrioles at the heart of the centrosome are not equivalent. One is the ‘mother’ centriole that is reading the mRNA tape and controlling the many vital units. The other is a subordinate, ‘daughter’ centriole that has a passive role until cell division.



The two centrioles come apart within the aster. The daughter cell becomes active, and the two centrioles read the same digital instructions conveyed to them on RNA. A new centrosome seems to extend at right angles off each old centrosome in a way reminiscent of semiconservative replication of DNA. These are granddaughters, and the end result is a mature mother-granddaughter centrosome and an immature daughter-granddaughter centrosome.



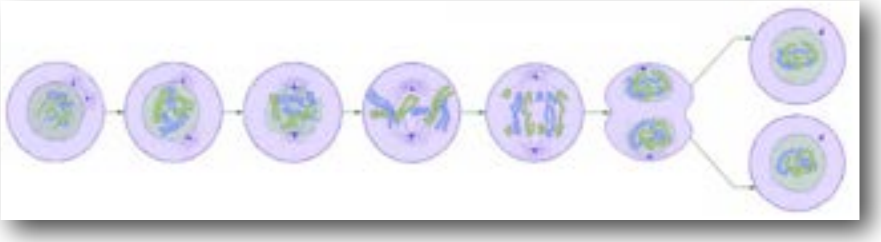
The immature centrosome now fully separates and is taken on what is called a ‘kissing tour’ of half the cell run by the mother centrosome. During this tour, the attachments of the life units to the mother centrosome are transferred over to the daughter centrosome.



After this transfer of responsibility over half the cell, the mother and mature daughter move to opposite poles to perform the amazing duet of cell division, or mitosis, learned from the Logos by the universal ancestor of all eukaryotes (protists, plants, fungi, and animals). The digital memory of how to do this has been passed on to all eukaryotes.

The next step involves the duplication of the DNA store and its complete condensation into a pair of chromosomes attached at their centromeres. The nuclear membrane is disassembled and a *spindle* of thick cytoskeleton forms between the separating centrosomes. The chromosomes are aligned on the *central plane* of the spindle and attached to it by their centromeres. The centromeres split and the duplicate chromosomes are pulled apart by the spindle to opposite ends. A new nuclear membrane is assembled around the chromosomes with the centrosome remaining outside.

The spindle is disassembled as the cell is pinched in two as new membrane is assembled at the central plane. The end result is two daughter cells, identical clones except that one has the original mother centrosome while the other the original daughter centrosome.



Spindle

During cell division, the gross manipulation of structure is visible under a microscope. Together, the two centrosomes run the same program that occurs in well-defined stages.

As the cell enters mitosis, the dynamics of microtubule assembly and disassembly change dramatically. First, the rate of microtubule disassembly increases about tenfold, resulting in overall depolymerization and shrinkage of the regular microtubules. At the same time, the number of microtubules emanating from the centrosome increases by five- to tenfold. In combination, these changes result in disassembly of the regular microtubules and their replacement by outgrowths of large numbers of short microtubules from the centrosomes.

Right before the physical cleavage separating the two cells occurs, the mother centrosome migrates to the cleavage furrow and gives it a final ‘kiss’ of farewell. This event signals the final separation of the two cells into mother and daughter. After the completion of cell division, the active centriole in the daughter cell (originally the inactive daughter) becomes a mother centriole in the next round of cell division.

Enumerating a lineage

When a bacterium divides by asexual reproduction into two, there is little to distinguish the two resultant cells. They are both called daughter cells.

This is not true in eukaryote multi-unit life. One cell gets the mother centriole, and the other cell gets the activated and educated daughter centriole, now an active mother centriole with attached inactive daughter.

This allows us to digitally record the lineage of each cell by noting which gets the mother centriole. A simple method would be to add to the lineage record a C-G pair (0) if it gets the mother and an A-T pair (1) if it gets the daughter at each cell division.

1st	0				1			
2nd	00		01		10		11	
3rd	000	001	010	011	100	101	110	111
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*

After 3 rounds of cell division, there are 8 cells each neatly labeled with a binary number from 0 to 7 with the labels being 3 bases in length. It takes roughly 45 rounds of cell duplication to get from a single zygote to the 50 trillion-or-so cells of a mature human being.

Using this method, the label on each cell is now 45 bases long, and each cell has a unique numerical label that, in binary code, ranges from 0 to 35,184,372,088,831, or $2^{45} - 1$. After 45 rounds, and assuming no cell death, every cell has a label that is 45 bases long. There is a cell that has the original mother centriole and comes from a lineage solely of mothers, with label:

00000 00000 00000 00000 00000 00000 00000 00000 00000

and another cell that comes from a lineage solely of daughters, with label:

11111 11111 11111 11111 11111 11111 11111 11111 11111

This universal method of keeping track of cell division has not yet been detected in living systems even though it has obvious utility. A similar, crude method of keeping track of cell division is in the telomeres, the caps at the ends of the DNA helix in a chromosome.

Telomeres

The telomeres are buffers capping the ends of the chromosomes, and are consumed during cell division and replenished by an enzyme, the telomerase reverse transcriptase, that copies RNA into DNA.

Telomere length varies greatly between species, from approximately 300 to 600 base pairs in yeast to many kilobases in humans, and telomeres are usually composed of arrays of guanine-rich, six-to-eight-base-pair-long repeats. Eukaryotic telomeres normally terminate with a 3′ single-stranded-DNA overhang which is essential for telomere maintenance and capping. The telomeres consist of hundreds of repeats of the base pattern 221000 (TTAGGG).

At each cell division in cells lacking telomerase reverse transcriptase (which is the majority of human cells), the telomere loses a few of these repeats and the telomere shortens. When it gets short enough, the division of the chromosomes becomes impossible.

The telomere shortening mechanism normally limits cells to a fixed number of divisions, and animal studies suggest that this is involved in aging on the cellular level and sets a limit on lifespans. Telomeres protect a cell's chromosomes from fusing with each other or rearranging—abnormalities which can lead to cancer—and so cells are normally destroyed when their telomeres are consumed. Most cancers are the result of ‘immortal’ cells which have ways of evading this programmed destruction.

The precise labeling of cells with a numerical label is probably important in the regulation of cells at the organ level of sophistication. A liver cell from a whale, a man, and a mouse are identical in all respects. They originate in the embryo in a similar fashion from a lineage of cells that goes, respectively, through 50, 43, or 36 rounds of cell division to create the 2^{50} cells of the whale liver, the 2^{43} cells of the human liver, or the 2^{36} cells of the mouse liver.

Hack a slice off the livers, and the identical cells will vigorously multiply until the original number is restored—the whale cells stop when there are 2^{50} of them, the human cells stop when there are 2^{43} of them, and the mouse cells stop when there are 2^{36} of them.

This would easily be accomplished by a register in the DNA heritage that translates as 50 in the whale, 43 in the human, and 36 in the mouse. The only difference between a whale, a human and a mouse liver cell is the content of this register; call it SIZE. The development and maturation of the liver is the instruction to multiply until the cell lineage label is SIZE bases long, each cell with a unique numeric label from 0 to $2^{\text{SIZE}} - 1$.

Healing is just maintaining the array of numbers. If one goes missing, cells duplicate and assign it the missing number. To accomplish this, each cell in the array is constantly sending a numeric message to its neighbors on a snippet of RNA, "I am #n." When the message is not received by its neighbor, #n+1, it duplicates and the daughter is assigned the label, n.

The daughter #n, in turn expects to get the message, "I am #n-1" and, if it does not, it in turn duplicates and assigns its daughter the #n-1 label. When the two edges of the wound meet, conciliation of numbers occurs. If this is perfectly accomplished, there is seamless healing; if it is not, 'scar tissue' accumulates until the mismatch is sorted out.

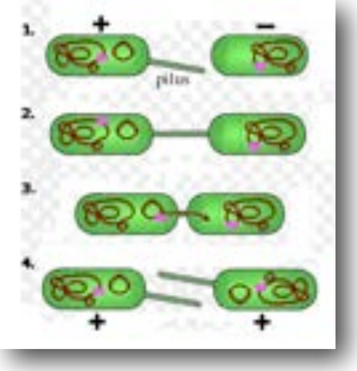
It has always been known that plant cells do not completely separate when they divide, there are tiny channels of cytoplasm through the thick cellulose walls called plasmodesmata connecting them. A typical plant cell may have between 103 and 105 plasmodesmata connecting it with adjacent cells. It had long been thought that animal cells lacked these connections, but it now turns out that they have them as well. Membrane nanotubes, as they are called, are transient long-distance connections between cells that can facilitate intercellular communication. They can also contribute to pathologies by directing the spread of viruses. Recent data have revealed considerable heterogeneity in their structures, processes of formation, and functional properties, in part dependent on the cell types involved.

Like the pilli of bacteria with their transfer of digital information during conjugation, these are channels of digital information transfer as well as other types of material transfer such as entire organelles.

Sex

All prokaryotes multiply by asexual reproduction. By making two identical copies out of one. An asexual lineage is a clone of many copies of a single founder and this is called *vertical* transmission of digital information. System building involves steps and, for an asexual lineage, all the steps must be discovered alone by that lineage.

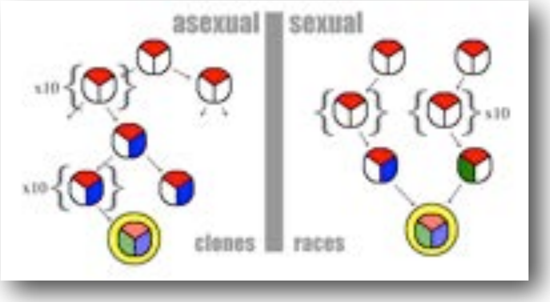
Stripped of all detail, all sexual processes are distinguished by a *horizontal* transfer of digital information between different lineages, usually, but not always accompanied by multiplication as sexual reproduction.



Many prokaryotes indulge in conjugation, the horizontal transfer of DI between different, but related, clones that does not involve reproduction. A *plus* bacteria extends a thin tube *pilus* that pierces a *minus* bacteria. DNA polymerase copies some DI of the plus and injects it into the minus through the pilus. As the DI usually includes the instructions on how to make a pilus, both are now of the plus 'sex.'

The DI for antibiotic resistance is stored on such mobile DNA and the ability can spread horizontally between lineages. In this way they get some of the advantages of sexual horizontal transfer. We can illustrate the advantage of sex with a system having a set of simple attributes, R, expressed from Level 1 in the Logos. A lineage can explore phase space and learn over time from the Logos how to use these simple attributes in two different, more sophisticated ways, B or G. With all three attributes present, a fourth quite different attribute emerges, i.e., a new level of sophistication, Y*.

If it takes, on average, 10 generations to learn either G or B, it will take a lineage of asexual clones 20 generations to learn both ways of doing things and make a jump in sophistication. Two sexual lineages, however, can develop into two races, one with RB and one with RG. A sexual union between the two races can then discover the new level of sophistication in just half the time. Sexual reproduction with horizontal transfer speeds up the emergence of levels of sophistication.



Origin-Division-Union

Sexual reproduction illustrates the philosophical principle of development that Unification Thought calls Origin-Division-Union. We have already encountered this in the leap in sophistication from fundamental fermions and bosons to atoms and molecules. The maelstrom of the Big Bang (origin) separated electric charge (division) into negative electrons and positive quarks, whose colors ended up as positive protons and neutral neutrons. All evidence suggests that, for every electron in the universe, there is a proton. When the universe cooled, the positive and negative charges recombined (union) in neutral atoms. This step, in turn, was the formation stage for the emergence of the elements, and a whole new level of sophistication in the Logos was expressed as their chemistry. Sexual reproduction allows the formation-stage origin of a new species to develop separate lineages of specialized races that can come together in a quantum leap in sophistication.

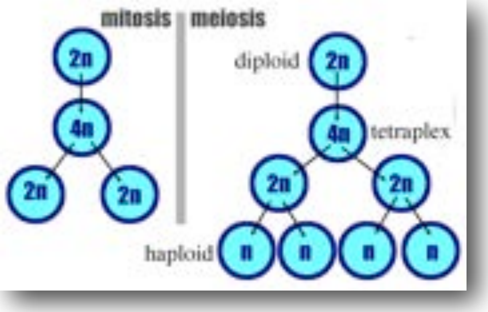
Haploid-Diploid

At some point in the evolution of the eukaryotes, a lineage discovered the advantages of having two sets of chromosomes that could slightly differ from each other, adding a layer of fine-tuning to digital manipulations.

The digital score of mitosis was partially duplicated to create the process of *meiosis* that allowed for the alternation of generations, one with a single set of chromosomes (haploid) and the other with two sets (diploid).

Meiosis turns a diploid cell into four haploid cells, while the fusion of two haploid cells creates a diploid cell.

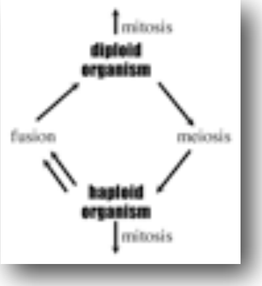
Meiosis



One of the great advantages of meiosis is that the diploid pairs of chromosomes are connected up and then the DNA is duplicated. There are now four chromatids attached together as a *tetraplex*. Sections of DNA can then be spliced together in different combinations following epigenetic digital information recorded by the lineage. It is at this tetraplex stage that the chromosome rearrangements occur that result in speciation.

The centrosome then performs two rounds of mitosis-like spindle separation of the four chromatids into four haploid cells each with one chromatid.

In the simple, single-cell eukaryotes, both the diploid and haploid cells multiply by mitosis, and the cells are very similar. The alternation of generations is often in response to a change in the environment.



EDENS AND EVOLUTION

So far we have discussed a sequence of edens that emerged under the guidance of the Logos, where all the conditions were just right for extending the systematic hierarchy. Edens in which system building occurred as simple systems interacted to form higher systems of greater sophistication. The creation of an eden involves analog waves coming together as a perfect wave, just as ocean waves sometimes combine as a rogue wave with exceptional properties. The main difference between system building in living and non-living systems is that living systems memorize analog waves as digital information and recall the analog waves as needed.

The sequence of edens, starting with the Big Bang origin of space, time and the fundamental entities, we have described so far is:

1. *Atom eden*. The expansion and cooling of the universe allowed system building of neutral atoms of hydrogen and helium.
2. *Element eden.* Gravitational condensation into stars, and H and He burning, generated all the other elements to be scattered in supernovae.
3. *Molecule eden*. Emergence of third-generation stars facilitated the accretion of the rock-and-water planet Earth with its moon.
4. *Macromolecule eden.* Driven by tectonic smokers, RNA, and digital manipulation, proteins and analog wave control as basic living systems emerged.
5. *Life eden.* The control of water and metabolism in a lipid confined volume was mastered and the LUCA left the smokers and radiated into the ocean.

6. *Eukaryote eden*. With the mastery of photosynthesis and colony formation, stromatolites emerged where a lineage could shed its armored coat and explore the possibilities of scavenging. The eukaryotes radiated into the ocean.

The next step that occurred, about 500 million years ago, was that single-cell eukaryotes had learned from the Logos how to aggregate into simple multicellular plants, fungi, and animals. The eden for this step in system building was probably the ooze that coated the ocean floor, but the details are still to be worked out.

Evolution

The unfolding of the Logos as a series of levels of sophistication is *evolution*. We shall use this word as in the dictionary meaning of:

1. Development, advancement, growth, rise, progress, expansion, unfolding; transformation, adaptation, modification and revision.

We shall **not** use it in the sense of its secondary definition:

2. Darwinism, natural selection of random variation.

We can roughly distinguish two types of evolutionary development depending on their outcome, on the increase in the level of sophistication attained.

Mega evolution

These involve major transitions in the sophistication of living systems. These are the steps upward that are preceded by the Logos constructing a distinctive eden. These steps in mega evolution include:

SOPHISTICATION		LOGOS-DERIVED EMERGENT PROPERTIES
Pre-life	0	Simple organics, clay catalysis, iron e^- transfer, high-energy bonds
RNA life	1	Water control, reading and writing digital memory
Prokaryote life	2	Triplet coded proteins, metabolism, ATP, phospholipids
Eukaryote life	3	Multiunit, organelle domestication, centrosomes, mitosis and sex

These mega-evolutionary steps which opened new vistas of phase space are the great leaps in evolution in which the Logos must provide an eden in which all the ingredients for system building are present together in a stable, safe environment.

Micro-evolution

In contrast, microevolution does not involve a leap in sophistication but in the exploration of the phase space opened up by the Origin event.

This microevolution exploration of an unoccupied phase space (the advance is often driven by the decay of the eden of the Origin event). Two examples of transitory edens are:

1. The emergent prokaryotes altered the chemistry of their smoker-clay eden with their oxygen and mopping up of organic chemicals.
2. The emergent multicellular eukaryotes grazed away the stromatolite edens of the eukaryotes.

The radiation of the prokaryotes from the LUCA in the smoker-clay eden into the world ocean, the radiation of the eukaryotes from the stromatolite eden into the ocean, and the radiation of the insects onto dry land are all examples of microevolution.

The evolution of computers from the 1980s Mac Plus with 128kB of RAM and 400kB disks to the MacBook Pro with 2,000,000kB of RAM and a 1,000,000,000kB disk is an example of microevolution. The two computers use the same basic architecture, except one is small and simple, while the other is still small but very sophisticated.

MULTICELLULAR LIFE

All of the living systems we have discussed so far are microscopic and invisible to the naked eye. The realm of prokaryotes and single-celled eukaryotes was unknown to the ancients, and was only uncovered by the invention of the microscope.

It is only when systems emerged in which the single cell was a subunit, that the multicellular life seen by the naked eye emerged.

It would seem that the evolutionary path of mono-vital-unit prokaryote to poly-vital-unit eukaryote is similar to the path of mono-eukaryote to poly-eukaryote. The former was a scavenger in the debris at the bottom of the stromatolite, the latter a scavenger in the ooze at the bottom of the ocean:

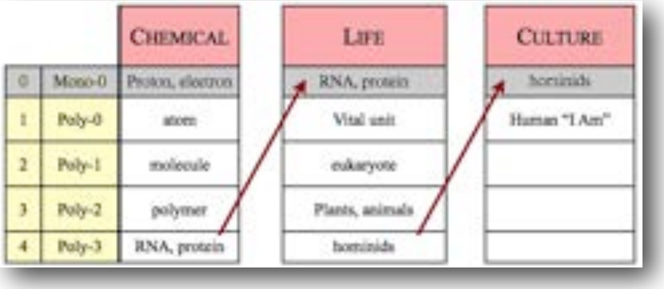
> It seems likely that an early step in the evolution of multicellular organisms was the association of unicellular organisms to form colonies. The simplest way of achieving this is for daughter cells to remain together after each cell division. Even some prokaryotic cells show such social behavior in a primitive form. Myxobacteria, for example, live in the soil and feed on insoluble organic molecules that they break down by secreting degradative enzymes. They stay together in loose colonies in which the digestive enzymes secreted by individual cells are pooled, thus increasing the efficiency of feeding (the "wolf-pack" effect). [38]

This was probably the earliest exploration of multicellular phase space. This is a rough outline of the macroevolutionary steps starting with the simplest levels:

SOPHISTICATION		LOGOS-DERIVED EMERGENT PROPERTIES
Multicellular life	4	Tissues, differentiation, plants, and fungi
Tube animal life	5	Nervous system, worm brain, muscles
Segmented life	6	Organs, segmentation wings, legs, insects
Deuterostome life	7	Gills, jaws, kidney, heart, gut brain
Amniotic egg life	8	Land adaptation, amphibians, dinosaurs, reptile brain
Mammalian life	9	Warm-blooded, milk, care of young, family brain
Primate life	10	Tribes, social awareness, clan brain
Hominid life	11	Upright, clans, fire, pidgin language, hunting weapons, tribe brain
Human life	12	“I Am” self-awareness, infinite creativity and potential

There is an interesting parallel between the systematic structure of the realm of chemical systems with that of the realm of living systems.

Both start at level zero, with systems that have zero chemistry—protons and electrons—or systems that have zero life—RNA and protein molecules.



		CHEMICAL	LIFE	CULTURE
0	Mono-0	Proton, electron	RNA, protein	hominids
1	Poly-0	atom	Vital unit	Human "I Am"
2	Poly-1	molecule	eukaryote	
3	Poly-2	polymer	Plants, animals	
4	Poly-3	RNA, protein	hominids	

Level One of both chemistry and life have multiple subsystems of level zero interacting to form the basic unit. In chemistry these are the atoms of the elements; in life these are the vital units.

The systematic hierarchy is constructed starting with chemical activity, and proceeding through molecule, polymers, and then the sophisticated biopolymers, RNA with its digital processing, and proteins that generate analog forms to manipulate many small molecules, starting with water.

The combination of RNA and protein is level zero in the hierarchy of living systems. A systematic hierarchy stands on this foundation. We will define that troublesome word *mind* to be the measure of the sophistication of the set of emergent properties, determined by the Logos at the Origin and memorized for the descendants, of the system wave that is confining all the electrons and nucleons it is composed of. Sophistication refers to the kinds of systems the wave is manipulating and organizing.

By this definition:

The mind of a prokaryote is capable of organizing chemicals into a unified whole.

The mind of an eukaryote can do all this, and also organize vital units into a unified whole.

The mind of a plant can do all this, and also organize sensory images into a unified whole.

The mind of an animal can do all this, and also organize motor images into a unified whole.

The mind of hominid can do all this, and also apply concepts in mastering fire and vocalizing simple language.

The hominids are level zero out of which the human has its origin.

The great leap is to the ability to name objects, to associate motor images (the idea in your mind) with distinct aspects of the environment. The stream of language you hear in your mind is exactly the same as if you were speaking aloud, except the destination is different. Naming and recognizing objects leads to the recognition of self and non-self, the "I Am" of self-awareness.

CELL DIFFERENTIATION

In all but the very simplest of multicellular organisms there is cell differentiation and, although the genotype is the same, the external phenotype is not. During cell multiplication, the somatic lineage diverges into same-cell tissues. The simplest seaweeds, for example, have a holdfast, i.e., a tissue that excels at attaching to and gripping rock, and the rest is photosynthetic fronds.

Differentiation requires that information be passed between cells. Much of this information flow is known to be in the analog form of chemical hormones that fluctuate in concentration and gradients.

We can speculate that digital information is also involved. We have already outlined a simple numbering system for a somatic lineage based on where the mother centrosome ends up in cell division. After three rounds of division, each of the eight cells that result is numbered 0 through 7 in digital store with address ###.

This numbering allows for a digital control of differentiation with a simple program, such as:

```
3. IF ### = 0 THEN RUN holdfast
4. IF ### = 1 THEN RUN holdfast
5. IF ### = 2 THEN RUN holdfast-blade
6. IF ### = 3 - 7 THEN RUN blade
```

Support for ways that the RNA-CPU can keep track of digital numbering in multicellular eukaryotes is, for example, provided by the mammalian liver. Once a mechanism is perfected, it persists essentially unchanged down through a lineage. The mammalian liver cell was perfected in the ancestral mammals, and a mouse liver cell is indistinguishable from an elephant liver cell.

The mature mouse liver contains $\sim 10^9$ of these cells, while a mature elephant liver contains $\sim 10^{14}$ of these cells. The precursor cell of the somatic lineage in a mouse goes through 30 rounds of division, while in an elephant it goes through 47 rounds of division. They then stop dividing. The relative sizes of most mammalian organs is the same, which suggests that there is a digital store of what scale the mature body is to be.

If either mature liver has a lobe excised, the cell division resumes and the liver regenerates to the normal size. This suggests that the array of cells are numbered, and when a section is excised, the array reestablishes itself. Something is keeping track of numbers. The simplest method would be the passing of digital information about who the neighbors are. This suggests that RNA is passed between cells, a phenomena not yet observed, but supported by the recent discovery of micro channels connecting cells together. These connections are reminiscent of the pili through which bacteria swap digital information. In normal circumstances, for example, cell #26 receives “my # is 25” and “my number is 27” from adjacent cells, and is content. If, however the array is damaged and the “my # is 27” is no longer received, the cell divides and assigns the daughter cell #27.

As differentiation is still a topic of debate, the strategy for growth and healing is as yet unclear. But all three of the main eukaryote lineages— plant, fungi, and animal—found ways of digitally storing analog patterns of differentiation and recalling them as required.

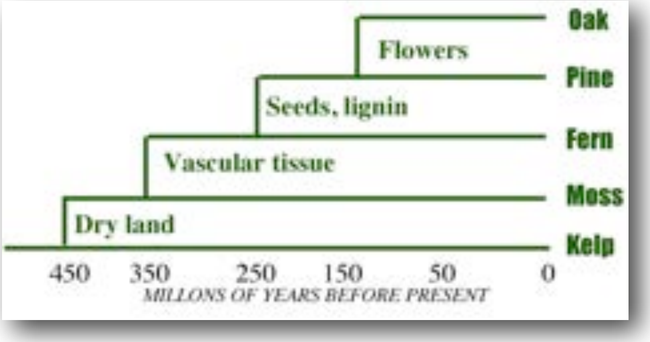
We will not go into great detail as these topics are well-covered in the literature. The only difference here is that each advance is learned and recorded in unified science, while such an advance is considered a fortuitous accident in the current mainstream view. To further reduce the length of this work, we will just outline the evolutionary steps learned in plants and animals, and not deal with the fungi.

MULTICELLULAR SYSTEMS

The ocean is so hospitable to plants that the only real advantage of multicellularity is the holdfast—once you find a good spot, you get to stay in it. So, plants in the oceans are really sophisticated seaweeds, with air pods for buoyancy and sexual spots for reproduction. The forests of sea kelp are habitats for a wide variety of organisms.

Unlike the ocean, dry land posed a series of challenges that we mastered as the plants radiated over the land, starting with the mosses radiating into the moist zones around the land.

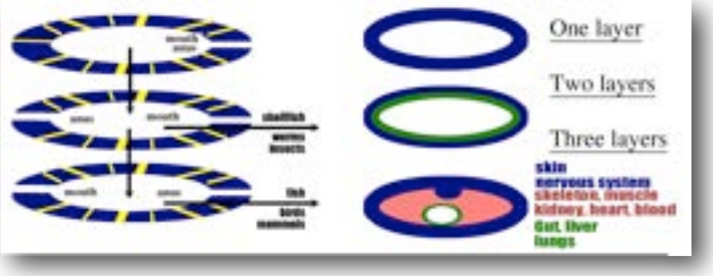
The next big advance was vascular tissue that could distribute food and water around the plants.



The discovery of lignin, which is used to strengthen cellulose, allowed for height and closeness to the light, and the seed for water-less reproduction allowed for a massive proliferation of simple trees over the land, whose remains are the great coal beds we mine today. It is thought that the recycling ability of the fungi was temporally stymied by lignin, a very tough molecule to degrade, allowing great swamps of undigested plant material to accumulate. The final innovation was the green broadleaf that was jettisoned in the fall, and later developed into a wide range of colored flowers.

OCEAN ANIMALS

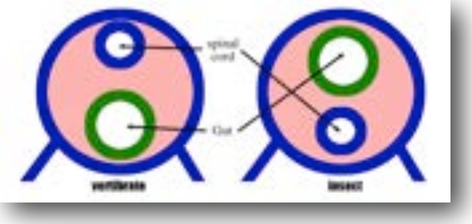
The animal lineage went through a much more complex series of developments in the ocean before attempting the colonization of dry land.



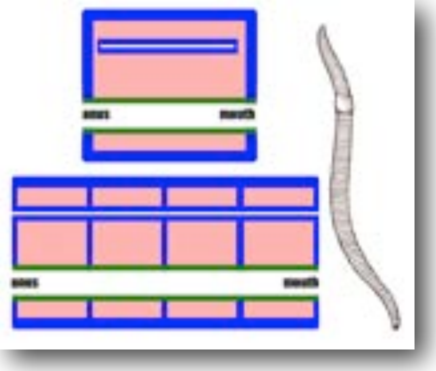
The very simplest animal was a sphere of cells with a hole in it. Prey could be engulfed into the proto-gut, digested, and the indigestible remains ejected. The hole acted as both mouth and anus. The next innovation was a second hole; the prey was engulfed by the first hole and ejected from the second. The exploration of *protostomic* phase space with mouth first, anus second, later radiated into the shellfish, one type of worm and the insects.

In ways that are difficult to explain except as digital program shift, one protostome lineage flipped things around so that the first hole was used as the anus and the second hole as the mouth. This *deuterostomic* lineage radiated into the other type of worm, the fish, reptiles and mammals.

The very simplest of animals had only a single layer of cells. This has a limited phase space, and the most complex extant animals are the sponges. A second layer of cells was added by outside cells slipping through the mouth and coating the inside. These *germ layers* are called the outer ectoderm and the inner endoderm. This is also a limited phase space, and the most complex *diploblastic* extant animals are simple worms.



The lineage that explored developing a third layer, the mesoderm, opened up a vast phase space, the exploration of which led to the emergence of all animals more sophisticated than flatworms. The ectoderm developed into the skin and nervous system, the mesoderm into bone, muscle, heart, and blood, and the endoderm into gut, liver, and lungs.



Both protostomes and deuterostomes independently discovered the versatility of a mesoderm third layer but, reflecting the mouth-anus flip, vertebrates and insects have opposite spinal cord/gut configurations.

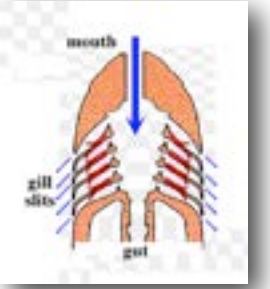
So far, we have discussed two examples of a phase space opened up by duplication and association: eukaryotes as poly-prokaryotes, and animals as poly-eukaryotes. A third example is the lineage that explored making attached duplicates of itself—the exploration of segmentation by both protostomes and deuterostomes, then differentiation of the segments. The mouth-end segments developed into the head with a centralization of the nervous system and sensory organs. Middle segments developed legs, and the hind segments developed into the tail. The spatial order of segments is reflected in the spatial order of the Hox genes on the chromosome, an aspect of digital processing that is under investigation.

The millipede is an extreme example of duplication of segments, while human segmentation is only preserved in the spinal vertebrae that protect the spinal column.

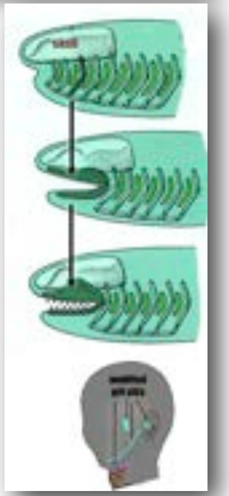
The digital control of segmentation and differentiation is uses a set of Hox genes. The Hox genes have been remarkably conserved down through the ages, and fly and chicken Hox genes can be interchanged and still function. While the genes are the same, sophisticated organisms have many sets of Hox genes to control local differentiation. The fruit fly has two clusters of Hox genes, while a human has four.

A simple circulatory system developed, with a separation between the water locally bounding a cell—the lymph—and mobile water that distributed oxygen, food, and wastes globally—i.e., the blood. Muscles developed to circulate the blood and developed into a heart in stages from a simple muscular tube to a chambered pump.

Muscles and a skeleton they could move developed. An external skeleton of chitin emerged in the anthropoids and insects, while an internal skeleton of cartilage emerged in the chordates. Up to this point in history, dead animals were soon degraded and left little impact in the fossil record. Discovery of how to calcify cartilage and construct bone changed that situation, since bones are sturdy enough to be occasionally fossilized.



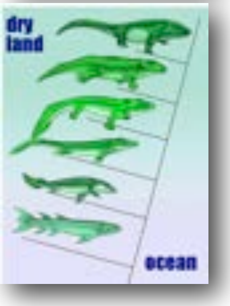
The oxygenation of the blood was accomplished by allowing oxygenated water to enter the mouth and, passing over gill beds of fine blood vessels, it was expelled out of gill slits in the sides so as not to dilute the gut contents. The gill arches were supported by cartilage or bone.



The phase space opened up in the Logos by the advent of the gill arches was enormous. Exploration dropping the first two arches and developing the third arch, generated lineages leading to the cartilaginous sharks and the bony-jawed fishes.

The arches still play a role in human development, ending up modified into bits that eventually ended up as the tiny bones of the inner ear, the jawbone, and the voice box. The radiation of the bony fishes filled the oceans with all kinds of fish that thrive to this day.

One adventurous lineage explored surviving the potentially-fatal circumstance of being stranded by tidal retreat, by gulping air and burrowing into mud—the lung fishes. One branch started using their four fleshy fins to crawl about—the coelacanths that were long thought extinct, but were discovered in the depths of the ocean off the coastlines of the Indian Ocean and Indonesia. Further exploration of the opening phase space of the moist edges of dry land resulted in the advent of the early amphibians.



LAND ANIMALS

The colonization of the land by both plants and animals required that both discover how to reproduce free of the constraint of limited water. The basic process was the same—learning how to generate analog forms and sample them for digital storage. This digital information could be used to regenerate the analog form or be copied and passed on down a lineage. As digital information accumulated, lineages became more sophisticated.

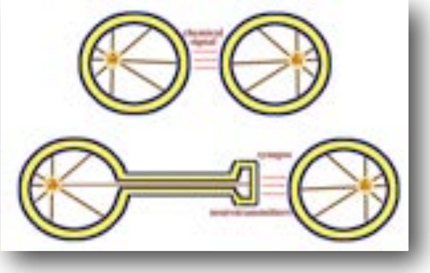
The simple mosses and amphibians remained dependent on environmental water. Just as the seed was protected by a coat, the eggs of reptiles were protected by an eggshell.

The higher plants discovered flowers and fruits to protect reproduction, while the mammals developed the womb and mother's milk.

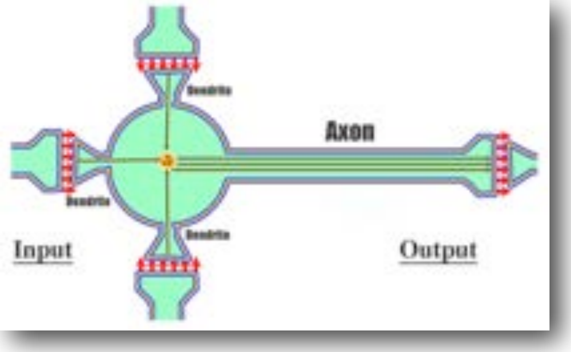
Only the animals, however, explored the phase space of muscular movement coordinated by a nervous system. While the muscles of mice and men are similar, it is in the nervous system that great leaps occurred as higher and higher levels of the Logos resonated with physical systems.

THE NERVOUS SYSTEM

The cells in multicellular animals communicate with each other in an analog fashion by varying the concentrations of small molecules in the lymph fluid that they are sharing. The ectoderm cells that developed into neurons extended thin protoplasmic filaments, driven by the cytoskeleton and the centrosome, to use these chemical signals to communicate over a distance.



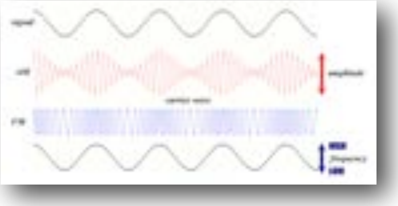
The final step was polarizing the bi-lipid membrane, so that signals from other neurons depolarized the membrane at many input filaments, the dendrites, which if sufficient, sent a depolarized signal down a single output filament, the axon. These connections created neural nets that could process signals, before output to an effector cell.



The basic pattern is the same for human neurons as it is for jellyfish neurons: There is a cell body that extends many short input filaments, the *dendrites*, and a single long output filament, the *axon*. The axon ends either on a dendrite or a regular cell. A stimulus arriving down the axon activates the dendrite, which can be either a plus or minus type. If the sum of the plus and minus activation of the dendrites is greater than the threshold value, a stimulus is sent down the axon to activate the dendrites it is connected to.

Waves of stimulation spread over neural nets, and they are *frequency-modulated* (FM) waves, not amplitude-modulated (AM) waves.

FM AND AM WAVES

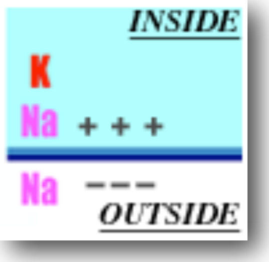


A radio station works by imposing a very low-frequency sound wave on a high-frequency *carrier* wave. The carrier wave is modulated with the sound wave. The radio receiver strips away the carrier and only allows the sound wave to enter the amplifier and loudspeaker.

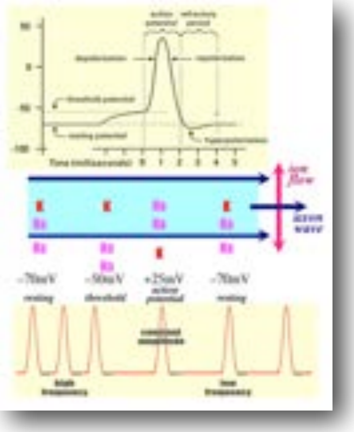
The first, and simplest type of modulation is to vary the amplitude of the carrier wave in time with the amplitude of the signal. This AM radio had a problem with static—stray waves generated by many diverse sources, such as thunderstorms and air conditioners.

The problem with static was solved by modulating the frequency of the carrier wave. A heterodyne receiver combines this modulated wave with a set frequency wave, and the variation in frequency, not amplitude, carried the signal wave.

In AM radio, the frequency is constant and the amplitude varies. In FM radio, the amplitude is constant and the frequency varies. Neurons use FM; the amplitude of a signal down the axon is constant and it is its frequency that varies.



We have already discussed proton-motive force driven by an imbalance of charge across a bi-lipid membrane. The membrane of a neuron in the resting state also has a charge imbalance but, in this case, it is because ATP is used to accumulate potassium ions so the inside of the cell becomes positive and the outside is negative. Like a battery, at rest the membrane of the neuron cell body is primed with electrostatic energy.



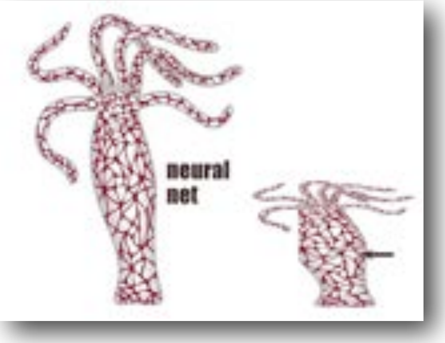
When a plus dendrite is stimulated by the incoming axon, a positive charge ripples outwards across the outer cell membrane. When a minus dendrite is stimulated, a negative charge ripples outwards, and the plus and minus ripples interfere with each other.

The axon has a root in the cell membrane. If the ripples at this root sum up to 20% positive, it initiates an action potential down the axon. The membrane depolarizes and sodium ions flood out of the cell, and the membrane now reverses polarity. Potassium ions flood out of the axon and the membrane peaks at a positive value. The membrane repolarizes as sodium and potassium are pumped in opposite directions. The rise in the action potential triggers the next bit of membrane, to depolarize, and the spike is propagated down the axon with a constant amplitude but varying frequency.

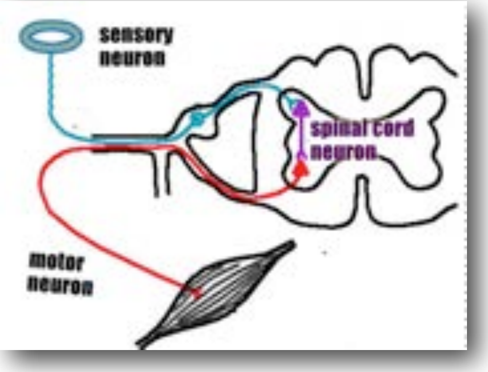
We earlier described an electromagnetic photon as having two orthogonal components—the electric and the magnetic—waving orthogonal to the direction of travel. The wave down an axon is similar, it has two *parallel* components—the sodium- and potassium-ion concentrations—that also wave orthogonally to the direction of travel down the axon.

The action potential lasts two milliseconds After this, for another two milliseconds, the membrane is hyper-polarized, and quite unresponsive to stimulation. The resting state of ion imbalance is restored after another four milliseconds. The nerve is now primed and ready for the next spike to arrive.

Analog neuron nets



Neurons deal in analog information. An analog pattern of inputs to the dendrites creates an analog pattern of waves down the axon. An example of the simplest of neural nets is the nervous system of the single-opening, mouth-anus hydra. This has sensory cells on the surface connected by a neural net to muscle fibers in the hollow body. Touch a hydra and it immediately con-



tracts, a simple example of a reflex arc. We humans still use such simple analog circuits in the reflex that immediately removes our finger from a hot stove without involving anything sophisticated in our nervous system.

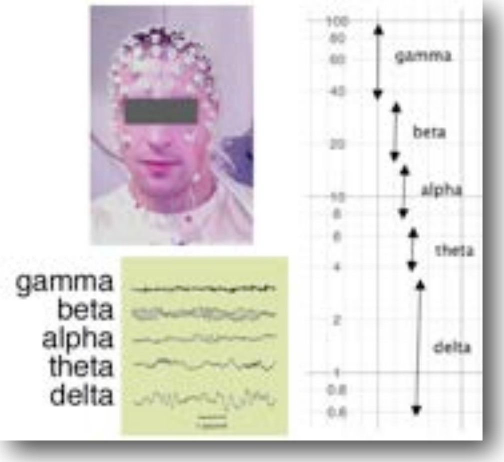
These neural nets also occur, with much greater sophistication, in all animals and humans. A single neuron can receive input from up to 10,000 different axons arriving at its dendrites. A neuron can ramify the end of its output axon and synapse with up to 10,000 different dendrites.

The human nervous system is estimated to comprise 85 billion neurons that connect together in the brain with 1,000 trillion synapses, i.e., a quadrillion. Each neuron creates a tiny electrical wave when it fires, and the firing of billions of neurons combine to create electrical waves that can be measured by electrodes attached to the outside of the skull.

Brain waves

Brain waves are created by the synchronized firing of neural nets—otherwise there would be no waves large enough to register. The science of electroencephalography (EEG) studies these brain waves, which are a global measure of synchronized neural nets firing in the brain. The waves measuring this global analog aspect of the brain can be divided into five types, characterized by their time period, that are associated with five different states of the brain:

1. *Delta waves* have the lowest frequency, ½ to 3 cycles per second (cps) and the highest amplitude, ~100 microvolts (μV). These waves are characteristic of unconsciousness and deep, dreamless sleep. When the delta waves appear with others in the conscious state, they seem to be associated with intuition and day-dreaming.
2. *Theta waves* have a higher frequency (4 - 7 cps) and a smaller amplitude (~50 microvolts). They seem to represent the subconscious mind, and are prevalent while drifting off to sleep, in dreaming sleep, and during meditation and peak creative experiences.
3. *Alpha waves* have a midrange frequency (8 - 14 cps) and amplitude (~30 μV). They are seen in the relaxed state, and also while daydreaming and in the recall of sensory experiences.



4. *Beta waves* have a frequency of 15 - 38 cps and amplitude of ~30 μV. They are associated with alert, normal consciousness and logical, analytical thinking, and conversation. High-frequency beta waves are associated with stress, anxiety, and inner conflict. Low-frequency beta waves are associated with a clear, alert and creatively focused mind.
5. *Gamma waves* have the highest frequency (38 - 100

cps) and the smallest amplitude (~10µV), which makes them difficult to study. They are seen in peak performance—both physical and mental—high focus and concentration, and in transcendental experiences. When they do occur, they involve waves of synchronization over large parts of the brain.

We earlier discussed the analog forms generated by folded proteins in terms of the sum of multiple individual Bezier generators, the aminoacids in the primary structure. The wavefunction structuring water and metabolism in a vital unit is the composite symphony of all the proteins generating their waves. In a similar way, the neurons of the brain generate a Bezier wave unit that combines into the wave of the neural net, and the overall wave of the brain is the combination of all the nets together.

The analog form generated by a protein is recalled by RNA from digital memory in DNA. The proteins specialize in generating analog form, and the RNA specializes in digital information. If the same pattern repeats itself, then the analog forms generated by specialized neurons are recalled from digital memory by cells specialized for digital storage and manipulation. The open question is: Where does this digital aspect reside?

Digital Memory

The digital aspect of memory is only now starting to be explored but there is one thing that might provide a clue: we can expect that the ability to store, recall, and manipulate digital information increases with the sophistication of animal mental ability, from worm to human.

As mentioned, the human brain contains ~85 billion neurons specialized in analog wave generation. They are a 10% minority, however, as the are embedded and surrounded by ~850 billion glia cells, which are the stem cells that give rise to the neurons in development.

The current consensus is that all that is of primary important in brain functioning occurs in the neurons and the synaptic strengths in neural nets. The iconoclastic *Roots of Thought: Unlocking Glia*[39] by Dr. Koob makes the case for neurons being directed and controlled by the glia cells.

He considers this glia programming of the neurons to be analog, conveyed bursts and waves of calcium. I consider this a gross effect, and that RNA is passed between neuron and glia, conveying digital information. Unfortunately, I cannot google anything about RNA transfer between these cells—like the centrosome, only single molecules need be involved as, noted earlier, a single molecule of RNA is quite capable of completely altering a cell’s state. So, we will just précis in the following section the case that Dr. Koob makes for glia analog control of neurons.

SOPHISTIC.	GLIA	NEURON	RATIO
Jellyfish	1%	99%	**0.01**
Worm	10%	90%	**0.1**
Rat	60%	40%	**2**
Chimp	80%	20%	**4**
Human	90%	10%	**9**

As might be expected, the ratio of glia controllers to neuron generators increases as one moves up the hierarchy of animal sophistication. In the jellyfish, only a small fraction of the cells in the simple nervous system are glia, while the rat's nervous system has twice as many glia as neurons. In the cortex where the highest functions are performed, the human brain has 35% more glia cells than the chimp brain does.

The neurons are rather like DNA, i.e., they both have a single function which they perform excellently—storing digital information or generating analog forms, respectively. The glia cells are akin to RNA in that they can perform a wide variety of functions. We have earlier listed the dozens of emergent properties possessed by RNA, from digital information manipulation to analog form generation. The glia cells have almost as wide a spectrum of properties:

1. Ependymal glia—lining the brain ventricles, stem cell for neurons and other glia
2. Schwann cells—myelination of axons in periphery
3. Oligodendrocytes—myelination of axons in white matter of brain
4. Müeller cells—glia in eye
5. Velate cells—glia in nose
6. Epithelial glia—surround brain blood vessels
7. Microglia—response to infection
8. Bergmann glia—astrocytes in cerebellum
9. Astrocytes—most abundant cell in human cortex

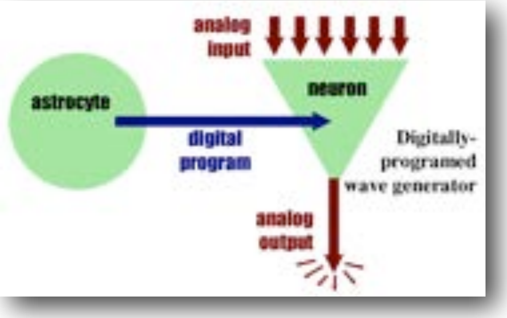
The astrocyte seems the most likely candidate that digitally programs neurons since the neurons cannot function without them:

> An astrocyte is a self-sufficient, self-replicating cell signaling to itself contentedly. Neurons have no reason to exist except to support astrocytes. Mature neurons cannot function alone, whereas mature astrocytes have no difficulty existing without neurons. When placing mature neurons in a Petri dish, they are unable to survive without astrocytes. Astrocytes are perfectly content without neurons.[40]

It is the astrocyte network over the which the Ca^{++} wave passes, and the cerebral astrocytes are connected to other astrocytes and neurons by *gap junctions* that are similar to synapses.

Astrocytes are known to store information and are involved in short- and long-term memory. They control neuron firing and control the addition, modulation, and deletion of synapses between axons and dendrites on neurons.[41]

In the wiring of the developing brain, the ependymal glia surrounding the ventricles send out radial extensions toward the outside. The cell body then moves outward along this extension and, as it returns inward, divides into two cells. The daughter cell moves outward along the radius and becomes a neuron, while the mother cell returns inward to the ventricle.[42] The neuron climbs the path established by its mother glia (and it can be expected that the mother glia also ends up with the mother centrosome).



In our view, the digital program, provided by the glia and running at the topmost level of the neuron, determines its output given a certain pattern of inputs. The variably programmed neuron recognizes, we might say, the analog form of the input in the output it sends down the axon and its many connections.

An example of such variable programming is the development of the visual cortex. The level of the cortex that is programmed to recognize vertical lines is divided into narrow stripes with alternate inputs from the left and right eyes. In normal development, the strips are of equal size. If, however, the eyelid of the right eye is sewn shut at birth—the experiment was on cats—the right-strips are vestigial and the whole layer becomes programmed to respond to the left eye. If the eyelid of the mature cat is opened, the right eye is oblivious to vertical lines and the cat just does not see them.

Universal Computer

Returning to modern computer technology to illuminate the digital aspect of living systems, there is the concept of the universal computer that can run any program. This concept seems commonplace nowadays, in that a digital computer can be programmed to emulate any number of devices, but it was only established by Turing a half century ago. Depending on the program, a computer can emulate a TV with full color and sound, a typewriter, a graphic design studio, a symphony manipulating sampled sounds, a film editing studio, and many other functions via a burgeoning variety of useful apps.

This is the *universal* aspect of modern computers, in that any number of different programs can be run on the same computer. There is a hierarchy of universal computers running in living systems.

The simplest is the ribosome. This will take any stretch of RNA and turn it into a protein. A ribosome will happily translate even a nonsense stretch of RNA made synthetically in the lab. It was this that allowed for the first step in uncovering the Universal Triplet Code when a synthetic RNA made only of uracil was translated by ribosomes into long strings of peptide-linked phenylalanines, and **UUU** was established as its digital code.

A step-up in sophistication is the universal computer that is the centrosome. The variety of digital programs received from the nucleus is reflected in the variety of cell shapes, movements, and behaviors of the eukaryote cell. The most elaborate program being that of mitosis and meiosis.

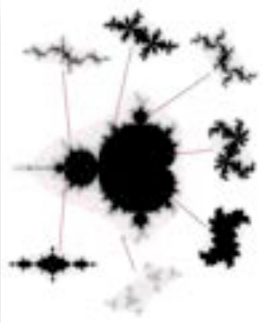
Finally, we reach the universal computer that is the neuron that runs whatever program it receives from the astrocytes. It is flexibility in neuronal programming by astrocytes that gives the brain a remarkable ability to alter and adjust:

> Neuroplasticity occurs on a variety of levels, ranging from cellular changes due to learning, to large-scale changes involved in cortical remapping in response to injury. The role of neuroplasticity is widely recognized in healthy development, learning, memory, and recovery from brain damage. During most of the 20th century, the consensus among neuroscientists was that brain structure is relatively immutable after a critical period during early childhood. This belief has been challenged by findings revealing that many aspects of the brain remain plastic even into adulthood.[43]

The centrosome uses the ribosome level to direct protein activity. The neuron level uses the centrosome level, with its connection to each dendrite and each ramification of the axon end, to direct synapse behavior.

Serial and parallel computers

At this point, the digital technology of modern computers fails to assist in understanding that in living systems, because current technology deals with *serial* computers while living computers run in *parallel*—massively parallel, to be precise.



An excellent example is provided by the construction of the Mandelbrot Set (MS) which, like matter and natural law, involves complex numbers.

As discussed earlier, the Mandelbrot Set illustrates the behavior of a complex number, z_0, under the iteration:

$$z_{n+1} = (z_n)^2 + z_0$$

This iteration generates a series of complex numbers, the *Julia* set that, when plotted on the complex plane, give the orbit of the z_0 under the operation.

A serial computer has a single CPU that draws the MS in the following way:

```
1. Read the complex coordinates corresponding to the pixel top left pixel of
   the screen.
2. Calculate the Julia set for that number, say up to n = 1,000.
3. If the magnitude of a result:
     a. Wanders off beyond 2 to infinity, the pixel is left white as the num-
        ber is not in the MS.
     2. Remains bounded around the unit circle, the pixel is instructed to
        turn black as the members of the MS are those with bounded Julia Sets.
4. Read the complex coordinates of the next pixel and repeat.
```

The sophisticated CPU rapidly examines each pixel in turn, one after the other, and instructs the display according to what happens to the series in the Julia set. This is the basic principle of the serial computer established by Turing. The MS appears line by line as the MS is displayed.

If there are one million pixels on the screen, the illustration is of the MS when it gets to the 600,000th pixel.

A massively-parallel computer has one million simple and slow CPUs, one for each pixel. Each CPU can send a message to any of the pixels, but the pixel only turns black if it receives many signals.

Each CPU knows its coordinates, and proceeds to calculate the coordinates of each member in the Julia set of its number. It sends a signal to the pixel corresponding to each result (so every pixel receives at least one signal because it is the starting number). As each simple CPU plods through its Julia set, the corresponding pixels are sent a signal. As the million Julia sets are being slowly calculated, the MS slowly emerges, fuzzy at first but with increasing sharpness as all the Julia sets merge and combine with each other.

The illustration is a low-resolution example after a few minutes, but the characteristic shape of the MS is already emerging from the overlap of Julia sets.

Human Mind

The question, "What is my mind that expresses itself in my thoughts and body?" has attracted the attention of philosophers—with varying success—and scientists—who tend to duck the question. To contribute to the discussion, we shall now attempt a 'theory of mind' by applying the principles of a unified science we have established.

In unified science, there are only two basic components to material systems—(1) a set of external fundamental entities and (2) this set of fundamental entities is confined and directed by the internal wavefunction.

So far, we have used the convention of dealing with systems as things-in-themselves. Things such as carbon atoms, glucose molecules, RNA macromolecules, bacteria, cells, organs, etc. Again, every single one of them is the same—a set of fundamental particles moving over time to reflect the form of the internal wavefunction. The external aspect does what the internal aspect tells it to do.

This is as true for a human as it is for an atom, the only difference being the number of external particles and the intricacy of the structure to the internal wavefunction.

When this intricate internal structure resonates with an internal structure in the Logos, a set of emergent properties is expressed in the external structure and function of the system. When it does not resonate, the emergent properties are absent and the system is described as broken or diseased.

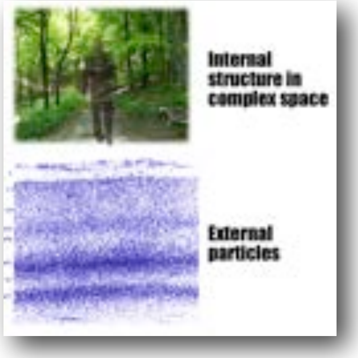
The internal analog waveform generated on waking has a resonance with the Logos, giving rise to the emergent property of self-awareness of the "I Am" object and its complement of other "I am not" objects. The mind is an emergent property of the intricate structure of the internal wavefunction, not the consequent movement of valence electrons and core nuclei and confined electrons.

This "I Am" structure in the Logos is a hierarchy of complex dimensions so we can assume that the human mind is also a hierarchical construct in an abstract poly-dimensional complex space.

The awake "I Am" with its thoughts and sense of self is the center of an environment. While walking through the woods, I see, hear, smell, and touch the world around me. As each complex dimension has two components—the real and imaginary, magnitude and amplitude—a 3-D world has six components. In order to model the external world, six components must be kept track of. We shall assume that it is no coincidence that the cortex of the human brain has six distinct layers.

It is in these six layers that the two aspects of awareness are projected onto these six layers. Like the massively-parallel method of generating the Mandelbrot Set, each neuron is contributing a tiny ripple to the overall wavefunction that is the mind:

1. The self. This is the 'I am' that inhabits the body. Every recorded memory is being expressed in this analog wave, but at a low level that we are unaware of, i.e., the subconscious. All are contributing a murmur to the sense of self, singing softly "I remember" and it takes little effort to magnify these and bring them into resonance with the "I Am".
2. This abstract entity is embedded in another abstract construct in complex space that represents the environment. It can also wander into self-generated constructs. I can walk through a forest but be totally unaware of the trees as I go over yesterday's argument and what I *should* have said.



As the Creator Parent also has the "I Am" awareness, we can assume that within God's abstract structure there is also a hierarchy of complex dimensions. For pure mathematicians, the implications are that the emergent properties uncovered in the exploration of poly complex dimensions will be intriguing and delightful. Eventually, the existence of God will be seen as inevitable as is the unique prime factorization of the integers. It is inconceivable that it could not be true as proved.

Systematic hierarchy

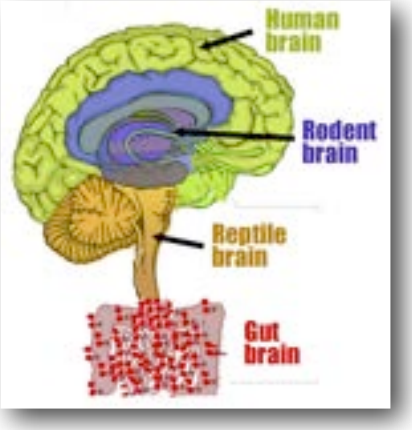
As with everything we have discussed so far, both the human mind and the nervous system that generates it are a systematic hierarchy. While the experience of a healthy human is that the mind is a single, unified entity and that the environment is also singular, exploration of the brain reveals that aspects of experience are processed in disparate areas of the brain. Each sense has an area it projects onto, and is also broken down to different areas. For example, in the visual cortex, there are areas that respond to color, areas that respond to grey, areas that respond to vertical lines, areas that respond to horizontal lines, curved lines, solid areas of color, etc.

This is called the *binding problem* in brain science. How are all these disparate bits of detail combined into the unified experience of a healthy human being. If we consider each area generating a wave that combines into a unified wave, this is no longer a problem. A cello and a piccolo locally generate waves that contribute to the unified whole that is the symphony. A protein locally generates a wave that contributes to the unified whole that is the water structure and metabolism of a vital unit. The same basic principle applies.

Externally, while the human nervous system is spread throughout the body, all the higher functions are localized, particularly in the brain. But the organ inside our skull is not the only location in the body, we have other concentrations throughout our body, in particular, in the gut and around the heart. They look very different from what's in our heads, but they do the same type of work – regulating the system they are attached to in ways that are responsive to our surroundings.

The brain in our gut, the "enteric nervous system" manages every aspect of digestion, from the esophagus to the stomach, small intestine, and colon. This solar plexus in the abdomen is situated behind the stomach and contains many ganglia distributing nerve fibers throughout the viscera.

There is also the heart, which has a complex intrinsic nervous system that is sufficiently sophisticated to qualify as a "little brain" in its own right. The heart's brain is an intricate network of several types of glia and neurons, like those found in the brain proper. Its elaborate circuitry enables it to act independently of the cranial brain – to learn, remember, and even feel and sense. The lowest part of the cranial brain stem is also a part of the gut brain.



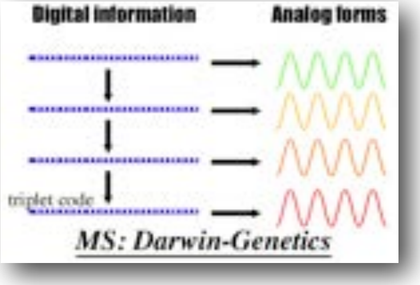
While the simplest of animals have basically a gut brain, this is the basic level of the systematic hierarchy of all animal nervous systems. The lineage that led to humans added layer upon layer as the sophistication increased. The systematic hierarchy, with each added layer working through the lower layers, is observed in the human brain structure.

At every level, the basic principle is at work, i.e., analog forms are recalled from digital storage and expressed as internal waves that organize and unify the external particles as a well-functioning body.

EVOLUTION AND EPIGENETICS

The current scientific theory of evolution is called the *modern synthesis* that unites Darwin's concept of survival of the fittest with the 'read-only' digital aspect of modern genetics and its random mutation and alteration.

The analog forms generated by this randomly-altered digital information in the genotype on the DNA are expressed in the phenotype of the body. If a form happens to increase survival and procreation, the DNA enters the gene pool. If it does nothing, it also enters the pool. If it is deleterious, it is purged from the gene pool by the death of the phenotype.



MS: Darwin-Genetics

As we have seen, the workings of a modern computer require that there be an ability to read and write digital information. Both read and write are crucial to the sophisticated manipulation of information.

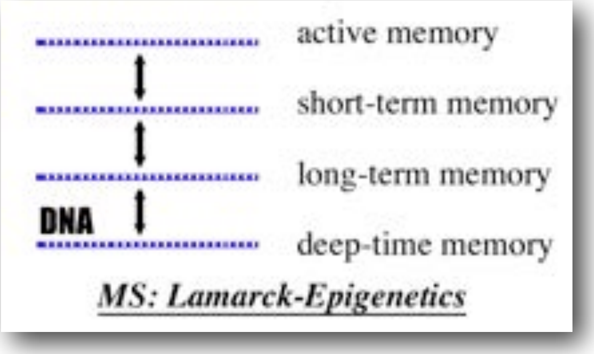
In unified science, learning about the Logos and writing it to memory for later recall, underlies evolutionary development exploring a phase space. This requires that both writing and reading are possible at every level.

While learning requires memory, memory does not imply learning. The computer is an example. It has a systematic hierarchy of memory, from active memory that is constantly changing, short-term memory in buffers and registers, medium-term memory in virtual images, and long-term memory when data is written to disk.

MEMORY
Active
Short-term
Medium-term
Long-term

With this in mind, we can expect to find that living systems have various levels of memory from short-term active memory on RNA to deep-time storage on DNA. In the early days of evolutionary thought, Charles Darwin became associated with the concept of *random variation* underlying evolution, while Jean-Baptiste Lamarck was associated with *accumulated learning* underlying evolution. Lamarckism implies that writing to digital memory must exist alongside reading from digital memory.

While this *writing to disk* is absent in the Fundamental Dogma of genetics, the new and burgeoning science of *epigenetics* is explicitly exploring this aspect of the writing of digital memory in living systems. In a unified science, the theory of evolution is a postmodern synthesis of Lamarck and epigenetics.



MS: Lamarck-Epigenetics

EPIGENETICS

While epigenetics is now so well-established as to have a recent Nova episode[44] devoted to it on PBS television, it is probably a field that is unfamiliar to most people. In many ways, it can be considered the reemergence of Lamarckism in a much more sophisticated form.

> "For years, genes have been considered the one and only way biological traits could be passed down through generations of organisms. Not anymore. Increasingly, biologists are finding that non-genetic variation acquired during the life of an organism can sometimes be passed on to offspring—a phenomenon known as epigenetic inheritance. An article … in the July issue of *The Quarterly Review of Biology* lists over 100 well-documented cases of epigenetic inheritance between generations of organisms, and suggests that non-DNA inheritance happens much more often than scientists previously thought."[45]

The 'central dogma' of molecular biology is that there is a one-way flow of information from the genotype—the genes and DNA sequence—to the phenotype—the proteins and the result of protein action—i.e., the development and eventual form and function of the body. It is upon this central dogma that the whole of Darwinism is constructed since, as there is no 'back-flow' of information from the body to the genome, the only changes allowed in the genome are random mutations, random rearrangements, and other such random occurrences for natural selection to go to work on.

This dogmatic assertion, so fundamental to Darwinism, is clearly up for revision. Note that the preeminent proponent of materialistic Darwinism, Richard Dawkins, assumes in his many works that all is now understood of the basic principles of evolution premised on random mutation and variation.[46] As he does not, however, mention epigenetics even once in any of his writings, by this fact alone he is condemned to have only a partial view of the truth; the classic mistake of the blind man confusing his odiferous grasp of the elephant's tail with the whole beast. Richard Dawkins is not unique in this respect; this premature assumption of complete knowledge happened to many elder statesmen in physics just a century ago:

> "It seems that every so often, a fairly large group of scientists begin to assert that science is just about complete, that the vast unknown is gone, and that all the really major research can stop because we now know everything except the details. For those who fall under the spell of this sort of belief, be aware that a similar belief seemed to have taken hold at the turn of the last century. This was just before Relativity and Quantum Mechanics appeared on the scene and opened up new realms for exploration…. 'The more important fundamental laws and facts of physical science have all been discovered, and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote.... Our future discoveries must be looked for in the sixth place of decimals.'- *Albert. A. Michelson, speech at the dedication of Ryerson Physics Lab, U. of Chicago 1894.* 'There is nothing new to be discovered in physics now. All that remains is more and more precise measurement' - *Lord Kelvin, 1900.*"[47]

Just as in physics—where the advent of relativity and quantum mechanics punctured this 'we know it all' attitude—so the advent of epigenetics has the potential to puncture the biological 'we know it all' attitude prevalent in current Darwinism as exemplified by Richard Dawkins in all his writings. One can only feel sorry for Dawkins as the dustbin of history is not a comfortable place for one so arrogant.

Emergence of epigenetics

The first hint that the one-way "central dogma" of Darwinism was wrong came when it was noticed that the identical genetic defect in the human genotype had very different effects on the phenotype depending on whether the faulty gene was inherited from the mother or the father.

> Even though both parents contribute equally to the genetic content of their offspring, a developmental process called genomic imprinting sometimes leads to the exclusive expression of specific genes from only one parent. This process was first described in 1984, when two laboratories discovered a mark, or 'imprint,' that differentiates between certain genes on the maternal and paternal chromosomes and results in the expression of only one copy of those genes in the offspring. The genes in imprinted areas of an organism's genome are expressed depending on the parent of origin.[48]

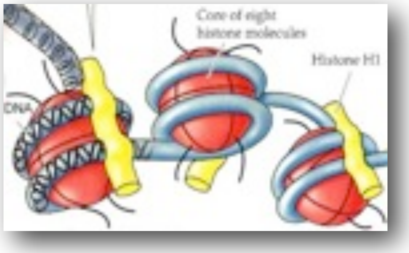
This phenomenon was eventually traced to a pattern of chemical alterations—methylation of the cytosine bases—imprinted on the structure of the DNA. Here the DNA was acting as the substrate for a layer of information to be written on. This has nothing to do with the base sequence itself—the genetic code—it is defined as a level of epigenetic information impressed on the genetic level.

Epigenetics and Lamarckism

Even more dramatic examples that violated classical Darwinism were soon uncovered.

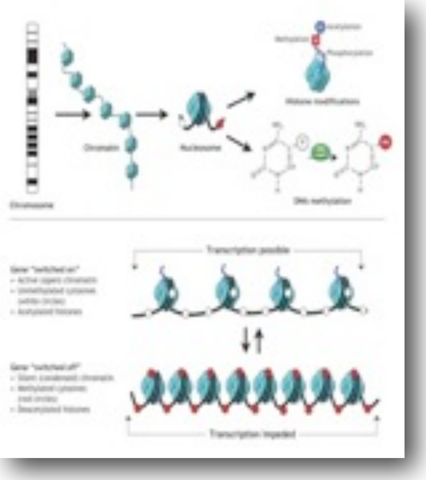
> "Toward the end of World War II, a German-imposed food embargo in western Holland—a densely populated area already suffering from scarce food supplies, ruined agricultural lands, and the onset of an unusually harsh winter—led to the death by starvation of some 30,000 people. Detailed birth records collected during that so-called Dutch Hunger Winter have provided scientists with useful data for analyzing the long-term health effects of prenatal exposure to famine. Not only have researchers linked such exposure to a range of developmental and adult disorders, including low birth weight, diabetes, obesity, coronary heart disease, breast and other cancers, but at least one group has also associated exposure with the birth of smaller-than-normal grandchildren. The finding is remarkable because it suggests that a pregnant mother's diet can affect her health in such a way that not only her children but her grandchildren (and possibly great-grandchildren, etc.) inherit the same health problems.
>
> "In another study, unrelated to the Hunger Winter, researchers correlated grandparents' prepubertal access to food with diabetes and heart disease. In other words, you are what your grandmother ate. But, wait, wouldn't that imply what every good biologist knows is practically scientific heresy: the Lamarckian inheritance of acquired characteristics?"[49]

In this case, the epigenetic information involved chemical tagging of the histones, the protein 'spools' on which the foot-long DNA molecules are wrapped around to keep them manageable. This is an image of how histones and DNA combine:[50]



Reversible and site-specific histone modifications occur at multiple sites through acetylation—replacing a hydroxyl with an acetyl group—of the histone proteins. It would seem—and this is currently an active area of research—that there is a connection between the epigenetic information written on the DNA and that written on the histones working in complementary directions: Methylation of DNA turns it off while acetylation of histones turns them on. It seems that methylated DNA on non-acylated histones is hard to unwrap—so its information cannot be easily accessed—while un-methylated DNA on acetylated histones is easy to unwrap and its information is more easily accessed.

This diagram is a summary of what is currently known about the mechanism of epigenetic inheritance:[51]



This mechanism of storing information about the current state of the organism is now well-established; there are probably other mechanisms at work as well.

Most of the investigations into epigenetic mechanisms are currently focused on medicine and the state of disease, such as cancer, etc. There has not been much work on how this field impacts the mechanisms of evolution but it is clear that a new principle is involved.

Information about the current state of the organism is imprinted on the genetic heritage and can be accumulated over the ages as it is passed on down a lineage.

> "The field of epigenetics has gained great momentum in recent years and is now a rapidly advancing field of biological and medical research. Epigenetic changes play a key role in normal development as well as in disease. The editor of this book has assembled top-quality scientists from diverse fields of epigenetics to produce a major new volume on current epigenetics research. In this book the molecular mechanisms and biological processes in which epigenetic modifications play a primordial role are described in detail…. The final chapter describes the fascinating potential transfer of epigenetic information across generations."[52]

RECOMBINATION AND SEX

Recombination, or 'crossing over,' as it is otherwise called, occurs in the generation of the sex cells where two copies of a paternal chromosome and two copies of a maternal chromosome (i.e., 8 strands of DNA) entangle and crossover their genetic material.

> Chromosomal crossover (or crossing over) is an exchange of genetic material between homologous chromosomes. It is one of final phases of genetic recombination, which occurs during prophase-1 of meiosis in a process called synapsis. Synapsis begins before the synaptonemal complex develops, and is not completed until near the end of prophase-1. Crossover usually occurs when matching regions on matching chromosomes break and then reconnect to the other chromosome.[53]

It is this mixing of the genetic material that is at the heart of sexual reproduction and, since only sexual species evolve and spin off daughter species Sex can be considered to have a central role in evolution.

In Darwinism, this process of breaking and reconnecting the DNA is considered random even though it is well-established that there are ‘hot-spots’ (where crossing over occurs with a high frequency) and ‘cold spots’ (where crossing over never occurs).

Epigenetics and Recombination

Evidence is accumulating that there is a link between ‘short term’ epigenetic information and recombination with its long-term consequences. This is from the report of a biology convention in 2006:

> “Carmen Sapienza (Temple University Medical School, Philadelphia, USA) reported that imprinted regions in humans are historical hotspots of recombination. Together with specific DNA sequences, epigenetic factors may have an important influence on the rate of meiotic recombination and the position of cross-overs. Using *in silico* and *in vitro* analyses, Sapienza's group have shown a relationship between increased rates of meiotic recombination and genomic imprinting. Imprinted regions showed more linkage disequilibrium, and had a significantly higher number of small haplotype blocks [passed down without recombination}, than the non-imprinted regions. Their findings suggest that several factors, including both specific DNA sequences and epigenetics, are involved in controlling meiotic recombination in humans.”[54]

Other groups have also established connections between epigenetics and the rearrangement of the genome in recombination including the arabidopsis plant,[55] in humans[56], in the centromeres that control the structure of the eukaryote cell[57], and in the recombination that underlies the antibody diversity in the immune system.[58]

WHY SEX?

One of the ‘open questions’ in modern biology is: “Why sex?” The overwhelming preponderance of sexual reproduction in multicellular organisms is a puzzle because asexual reproduction is so much more efficient at generating progeny.

It is a well-known fact that, while Darwin titled his epochal work, *The Origin of Species*, he did not actually propose any mechanism for the emergence of new species. The ideas he proposed, at best, dealt with the origin of races within a species, not new species themselves. To this day, there is no consensus as to how this happens other than a process of gradual divergence and gradual infertility between races.

This does accord with what is known, however, as illustrated by the human race. There has certainly been a lot of epigenetic learning and writing to genetic memory in the many tens of thousands of years since the first humans emerged in Africa. These are the human variants we call races.

> The first theory, known as the 'Out of Africa' model, is that Homo sapiens developed first in Africa and then spread around the world between 100 and 200,000 years ago, superseding all other hominid species. The implication of this argument is that all modern people are ultimately of African descent. The other theory, known as the 'Multi-regional' Model, is that Homo sapiens evolved simultaneously in different parts of the world… Although the debate is far from concluded, it is probably fair to say that the bulk of scientists support the 'Out of Africa' hypothesis and believe that all humans share a common origin.[59]

Examples of the innovations expressed in the emergence of the human races are the ability to digest milk through adulthood (a rarity in the stay-at-home Africans; common in Europeans) and the loss of UV-protecting-but-vitamin-D discouraging melanin in the races in sun-deprived northern latitudes. For all these epigenetic and genetic changes, however, the ability of Black Africans and White Europeans to interbreed is in no way diminished.[60] In fact, a quite-opposite phenomenon is firmly established in biology: that of hybrid vigor: “An increase in the performance of hybrids over that of purebreds, most noticeably in traits such as fertility and survivability.”[61]

In the theory presented here, the epigenetic-directed recombination of genetic material is the key mechanism of speciation and resultant reproductive isolation. Evidence that this might be correct is to be found in the rather odd sequence of events leading up to the formation of the haploid sex cells (with one set of chromosomes) from the diploid germ cells (with two sets of chromosomes). One obvious reason for this haploid-diploid alternation is to prevent a buildup of chromosome number that would happen if the sex cells were diploid—the children would have four sets, the grandchildren eight, the great-grandchildren sixteen, etc.

The obvious way to get two haploid cells from a diploid cell would be to have a regular cell division (mitosis) that skips the chromosome duplication step. This is not the case. The formation of the sex cells (meiosis) adds a seemingly unnecessary step that just adds to the workload. First, the two sets of chromosomes—the paternal set and the maternal set—are duplicated. The cell now has four sets of chromosomes! These all commingle into what is called the tetraplex or synaptic complex[62]—the stage when recombination and reorganization of the genetic material occurs. The four sets of chromosomes are now progressively reduced to one set by two rounds of cell division to create four haploid sex cells.

Current biology has no good rational for this complicated way of doing things as recombination is considered to be random chance-and-accident. In the perspective developed here, however, this abundance of chromosomes hints at some currently-uncharacterized mechanism for the directed reorganization of genetic material while also ensuring that the new daughter species can be 'brought to term' successfully by the mother species.[63]

If epigenetic-directed recombination turns out to be at the heart of speciation, it would provide a simple answer as to why almost all species are sexual: only sexual species can evolve, only sexual species can give rise to new species and more sophisticated organisms. The adoption of the asexual mode of reproduction, while advantageous in the moment, is an evolutionary dead end.

> The evolution of traditional, female-only asexuality typically leads to a swift extinction. We know this because although such species frequently evolve, they don't stay around for long. If you look at the tree of life, female-only asexual groups are all out on the twigs: there are no great asexual lineages equivalent to fish or birds. Instead, the asexual groups are a few species of snail here, a dandelion there.[64]

Without sex, the highest form of life would be the simple unicellular forms that predominated the first billion years of life on earth and there would have been no Cambrian Explosion of multicellular forms and certainly no humans.

Unification Thought puts sexuality at the very center of human life (and the Fall). If this perspective has any validity, it would seem that Molecular Biology has sex as the dynamo of evolution.

Memory and aging

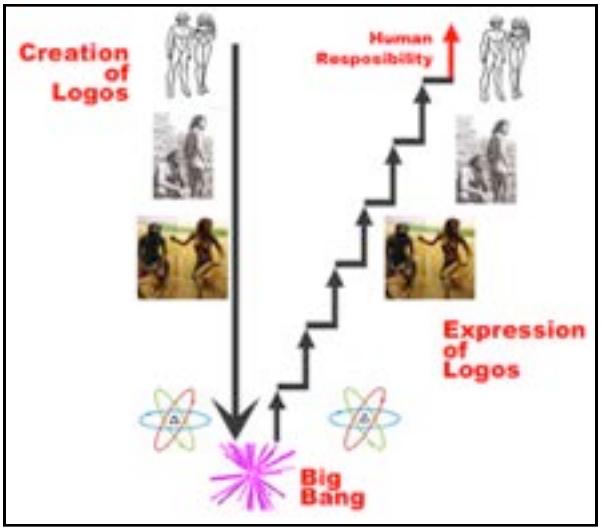
In the perspective we have developed, DNA is a long-term digital storage medium for analog memories. RNA, being more labile, is for short-to-medium storage. If this is so, then the DNA sequence of, say, the aged human brain, should be different from the sequence from aged cheek cells. If these were just mutational errors, these differences should be randomly scattered. If, however, they are a result of accumulated memories, they will be localized in distinct areas. This is akin to the paradox in the Modern Synthesis that states that 'mutations' are random events that are confined to 'hot spots,' while the conserved 'cold spots' show very little change. The changes are clearly not random, as the living system is controlling where they are occurring.

It has been said that the changes in the DNA sequence of modern humans are too great to have occurred if there were a single First Human pair ~100,000 years ago from which all humans are descended. In the Modern Synthesis, this would necessitate a mutation rate so great that it would be inimical to any continuity. For in the Modern Synthesis view, for every random change that is 'fit to survive,' there are many more that are not.

In the view developed here, these changes are not random, they are 'ancestral wisdom' accumulated down a lineage.

ORIGIN OF MAN

Step-by-step, the Logos is sequentially expressed in living systems over time, passing through what can be colloquially called the Age of Bacteria, the Age of Protists, the Age of Worms. the Age of Fishes, the Age of Reptiles, the Age of Mammals, and the Rise of the Primates. An overview of this sequence was given at a UTI symposium in Tokyo.[65]



The focus here is on he final stage, when the Logos reaches its complete expression in the birth of the first human pair, Adam and Eve. Unification Thought states that the final stage of becoming one with God is a creative act of human will, the fulfillment of human responsibility as humans mature.

The exact sequence is still a matter of debate so, for convenience, we will equate the prehuman stage with the Neanderthals.

Materialism has that the transition from Neanderthal to human was a gradual event over an extended period. The science of Godism, as presented here, proposes that there was a specific speciation event in which epigenetic information, gleaned from the Logos via the environment, directed a reconfiguration of the Neanderthal genetic material into the human configuration. A new set of qualities was inherited from the Logos, including the knitting together of the mind into the "I Am" sense of self.

I discussed a plausible mechanism of universal speciation directed by the accumulated epigenetic information in *Volume One*.[66] The speciation event always involves a male and female, and the result was the birth of Adam and Eve, as the first humans are traditionally called. Classical science states that the transition from Neanderthal to Human was caused by random variation and survival of the fittest. A modern spokesperson for this view is Richard Dawkins. Unified Science proposes that speciation occurs by a specific mechanism directed by accumulated ancestral wisdom inherited from Logos and passed down a lineage.

Abilities that for the Neanderthals were learned with great effort became hard-wired into humans. The mental abilities of a mature Neanderthal were comparable to those of a six-year-old human, and they could develop no further. In yesterday's psychology, a Neanderthal would have been classified as an *imbecile* (above an *idiot* but below a *moron*). There is evidence that various races of Neanderthals, specialized for various environments—lakes, forest, savannah, etc.—came together and 'pooled their wisdom' in the lineage leading up to humans.

Neanderthals probably communicated with a simple pidgin of nouns and verbs, had mastered fire, and were successful gatherers and hunters wielding crudely-chipped lumps of flint rock.

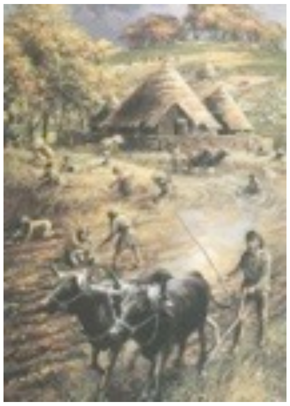
The time and place in which the first humans were born is traditionally called the Garden of Eden and science has a rough idea of when it occurred—the transition from the Paleolithic age (Old Stone Age) to the Neolithic age (New Stone Age).

THE PALEOLITHIC

We will equate the period in which the Neanderthals were the most sophisticated of the primates with the paleolithic age, which lasted about 2,500,000 years. The cultural changes over this vast stretch of time were very slow and incremental, with the controlled use of fire appearing just 400,000 years ago.[67] The sophistication of the stone implements, for example, hardly changed over millions of years. Stasis was the rule.

Archeological evidence exists that shows that they buried their dead and eventually had mastery of fire for cooking. They were communal (clan and tribal level) and probably had a pre-language (pidgin) of simple nouns and verbs. They fashioned simple stone and bone tools, and were successful hunters and could fend off predators such as the great cats. The fossilized Laetoli footprints left in 3,000,000-year-old volcanic ash—footprints of a male, a female and a child[68] pre-Neanderthal—suggest that pair-bonding reproduction was already established at this early stage.

THE NEOLITHIC

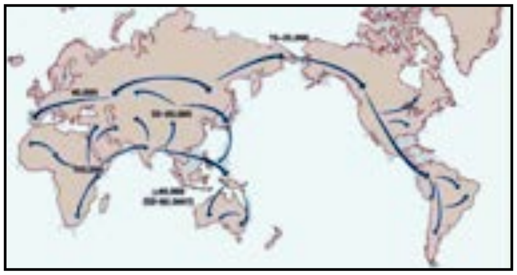


This million-year stasis was ended by the emergence of Man and the start of the neolithic age about 100,000 ago, and was in full swing about 50,000 ago. The stone and bone shaping of tools was much more sophisticated and decorated. They had a true language of syntax and grammar. The hunter-gatherer stage developed into that of agriculture and the domestication of animals >20,000 YBP and, most distressingly, the earliest evidence of a battle is 14,000 YBP.[69]

Habitations beyond caves were developed. The discovery of how to smelt copper from its ores and how to create its alloy, bronze, marked the end of the neolithic and the start of the Bronze Age ~15,000 YBP. Writing was developed soon after. Unlike the million-year stasis of the Old Stone Age, innovative change over thousands of years was the rule in the New Stone Age.

The location of the Origin of Man, the *Garden of Eden*, has been roughly established by three lines of evidence that are all in essential agreement. These are the study of the spread languages, the study of the female lineage using mitochondria, and the study of the male lineage using the Y-chromosome.

Female lineage



The history of the female lineage is tracked by tracing the spread of genetic markers on the mitochondrial chromosome, which is passed down the female lineage from mother to daughter. The mitochondria are not passed on by males. If a mitochondrion does make it from the sperm into the egg, it is immediately surrounded and destroyed.[70]

The pattern of human migration that emerged from these studies indicates that it started off in East Africa, then humans spread south into Africa and north to the rest of the world.[71] This original female is called “mitochondrial Eve” in the literature.

Male lineage

The history of the male lineage is tracked by tracing the spread of genetic markers on the Y-chromosome which is passed solely down the male lineage from father to son, and is not passed on to females. The pattern of human migration that emerged reveals that it started off in East Africa, then humans spread south into Africa and north to the rest of the world.[72] This original male is called the “Y-chromosome Adam.”

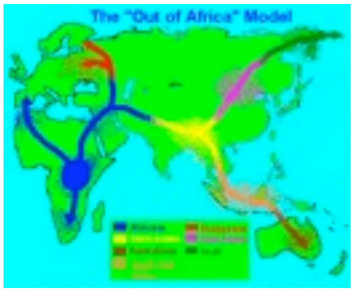
The materialistic view of gradual speciation posits that the mitochondrial Eve and the Y-chromosome Adam were members of a “small breeding population.” The unified view of a directed, specific mechanism for speciation affirms that this population was as small as two.

Linguistics

The study of how language has changed over time as humans migrated locates the origin of language in East Africa, from where humans spread north to the rest of the world:

> “A new linguistic analysis attempts to rewrite the story of Babel by borrowing from the methods of genetic analysis – and finds that modern language originated in sub-Saharan Africa and spread across the world with migrating human populations.”[73]

All three lines of investigation suggest that the eden into which the first humans were born was in East Africa less than 100,000 years ago. Genetic analysis of the genes for skin color indicate that



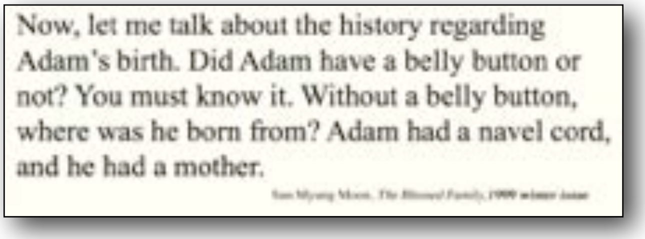
the first humans were black, and that the yellow and white pigmentation arose much later as human migration progressed.[74]

There is evidence that different races of Neanderthals commingled on the route to Humans, including races adapted to water as well as other races adapted to forest and savanna.[75] The advantage that occurs in such 'miscegenation' is known as 'hybrid vigor' in practical genetics.[76]

On purely esthetic grounds, I like to think that the Neanderthal tribes gathered, interbred, and gave rise to humans in East Africa's most dramatic and bountiful landscape between Mt. Kilimanjaro and the Great Lakes.

COMPLETE EXPRESSION OF LOGOS

Unificationism rejects the idea that the first humans were created fully formed, and accepts that they emerged much as children emerge today. Basic physiology was then as it is now, so we can infer much about their situation.



Now, let me talk about the history regarding Adam's birth. Did Adam have a belly button or not? You must know it. Without a belly button, where was he born from? Adam had a navel cord, and he had a mother.

Sun Myung Moon, *The Blessed Family*, 1999 winter issue

Putting this altogether, we conclude that the 2nd stage of Creation, the expression of the Logos, was completed with the birth of the first two humans, and their natural development to about 6 years old and to the Neanderthal level of personality. Their development from then on to maturity, the ability to love as God loves, was their own creative responsibility.

Physiology

We can assume that Adam and Eve were born into the midst of a flourishing and supportive tribe of Neanderthals. They had a biological father and a biological mother and, furthermore, as these parents were at the highest level of Neanderthal development, we can assume they had a high status in the tribe, perhaps even being the leaders of the tribe.

As is normal for all human beings, the first two humans emerged as helpless newborns and they were fed at their Neanderthal mother's breast.

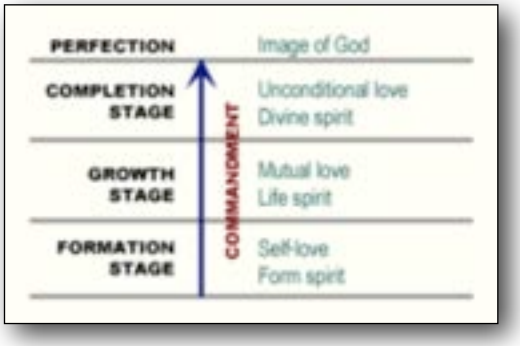
As they grew, they were protected from predators and provided with food. They played with Neanderthal children, and were taught the ways of the tribe. They were similar to their peers in their capacities until they were past the age of six. Then they left their peers far behind them.

In particular, human children have the innate capacity, inherited from the Logos, to create a true language out of a pidgin, i.e., to create a language with grammar and syntax.[77] So Adam and Eve would have created their own language, a level of sophisticated communication unavailable to the Neanderthals, the ‘ur-language’ as it might be called.

The first humans were two golden children maturing in a world of kind and supportive imbeciles.

ORIGINAL PLAN

Adam and Eve were to grow to perfection, to love as God loves, with unconditional parental love for all. They were to grow through the stages of their scope and capacity to love, using their free creativity until their love was mature.



To guide them along this path without mishap, the Bible parable states that God gave a commandment to Adam and Eve, and their responsibility was simply to follow this guidance. The Commandment could have been as simple as: *Stay at home*, and it would have been quite natural for this admonition to come from the male parental Neanderthal. This is the principle behind the adage: *Two’s company, three’s a crowd* and why, in this age of sex abuse, priests and teachers are advised to always have another person present. It is the difference between a private and a public relationship. Indirect support for this simple Commandment is given in an early systemization of Unificationism when discussing how Lucifer’s love-to-lust occurred: *If Adam had watched over Eve more closely and spent more time with her, this would not have happened.*[78]

In this balanced situation, the male parent of Adam and Eve would be dazzled by the brilliance of his children and nothing untoward could occur, and the purpose of Creation would have been completed with the uniting of Adam and Eve in True Love.

To put it simply, the Commandment was to keep them out of trouble, to keep them safe. In this situation, their characters and ability to love, their spirits, would have naturally grown from self-love, through mutual love to unconditional love, God’s love. From being self-centered spirits, through what Unification Thought calls Form and Life spirit stages, to becoming Divine spirit. They would live out their days on earth, raise a true family of children and grandchildren, and then, discarding their physical bodies, pass into the spirit world where they would spend the rest of eternity with God in the realm of True Love, the kingdom of heaven.

With Adam and Eve raising their family in true love, there would be no more necessity of the Commandment since Adam and Eve were quite capable of keeping their children out of trouble.

The human race would multiply and develop true love culture as the natural leaders of the Neanderthals, who would greatly prosper under their loving and creative care. This is the dominion of true love humans were meant to exercise over Creation, and is the fulfillment of the Third Blessing.

Domestication of hominids

One rather surprising implication of this view is that the first animal to be domesticated would be the Neanderthal, not the dog. The Neanderthals would be the natural servant class, while the true love humans would be the natural aristocrats. With plenty of leisure time, humans would rapidly develop agriculture, science, and an abundance of art.

The image of a natural, hereditary aristocrat and servant class tends to be associated with the endless examples of unnatural slavery in human history. The images of White master beating Black slave, or Japanese overlord and Korean underdog are two not-so-distant examples of attempts to enslave human beings. The true love relationship is quite different to these shudder-inducing examples from fallen history.

The relationship of Human lord and domesticated Neanderthal is the ideal portrayed on American TV by the relationship between Joe and his dog Lassie, and the Lone Ranger and his horse Silver. The image is not master-beating-slave but rather, “Dogs who talk, do dishes and can be toilet-trained.”

A ‘slave rebellion’ would be as unthinkable as is a pedigree-dog revolt. The true love culture would fill the earth, and then spread out to all the galaxies. We can expect that God included pathways between the stars for this expansion, and one possible way was discussed in an earlier UTI paper on physics.[79]

An Aside on Astrology

Most of this essay was written in the 1980s.

Poor President Reagan! The 40th President of the USA, and forty is usually considered such a lucky number in history. It seems our Ronald is having to weather storm after storm these days—such a difference from those early triumphant years. Hardly anybody seems to like him these days, although I have a feeling that by this time next year we will all miss him sorely. The latest goad with which the press torment him is that he and Nancy are being mocked for taking cues from astrology.

We can assume that much of this mockery derives from a politically motivated desire to discredit. As this paper is supposed to be mute about political issues, I will pass over this source of criticism.

There are, however, at least two other perspectives that cast doubt on the wisdom of heeding astrology: Science and Religion. To my mind, from a certain perspective, these rather strange bedfellows have much the same comment to make about astrology. Let's take a look at the religious perspective first.

Religion and Astrology

An almost universal concept in higher religions is that God created man to be the ruler of the physical world. It does not make sense, therefore, that man would be objective to, and ruled by, the planets. The idea of planetary influence has to be thrown out for this reason.

Another of the basic ideas in astrology that has more going for it, is that you can predict much about the characteristics of a person from the positions of the planets at the moment of their birth. This actually makes some sense, even though, as you will see, we will have to turn some concepts upside down.

A human being is created in the image of God while the rest of the universe is created as a partial reflection of God. Man is not just physical material; he also has a spirit. Just as the physical body is constructed in the womb, the Divine Principle teaches that the spirit is also coming together during this time and, at the moment of birth, with the first breath, the spirit completes itself and becomes eternal.

So here we have a situation where, at the moment of birth, a human being becomes an eternal being, a truly human being, reflecting God. God's image is fully expressed there (in potential, actually, but that's another topic) at that moment. But at that same moment, the rest of the universe is also a (partial) reflection of God's image. This means that the universe is also a partial reflection of the child at the moment when the child first becomes like God. We can speculate that people throughout the ages noticed the correlation between the planets and birth, and went on to develop the familiar theories to explain it, Voila! Astrology.

While it does not make sense to say that the planets 'influence' the newborn child, it does make sense to say that the universe is proclaiming the special qualities of the child born at that moment. There is a sound theological reason for this: The parental heart of God wants to celebrate the birth of His children—wouldn't you have designed things that way if you were a cosmic "mush-heart" parent?

That's why you can proudly say that the planets proclaimed the glory of your birth, just as they have for everyone else.

If religion can give a reason and purpose for the phenomenon, perhaps science can come up with an explanation for it, a better one than "we are ruled by the planets."

Science and Astrology

Our contemporary science seems to have little good to say about astrology. The central tenet of astrology is that the positions of the planets influence human behavior. In our science, the only interaction that both humans and planets respond to is gravitation. The gravitational forces of the planets on us, however, are extremely small. If the planets did influence us through the gravitational force, the much greater gravitational effects of local mountains and oceans could then be expected to have an even greater influence. If this were so, we would expect that people would have noticed it and developed 'geology' instead of astrology.

This is not to say, however, that science proves that astrology is bunk. Science can state that the astrologers have got their theories that explain their observations all wrong (unless there is some totally unknown interaction yet to be discovered by science—unlikely, but not impossible). A good historical illustration of this situation is that while the theories of the alchemists were way off, their descriptions of how one material could be transformed into another became the foundations of modern chemistry.

Unfortunately, I am not aware of any scientific study of the relationship between the predictions of astrology and what actually transpires. One thing is apparent, however, and that is that many people in many different cultures have placed a lot of confidence in the capabilities of astrology over thousands of years. As you are probably aware, you are not alone, Nancy.

So let's give all these people the benefit of the doubt and assume that astrology is describing a real phenomenon (even though its theories as to how it works might be wrong) and that the positions of the planets at birth do correlate with peoples' dispositions and fortunes. Assuming this, is there anything in modern science that could begin to encompass and explain the phenomenon?

Least Action

Even though we have gone through a tremendous revolution in physics this century, most scientists still think in terms of 19th century concepts of particles and forces. Astrology could never fit into that structure. There is, however, a way of thinking that is gaining hold within the mainstream of modern science that can encompass such speculative proposals as astrology. This is the "Principle of Least Action," which—even though it has only gained greater acceptance in this century because of its perfect fit with quantum mechanics—first appeared in the seventeenth century as an alternative formulation of Newton's laws of motion.

This action principle (or 'action formulation' as the scientists put it) is universally applicable: It applies to every system studied by science—classical physics, quantum mechanics and relativity included. An excellent overview of the action principle in modern science can be found in the chapter "Where the Action is Not" in the book "Fearful Symmetry: The Search for Beauty in Modern Physics" (Macmillan Pub.) by Dr. Anthony Zee. Incidentally, the formula describing the workings of the whole universe in that column was an action formulation: No other description is so succinct as to explain the universe on a table napkin—a small one at that.

The action principle is such a powerful tool and so universal in its applicability that Dr. Zee comments, "Some physicists would like to believe that the Ultimate Designer thinks in terms of action."

The principle of least action is very simple to state (and complex to calculate). For any system changing from one state to another, consider each and every way in which the change could happen. For instance, the gravitational change of falling off a wall. For each of these ways, calculate a number—there are no units involved such as miles or seconds—called the 'action' using the formula for gravitational change. The fascinating thing, and no one knows the reason why (and some scientists have waxed quite metaphysical about it), is that the change that actually happens is always the change that has the smallest number—the lowest action—associated with it (hence the name).

The great challenge of using the Principle of Least Action is, of course, being able to figure out the appropriate formula needed to calculate the action. Some have already been figured out, such as the formula for gravity and the formula for the nuclear force. Others are still unknown. Once you know the correct formulas, however, it becomes possible to deal with complicated situations, because all you have to do is add up the numbers—simple math still has a place in modern physics! For instance, consider a change that involves both gravity and electromagnetism. First, figure out all the ways the change could happen. For each way, apply the gravity formula to get one number, apply the electromagnetic formula to get another number, and add the two numbers to get the total action. The way of change with the lowest total action will be the one that actually happens. Simple.

It is an aid to humility to remember that, for all its successes, our contemporary science knows the appropriate formulas only for simple cases, but there is every reason to suspect that the same principle holds true for something as complex as childbirth.

A Common Factor

How does this relate to astrology? Is there a factor whose formula appears in both the action for planets and the action for what happens to the child at birth? If so, then we could expect a correlation between the two.

One excellent contender is gravity. Now, I know that I just wrote that gravity was out of the question, but up there I was talking about the *force* of gravity, now I'm talking about the *principle* of gravitation, a formula describing gravity. While the force is something between two individual objects, the principle is a mathematical construct that appears in the equations for calculating action.

It is obvious that the gravitational formula appears in the action formulation of planetary motion. But does the principle of gravity appear in the action for childbirth?

I think it probably does for the following reasons. There are clear rhythms, sort of built-in clocks, in all living things. Naturally enough, we humans have them as well, including daily, monthly, and yearly rhythms. Now, to be of use, these internal clocks have to be 'in sync' with the rest of the world (as any frequent flyer will testify to their clocks getting jet-lagged out of sync.). Whatever the total action is that governs these clocks, we can expect that one of the components will be the gravitational formula, as it is this formula which governs the external rhythms with which the clocks have to sync with.

In the womb we are relatively isolated from the rest of the universe, the womb being the total universe to the developing child. At birth, however, our rhythms have to sync up with the rest of the world—a situation that could be considered similar to nine months' jet lag. This adjustment process of the internal clocks has an associated action that also includes the gravitational formula.

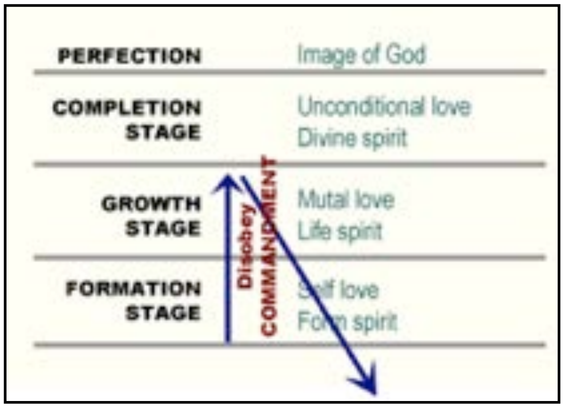
We have the two separate phenomena of planets and one of the happenings of childbirth, both involving the gravitational formula in some way. So, it would be no surprise if there was a correlation as witnessed by the astrologers.

Please understand, however, that I'm not saying that this is the way it is, but that it is a plausible, scientific explanation of the phenomenon observed by the astrologers that has implications that can be tested—something scientists insist on.

So, there you have it. As I said at the start, from a certain perspective, both religion and science have much the same to say about astrology: The phenomenon might well be real but the astrologers have their explanations all wrong. So, Ron and Nancy, I can only hope that these speculations help soothe the sting of criticism: Perhaps you are not as far off the mark as your tormentors would have us believe.

WHAT WENT WRONG?

This loving, leisurely civilization never emerged. Instead a brutish culture developed where there was no true love and all humans were out for themselves. Family dysfunction was the norm—see *King Lear* or all of the classical Greek plays for examples. It was a culture into which "Thou shalt honor your father and mother" had to be injected as a divine revelation. Life was nasty, brutish and short, and the spirit of those times has been chillingly recreated in a recent movie featuring slaves and human sacrifice.[80]



Unificationism states that there were two stages in the Fall of Man:

1. Adam did not obey the Commandment. In fact, the Bible relates that he went off naming all the animals. He did not stay home, and the father-Neanderthal was left with only Eve to fall in love with.
2. Lucifer was twisted into Satan by the misdirected power of love, and in this state had a sexual relationship with Eve.

Because Adam disobeyed, the Neanderthal male parent, called Lucifer in later ages, was left alone with an enchanting, beautiful young woman, Eve. This was an unbalanced situation and Lucifer's love for Eve became twisted into lust. His mind was filled with things that had nothing to do with the Logos which he had resonated with before.

Now, we have to ask the disquieting question: What kind of sexual relations did this parental, grown male have with the young woman? What kind of sexual relations could have so brutalized Eve that she brutalized her children and her children's children down to the present day.

For an answer to this, we turn to what is known from human psychology about the ubiquitous and deeply-disturbing prevalence and consequences of fathers raping their daughters.

Child Rape

It is only in these supposedly best-of-times that the prevalence of father-daughter rape has become well -known; we can assume that it was even more prevalent in more barbaric times.

> In North America, approximately 15% to 25% of women… were sexually abused when they were children. Most sexual abuse offenders are acquainted with their victims; approximately 30% are relatives of the child… Most child sexual abuse is committed by men… The most-often reported form of incest is father-daughter and stepfather-daughter incest…[81]

For a young girl who has been raped by a father-figure, the consequences on her psyche and spirit are extreme and devastating.

> Child rape can result in both short-term and long-term harm, including psychopathology in later life. Psychological, emotional, physical, and social effects include depression, post-traumatic stress disorder, anxiety, eating disorders, poor self-esteem, dissociative and anxiety disorders; general psychological distress and disorders such as somatization, neurosis, chronic pain, sexualized behavior, school/learning problems; and behavior problems including substance abuse, self-destructive behavior, animal cruelty, crime in adulthood and suicide… Long term negative effects on development leading to repeated or additional victimization in adulthood are also associated with child rape. The risk of harm is greater if the abuser is a relative…[82]

It is a phenomenon of these last days that such sexual abuse by fathers, uncles, teachers, priests, etc., has come into the open, but it was probably as prevalent in the past.

> Most children are abused by someone they know and trust. A study in three states found 96% of reported rape survivors under age twelve knew the attacker. Four percent of the offenders were strangers, 20% were fathers, 16% were relatives and 50% were acquaintances or friends.[83]

Dysfunctional lineage

The abused becomes the abuser, and so it continues down the generations.

The study of the science of epigenetics was initiated in the last decade by the astonishing discovery that women who had experienced the starvation and deprivation of the Siege of Stalingrad had grandchildren with significantly shorter life expectancies.[84] So, it is not too much of a conceptual stretch to think that the far more devastating experience of child rape by a parent figure would affect all of the descendants. This epigenetic imprint is the Original Sin, the twisted wisdom of the ancestors, which has kept all people from being able to love as God loves.

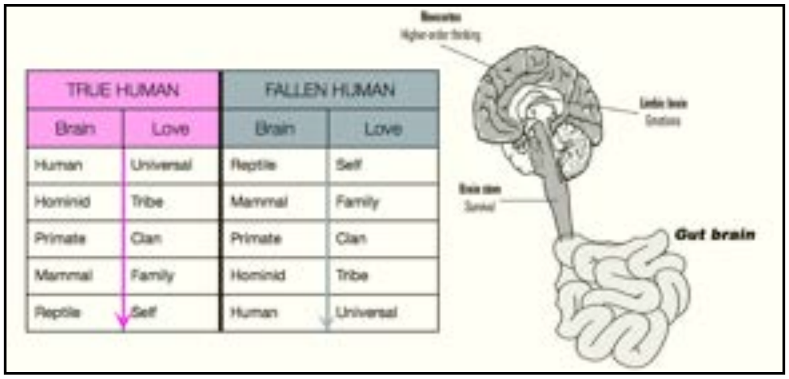
The merit of the age is such that father-daughter incest is universally deplored. Even so, it occurs in even the most spiritually advanced communities, as recounted in In Jin Nim's sermon dealing with a father-daughter rape in the unification community.[85]

Epigenetics explains the seemingly-unfair warning in the Bible: “Visiting the iniquity of the fathers upon the children and the children’s children to the third and the fourth generation.”[86]

A consequence of the Fall, mentioned in the Bible, is the prediction that Man would now need to earn a living by great effort. *Cursed is the ground for your sake; In toil you shall eat of it.*[87] For in this broken, loveless situation there could be no natural servant class. The Neanderthals were not domesticated with God’s Love; instead, they were all completely exterminated, and even eaten,[88] by brutish, fallen humans within a few thousand years.

Reversed Dominion

The human brain is organized into a hierarchy of modules that each arose in evolution as a step in the expression of the Logos. At the very bottom is the gut brain—the brain stem and the voluminous, if diffuse, network of ganglia that are spread over the internal organs. This is concerned with the survival of the self, and it arose in fish and was perfected in reptiles.



TRUE HUMAN		FALLEN HUMAN	
Brain	Love	Brain	Love
Human	Universal	Reptile	Self
Hominid	Tribe	Mammal	Family
Primate	Clan	Primate	Clan
Mammal	Family	Hominid	Tribe
Reptile	Self	Human	Universal

Above this is the mammalian brain with ability to love on a family level. Above this is the primate brain, with ability to love on the clan level. Above this is the hominid brain, with ability to love on the tribal level. At the very top of the hierarchy is the human module with the potential for universal love.

The trauma of the Fall reversed this hierarchy, and the self-centered gut brain became dominant. Incidentally, much of the gut brain is a hollow tube about the intestines, making the snake an appropriate symbol for Satan. This is why our Founder is always admonishing, “Your body is your enemy.” The human level and the gut level are at war for control of the whole.

Role of angels

Many religions, including Unificationism, include angels, as well as God and humans, in the parables about human origins. Angels are usually considered to be God’s helpers and assistants.

What kind of assistance would be helpful to the Creator God? Surely not in mastering calculus, or figuring out the exact balance between the electromagnetic and gravitational forces so that suns are possible. No, in all that has been said about Adam and Eve, by far the most useful things angels could do for God are the things He cannot do Himself, such as:

- Give birth to Adam and Eve
- Suckle them with mother’s milk
- Protect them from lions, tigers and bears, etc.
- Wean them and then feed them nourishing food
- Teach them toilet discipline, etc.

We reach the conclusion that angels are symbols for the Neanderthals that did all of this for Adam and Eve. The concept of angels existing with God from the very beginning is in contradiction with the two-stage creation, and the stepwise expression from simple to complex. Angels, being just less than human, could not have appeared first, and Unification Thought gives angels no role to play alongside the Logos.

Our mental picture of angels should be not the Sistine Chapel but rather a Neanderthal diorama.

Only one other entity besides God, Adam and Eve is mentioned in the Bible—Lucifer, an archangel, a leader of the angels in a position to influence Adam and Eve.

From what has gone before, we can state that Lucifer is the male Neanderthal whose mate gave birth to the first humans, and that Lucifer is a symbol for the biological father of Adam and Eve. It was he who raised the first humans, and gave them the Commandment that was to protect them.

Lucifer, the kind, imbecile father-figure, was intended in God's plan to fall totally in love with his beautiful children, to fall in love with Adam and Eve. The love that developed in the male parental Neanderthal would be balanced and healthy, just as God intended. Adam and Eve were to grow and develop in this environment to maturity, and so complete of the purpose of creation.

First, we will discuss what God intended for His first children; then we will discuss what could possibly have gone so wrong as to infect all of humanity thereafter with a broken capacity for love.

Surprising Absence

Many religious people are offended by my demotion of angels. While the *Divine Principle* demotes them to a position less that True Man, my thesis goes even further and demotes them from a class of eternal beings to a symbol in human history.

A period of reflection produced an answer to their questions by a more indirect route involving the Archangel Gabriel, a contemporary of Lucifer's, who did not Fall and has appeared throughout providential history at many important points (the logic also embraces the other unfallen Archangels such as Michael and Uriel, etc.). Given their basic similarity, we have three logical possibilities:

A. If Lucifer is a symbol, then so must be Gabriel.

B. If Lucifer is a literal, individual, eternal spirit being, then so must be Gabriel.

C. If Lucifer was created before the Big Bang and has been in the spirit world for 13.5 billion years, then so must have been Gabriel.

The converse is also true: whatever is true for Gabriel on these points must also hold for Lucifer (except for the Fall, of course). So, if we can show that Gabriel is most probably a symbol, then it is within the logic of Unification Thought to suggest that Lucifer is also a symbol.

In studying True Father's words, I realized that the solution is to be found in the curious role that Gabriel has played throughout Father's life in the contemporary providence since Jesus appeared to Father over 75 years ago. The point I wish to make is best illustrated in the adventures of Sherlock Holmes, the famous detective created by Sir Conan Doyle.

Curious absence

One of the most popular Sherlock Holmes short stories, “Silver Blaze,” focuses on the disappearance of a famous race horse on the eve of an important race and the apparent murder of its trainer. The tale hinges on the “curious incident of the dog in the night”:

Gregory, police detective:
“Is there any other point to which you would wish to draw my attention?”

Holmes:
“Yes, to the curious incident of the dog in the night.”

Gregory:
“But the dog did nothing in the night.”

Holmes:
“That was the curious incident.”

Now, I have a dear friend who is a firm believer that both Lucifer and Gabriel are individual spirits who have been in existence for the last 13.5 billion years and are currently inhabitants of the spirit world, and he believes that they are distinct individuals and not symbols of anything at all like a Neanderthal.

But it was he who first researched the topic and reported the following curious fact:

“In my file of 1,500 speeches by Father, I found 15 in which he mentioned Gabriel. None talk about Gabriel's providential purpose.”

What is so curious about this fact is that all the mentions of the Archangel Gabriel are all from the distant past—what happened 2,000 or 4,000 years ago.

Gabriel has done nothing in the contemporary providence, and Gabriel has played no role in Father's life course. What makes it so curious is that Gabriel has done nothing at all in the current era of the Providence. This is exactly what I noticed when researching Father's words:

Gabriel has played no role in the Second Coming, not a single one!

Why do I find this so curious, and thus an important clue? For the following reasons:

1. We are all agreed, I think, that True Father has fulfilled the First Great Blessing of becoming one with God in heart. That he has become a Divine Spirit. That God and True Father are united as mind and body.

2. Unificationists agree, I think, that True Father has raised up True Mother to the same state, and that in their Holy Marriage they fulfilled the Second Great Blessing of becoming True Parents. They are the complete and substantial expression of God's dual nature, the substantial God on earth and in the spirit world.

3. We are all agreed, I think, that True Parents have fulfilled the Third Great Blessing, of becoming Lord of Creation—and this includes having God's authority over the angels, or at least over the unfallen ones, including Gabriel.

4. Unificationists believe that this is the time of the Second Advent and is, at the very least, as important a period to God as was the time of Jesus; and that God is exerting His maximum effort to assist True Parents rid the world of the satanic spirit and to bring in the Kingdom of Heaven world of true love.

Given these points and the assumption that the Archangel Gabriel is a literal spirit being who is close to God (point B. above), then surely we would expect, at least once, in Father's recollections to encounter a statement such as:

"I instructed Gabriel to take this crucial message to…."

or

"Gabriel brought me this warning not to …."

or

"I asked Gabriel about what happened between Zachariah, Mary, and Elizabeth, and he told me that they….."

or, if angels have been around since the Big Bang:

"I quizzed Gabriel about what happened on Earth four-and-a-half billion years ago when the first living things emerged…."

But there is nothing of the kind to be found in Father's words. There is no contact with an individual called Gabriel.

This total absence is very odd if Gabriel is an individual spirit being who is under True Parents' authority, if point B. is correct.

This absence is not at all odd if Gabriel is symbol; it is to be expected. You do not do literal things with symbolic beings.

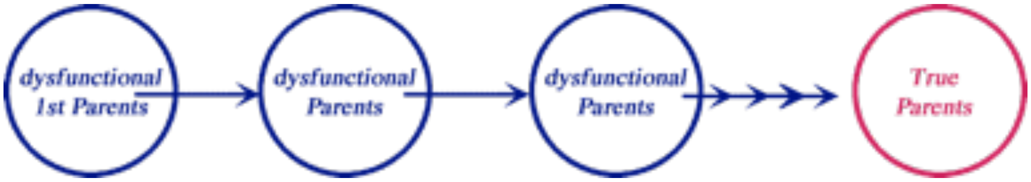
We conclude that point A. is more likely to be correct.

If Gabriel is a symbol, then Lucifer is also a symbol. Here, I suggest that Lucifer was a symbol for the Neanderthal male parent of Adam and Eve.

Because I think this is an aspect of Unification Thought that must be clear before there is any possibility of religion-science unity, I am happy to continue debating the question.

Restoration

The cycle of dysfunction, the inability to love, has been passed on from generation to generation. The history of restoration is God's effort to lead humanity out of this dreadful state, to break the cycle. The cycle of dysfunction will be broken with the advent of the True Parents and the start of the original ideal.



God's work of restoration of this ideal is constrained by the Logos, which is still running things. What was twisted must be untwisted, what was bent must be straightened. The terms 'twisted' and 'bent' do suggest some kind of rotation as well as size, which suggests that *sin*—actions not aligned with the Logos—will one day be expressed quantitatively using complex numbers. Our current mathematics is a long ways from that, as yet.

As described in the *Divine Principle*[89]—mainly in words but with a touch of mathematics—the history of restoration involves the development over time of an opportunity to unbend what was bent by a relational force, by an equal and opposite relational force. Given such an opportunity, it is the choice of a *central figure* to do the right thing, or not do the right thing. The paradigmatic example of this is the Cain/Abel situation that, in the second generation of humans, arose to correct one aspect of the fallen situation.

In the rape of Eve, the animal brain came to dominate over the human brain of the first mother-of-all. This reversal of the intended order in the Logos for the systematic hierarchy of the nervous system is called the *satanic* personality. This satanic perspective on life was created by the animal, *older* male stealing the intended position of the human, *younger* male.

This mixed human-animal nature was passed on to the children, but not in equal measure—the eldest son, Cain, was born with the animal aspect predominant; the second son, Abel, was born with the human aspect predominant. In the way of the Logos, it is natural for the eldest son to be subjective, and the younger sons to be objective to their leader. For Abel to win over his elder brother would be a force against the Logos, but opposite to that in the dynamic of the fall. If Abel had won over his brother using his human heart and abilities, the equal but opposite force generated would straighten-out that animal-over-human aspect of the fall, and the human brain would take its intended position in full control of all the lower animal levels.

Unfortunately, the opposite occurred, and the animal-Cain slaughtered the human-Abel, and the animal level dominated the human level completely for thousands of generations down the lineages of mankind as it spread out across the globe. It was only after a long and miserable history that the Cain/Abel dynamic was corrected in the Abrahamic Middle-East by Jacob winning over his elder brother Esau.

This is just a fragment of the long, complicated, miserable history of restoration outlined in the *Divine Principle*. We will leave to future generations the task of using complex numbers to make a quantitive hard science out of the, as yet, qualitative science of sin and salvation.

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