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As Real As We Can Make It

The Codes of Consciousness

“*One ought to know that on the one hand pleasure, joy, laughter, and games; and on the other grief, sorrow, discontent and dissatisfaction arise only from the brain. It is especially by it that we think, comprehend, distinguish the ugly from the beautiful, the bad from the good, the agreeable from the disagreeable...”*

— Hippocrates

Our perception of the world and our thoughts about it take place in our brain at the same time. There is a difference, however, between the world we perceive and the world as it actually exists. Take sight, for instance. As early as 1709 George Berkeley, whose name adorns the famous California campus, argued that it couldn’t all happen at once. Now we know why. First a photon has to bounce off whatever and ricochet into our eye. This part happens instantaneously because all photons travel at the speed of light. It zips through the eye’s transparent lens and hits the retina, slamming into a molecule called *retinol* or *rhodopsin*, The rhodopsin acts like a spring, bending momentarily and snapping back. This is good because if it stayed bent our first look at the world would leave us blind. It’s important to snap back soon as possible to be ready for another photon. But the 200 quadrillionths of a second it takes for this twist-and-back is longer than it took the image to get to us. By the time the message makes it through three layers of cells in the retina and gets routed via the optic nerve to the visual cortex, the rhodopsin has already snagged a dozen new images. This is before we've "seen" the old one. Like a photo shop developing machine, the brain develops these signals to "sight" as fast as we feed them but it still takes a little time in the processor. As a result, at any given moment we experience a world just slightly behind "real time". It is this perception we react to and relate with, a magic mental carpet endlessly woven on the loom of our own internal time and space. Moment-to-moment life appears seamless to us because we can't perceive the mechanics of perception. Still, just as the magic of Disney World is limited to the ranges of the pumps and gears that move the magic kingdom, human consciousness also works within limits and according to strict rules.

From Zero to One

Consciousness awareness is a dynamic with two ingredients. The first is perception; the ability to extract useful information from the environment. Second, reaction, the manner in which this information improves our interaction with our environment. Conscious creatures, even those with limited self-awareness, exhibit both. Limited perception naturally leads to limited reaction. Were there no need for complex reaction, we would likewise have no reason for complex perception. When a synthesis of conscious perception and memory is guided by abstraction and prediction, we call it reasoning. It is finer levels of reasoning which we call "intelligence."

When it comes to judging consciousness in other creatures it is useful to remember these variables. The honeybee does perceive and is aware of ultraviolet light. It sees a color we cannot imagine. On the other hand, a bee's brain is so small that it cannot adapt or decide anything consciously. It cannot reason at all. Moreover, its minimal insect awareness must act through a nervous system of great simplicity and efficiency. Insects are practically hard-wired and entirely pre-programmed. If a bee heading in a beeline meets a breeze, increased air pressure on one side of its body trips a muscle linkage that adjust wing angles, like helicopter rotors, to compensate for sideways drift. The bee doesn't know it happened. It's an automatic transmission.

Returning with nectar or pollen, it dances directions to the flowers, turning in patterns on the hive wall as other bees brush up to get the latest travel reports. It would be nice to imagine bees are scrupulously honest since not once has a bad bee knowingly passed on false information. In fact, they can't. It's the playback of a flight recorder operating the bee, turning the insect into a dancing marionette mindlessly miming something it can never understand. Aside from lacking alternatives, insect brains have little internal redundancy because insects don't live long enough to need replacement parts. The life span of a bee is only four years, the same time it takes a human brain to mature. Ultra violet isn't the only color we are denied. Some birds can see "red approaching" as distinct from "red receding". It's a shame they can't tell us what it looks like. Eagles have greater visual acuity than we do, but they never think to nest over VFW halls and get fat. Birds can't think. Descended from dinosaurs perhaps, but they're still bird brains. Great perception, but not doing a lot with the information. True, crows are very clever and parrots are amazing mimics, but still it's nothing to crow about.

Human neurons are more complex, more efficient, and interconnected at a level not available to most other creatures. Observing even a single neuron going about its solitary business is to witness extraordinarily complex activity. Aside from life support functions such as metabolizing glucose and oxygen and managing all sorts of chemicals and hormones, each cell is always communicating with hundreds, even thousands of others. Each neuron has its own unique voltage threshold. Any time its internal voltage rises high enough, the neuron will "fire," sending an electrical pulse downstream to every neuron it touches. Constantly juggling pulses from other neurons, it adds its point or its pause many times a second to a dense network of interconnected neighbors. It fills the brain with a dense and chattering static of excitatory, inhibitory and modulatory messages. For any sudden activity, the time period between pulses shortens, hustling signals along in fast staccato bursts to handle temporary information overloads.

It's interesting to note the resemblance between each neuron and a tiny process computer. It has internal instructions to fire if the internal energy passes a certain voltage level. Then rest and reset. Its life is endless cycles of averaging, pulsing or not pulsing, and resting. It is a world of adding, subtracting, and calculating like a tolerant little accountant living on air and Twinkies™. Several times a second it says "something" or "nothing" and rests for a new cycle. This regrettably leaves us with an inevitable conclusion. At some level every thought, feeling, and perception has been perceived, remembered, or recalled as a complex pattern of voltage potentials and pulses. This is hardly poetic. For most it conjures up images of analog to digital interfaces chopping up the harmonious ebb and flow of life into binary bits like some virtual Vegematic™. Once again we are confronted with the popular image of the brain as the ultimate personal computer. Still, it makes sense the brain would have by now evolved to using the most efficient way of doing its work. For information processing this means simple pulse codes.

The underlying basis for digital codes in computers is that as long as one has sufficient speed, it is immaterial whether the computer sees the number 357 as "357" or as a string of ones and zeroes. If the mechanism, or the organism, has to distinguish between only two possible states it's much easier to identify a signal against the background "noise" present in an environment, silicon or cellular. Everything can be simpler and more efficient. Since computers are so exceptionally quick, they don't mind working in digital and it's been policy from the beginning.

We had a small computer back in the dawn of such things, when the first personal computers were ten years in the future. The Varisystems 1000 was dumber than most hand calculators. All it did was convert typed code into punched tape read by a phototypesetter. It had a program with about 800 steps, functionally lower than a sea snail but impressive for its time. The poor idiot was forced to go through its entire program every time it wanted to do anything. Everything it knew was in 800 consecutive steps, a one-way smorgasbord-on-a-track allowing no deviation. It didn't even have the sense to go looking for anything in particular. We would type a "*q*," and in one cycle it noted a "*q*" had been struck. It registered "*q*" in a little cache memory and ran through all 800 steps again to find out what this "*q*" would look like in Litton punch code. Finally, it located the code and jogged through the whole shebang a third time to tell the punch to do "*q*." IBM made the keyboard, Photon sold the computer, and Litton Industries made the tape punch. If anything went wrong, which was not uncommon in those Neolithic times, repair wallahs from a trillion dollars worth of corporations would show up and blame each other as old stupido ran around in 800-step circles.

Of course, silicon solid-state switches are very fast. So fast, in fact, our poky little computer ran through all 800 steps about a thousand times a second. It was a manic whirring electronic conveyor belt, hungry for digital bits. We'd hit the "*q*" on the keyboard, and zap, it was punched out on the tape faster than we could think about it. A device wolfing down digits by the microsecond doesn't mind if 357 comes in threes, or three hundred ones and zeroes. It has all the time in the world; a relaxed sort of digital virtual reality./

Human brain speed is not nearly as fast, rarely exceeding eighty miles per hour. Yet it more than compensates with massive redundancy and complexity. Initially most computers used the model developed by John Von Neumann. Computational steps occurred sequentially. From relics like our early computer to multi-million dollar mainframes, programs executed commands consecutively. Later advances made possible a new generation of computers built on another plan. "Massively parallel" designs separate computational tasks, sending them simultaneously to a collection of powerful little processors and reassembling an answer at the end. Much faster. The human brain, composed of billions of data processors in a dense three dimensional matrix is massively parallel to a degree we have never even tried to explore. "Unimaginably intricate" is both an accurate description and an understatement.

If we are to send information around in a complex structure, and the brain is infinitely more complex than any computer, it would be helpful to use the simplest codes possible. The binary system is simply less confusing. Pulses are "there" or "not there." Ultimately, if these multiple, multiplexed, interwoven codes are complex enough, we can express nearly anything. As a result, all of our senses, both internal and external, send information to the brain coded into a string of pulses. From the taste buds on the tongue to the tone receptor hairs in the inner ear, everything comes to mind originally as a pattern of pulses and zeroes. It is the major business of the brain to integrate this information sequentially with any and all pertinent information available in memory and react to it, incidentally creating the grand virtual reality we call the conscious experience of life. It seems impossible a consciousness such as ours could be adequately perceived through something as simple as a molecular Morse code, but it is not as hard as it appears. Our own visual system is a good example of how neural codes can still make poetry.

Painting by Numbers

When it comes to scanning photoreceptors, the human eye is without question unique in the animal kingdom. We share the gift of color sight with very few other creatures. Every dog has his days but they're all in murky greens, browns and grays. Aside from the ability to see over 30,000 shades of color, we are one of the few species with true stereoscopic three-dimensional vision. More important, we do much more with it than any other beast or bird. The wild turkey has a more accurate eye than even the eagle, but they're still turkeys when it comes to the thinking part.

One of the most amazing things about the human eye is its ability to handle gradations in color and brightness from bright sunlight to shadow without altering color values. It never has to change film or rely on filters. In the brain's visual cortex, areas that interpret the right eye are physically interwoven with the left eye in natural patterns that resemble a fingerprint or a zebra's stripes Between our optics and the interpretive ability of the various layers of the visual cortex, the human 3-dimensional-all-color-correcting sense of sight is the number one picture show on earth. Still, it's all in pulse codes. The cone cells in the retina register blue, blue-green, and red light. The rod cells, used mainly for low light vision, register only black and white. By a complex process known as color subtraction, not so complex as to prevent Polaroid from working it into instant color film, those three colors do the same job as the three basic printing colors red, blue, and yellow. The retina contains several levels of cells allowing it to distinguish not only colors, but edges and movement as well. With the delicate muscles and the lens of the human eye to direct and focus images on our retina, we have a natural grid to scan any visual image between the infrared and ultraviolet ranges.

How subtle should we get? As it happens, each eye has about 120 million retinal cells. It's difficult to imagine scanner operating at twelve million lines to the inch but it's what we have at our disposal. It's a pity to waste it on black-and-white type. Looking closely at color printing most of us can make out the color dots at 120 lines to the inch. National Geographic likes to be special and prints at 180 lines to the inch on their own presses. When we pass 600 lines to the inch the eye cannot tell printing from photography. At twelve million lines to the inch we can't tell the visual mosaic from reality. We will never detect the color dots, the brain erases them before we see them. The patterns appearing the mental theater of the mind's eye are seamless and totally believable. We think we see with our eyes, but it's so much more.

Depending if a photon hits the rhodopsin, about twelve times a second each rod or cone cell reports a zero or a one. As a result, every moment our retinal grids are broadcasting billions of bits of information that shower down through three layers of interconnected neural networks like a galactic Pachinko game, further defining shapes, shades, and shadows. This results in some signal compression but the two optic nerves cris-crossing through the optic chiasma and lateral geniculate body, back to the twin screens of the visual cortex carry eight million fibers, each chattering away in strings of pulses up to a hundred times a second. This is all happens before we see a thing. We watch films at twenty four frames a second, at thirty frames a second we watch television. They make pictures move because our own visual images are also produced frame-by-frame at the very back of the brain, but at about twelve per second. Neural activity then washes forward, picking up meaning and context from other brain structures downstream. A stroke here and the victim might see perfectly well but can't make sense of it. Human sight is much more than a cellular camera. In 1992, a research team from Fuji Photo Film created the first synthetic retina, a sixty-four pixel grid a tenth of an inch square of synthetic rhodopsin that can sense basic movement. We have a long way to go.

Virtually Real

The term "virtual reality" in computer language describes the scenario perceived within a computer-generated environment. Computer-created interactive environments have by now progressed to the point where cutting-edge entrepreneurs are already promoting new dimensions in entertainment. Customers don stereo-vision helmets, put on interactive gloves, clip on body-movement sensors and become part of the scene they're watching. For a dollar a minute they can actually "be" an interactive part of a complex computer games. It's a kareoke sort of reality, but the kids love it. The U.S. Defense Advanced Research Project Agency (ARPA) went one further, creating complete databases by obtaining interviews with every single participant of certain Persian Gulf battles. The result is interactive group exercises involving dozens of trainees in video helmets blasting their way through unreal encounters of the virtual kind. It seems to train them just as well and saves a lot of ammunition.

Needless to say, aside from the ARPA-level boy toys, these “virtual realities” are a lot less than believable. The concept has already been exploited beyond all technological boundaries in Hollywood films and television series. Still, bearing in mind the rapid advancements in other areas of computer science, it is not unreasonable to expect within a dozen years or so we’ll enter a booth, activate a wrap-around screen, put on a pair of transducer gloves, sink into a senso-lounger and find ourselves in a jungle, on a beach or trekking the surface of the moon. For a dollar a minute, we could live in a computer generated “virtual reality” hunting tigers or romancing a movie star.

There are clearly a number of levels of reality at work in such a scenario. The first level, the interactive scene, is the only one the player can and should perceive. Supposing, though, the player is a software consultant who worked on the program. She might know her virtual Tom Cruise can say lovely things but can’t hum. He might be programmed to play an instrument or even harmonize with the player but only in major and minor keys. Limits like these would be challenged so rarely few would notice. However, there are deeper limitations at work. What’s the platform? How does the program itself operate? Does Tom run in UNIX or MS-DOS? The rules for UNIX and MS-DOS differ, but they limit and structure the program itself. If a player slashing his way through a virtual jungle were a UNIX expert he might wonder what language the program was written in. Unless he saw the program itself, however, he would have no way of knowing. Some things can’t be found even if we know they must be there.

Underlying the program’s language are the elementary computer instructions, the microcode. The basic computational environment of a digital computer is a binary reality. It is a quantum world of zeroes and ones, the everlasting search for “signal” versus “noise,” “there” or “not there” of minute electrical pulses streaming in their frantic missions through the murky chaotic static of an electromagnetic universe. No matter how complex the data or program instruction, it is ultimately known to the computer as a series of ones and zeros. “001001100111,” says the microcode. “Multiply value in memory location x by 2 and store in location y,” says UNIX. “Horizontal pixel generator, intensity double, all edge-reference shapes in “cloud” image bank, next scan,” says the program” On the visi-screen, wisps of fractal clouds drifting in front of the virtual moon on the binary beach flicker softly. So our programmer asks virtual Tom to kiss her. She knows he will. She wrote the subroutine. Finally, there are ultimate physical limitations in the nature of all computers underlying everything else. A value is either zero or it is one. There is no half-way or “maybe.” There must be constant voltage and a working memory. The silicon, metal, and plastic environment cannot be baked, burned, broken, steamed, shocked or boiled. If anything like that happens, the computer simply won’t work at all and probably won’t ever again. Good-bye Tom, good-bye beach.

This illustration describes a series of interdependent invisible rule structures and logical systems limiting all forms of virtual perception. This nesting of systems within systems to create the perception of reality is as close to the meaning of the Sanskrit word “*Dharma*” as we in the West can get. An honest philosophy of the mind cannot speculate beyond perception, which itself dependent on a system. There is no God operating the virtual world inside a computer. It works by a system starting with a one or a zero. A similar hierarchy of rules is at work in the human brain at any time. They limit and structure a vast interconnected biological environment, the unimaginably complex system required for the perception of human consciousness. By observing some systems underlying the perception of consciousness, we may begin to determine some basic rules behind all the others.

The physical ground rules of our consciousness are short, simple and absolutely certain. Our brain requires oxygen and glucose and must eliminate waste toxins. This requires a rich circulatory system. Every part has specific requirements and limitations. It can’t survive ten minutes without oxygen. Any single blood vessel can clog or rupture for any reason. Irreparable parts could be gone forever in minutes. We might never speak again. A serious glucose irregularity can kill in two hours, a threat too well known to diabetics. Minor electrochemical irregularities can be fatal and anything interrupting blood flow will stop everything. The result is always coma followed by death. These are unalterable operating rules. Nobody has ever recovered from brain death. There are other limitations, however, that are not so obvious.

Warps in the Enchanted Weave

The brilliant neurologist Charles Sherrington often referred to the brain as the “enchanted loom,” as it seemed to create without effort the seamless tapestry of mental experience. We have progressed beyond learning the basic needs of the brain. We have reached the point where we can begin to describe both how the loom works, and why it doesn’t work quite so well in some cases. Many insights gained this way have only limited use. It’s true that we cannot see ultraviolet or hear much above twenty kilohertz but these are not limitations affecting us. The unheard and the unseen have little effect on everyday life. At the most basic level, however, nobody is suggesting the brain is operating with anything but neurons. Whatever consciousness is, we perceive it with nerve cells and not muscle fibers. We also know these nerve cells, when excited biochemically, “fire” minute electrical pulses. Information is relayed this way from cell to cell during normal brain activity. This is not a theological point or a philosophical conjecture. It’s a known fact.

Since the electrochemical pulse from an activated brain cell is the equivalent of “1,” while the latency period without a pulse is the equivalent of a “0,” the most basic underlying operating imperative of our perception would be the ability to sense the difference between the two. Consciousness itself seems to arise from a sophisticated form of chaotic pattern recognition, and a pattern can only be defined by the use of contrast. To that extent, brain cells and computer chips share a common reliance on comparative functions to get the job done. It's the same signal-to-noise ratio, pulse or no-pulse, dot or dash, "there" or "not there." A neuron that couldn't tell the difference would be as useless as a binary circuit that couldn't tell zero from one. This delicate separation between "this" and "that", the distinction between subject and background, *ma* and *mu* in Chinese philosophy or the Tao's *ying* and *yang*, might seem impossible in such a mass of ongoing activity as the human brain. Still, it forms the foundations of all our conscious thought and perception.

At the surface level of awareness, this basic functional operative is almost completely invisible. Like the computer's program, it does not affect the colors of the day or the thoughts of our mind. Only when we try to think about something that a pulse-based consciousness cannot compute do we get into any trouble. Usually when we try to do this it's either difficult or disturbing, almost as if there were something wrong with our mental focus button. Try, for example, to picture "forever." Non-comparatives just won't operate in our comparative cognitive environment. We know what the word means, but we can't access a mental description for non-comparatives as we can with mental images we acquire from experience or conjecture. In fact we can't even "think" about anything we can't compare. Just try it.

"Forever" is just one example. Human consciousness is perceived through neural communications in which everything depends on the presence or absence of voltage potentials. Since our method of cognition is comparison, we can't communicate about any non-comparative states at all. We can't really describe "perfect" any better than we can paint "never". It's a basic problem with information being passed around in a pulse form. This is not to say that we cannot have experiences or feelings in which such non-comparative mental states are momentarily present; just that we cannot describe or articulate them. Life events in which non-comparative perceptions take place are generally intensely emotional personal or religious experiences. Nobody would suggest we're thinking clearly when we're overcome with emotion. Emotions, true to their hormonal origin (See Chapter 7) feel to us like moving wave phenomena while mental reflection and cognition behave more digitally. Our neural electrochemistry embraces both levels but we "perceive" in ways we can discuss with other people and "experience" states that we cannot ever really communicate in a rational or reflective manner.

Perhaps, then, we cannot know the nature of God simply because neuron-based brains can't handle "infinite" at all? Maybe in early infancy, but our brain grew up. From an evolutionary point of view this makes very good sense as we don't encounter many incomparable beings in our lifetime. It also explains why it has been so difficult to communicate with the Divine, or at least why it might be hard for normal adults. Even if we could experience perfection, we couldn't describe it to others without seeming irrational. The incomparable can happen but it won't compute, just as we can "know" and "experience" things we can't think about rationally or ever describe in words. This is one example of the perspective required if we are going to interrelate the truth of science and the truth of religion. There is no scientific problem with saying "The perfection of God is hidden from the understanding of man" because, neurologically speaking, the mature human brain can't really mentally image a "perfect" state whatever it is. It is an inherent built-in design limitation of our method of perceiving consciousness and we wouldn't be humans without it. It doesn't really matter. We are making it through a complex world every day and it's a blessing consciousness does as well as it does even if we can't see the ultraviolet or describe the transcendental. Maintaining a flexible viewpoint, however, can provide space for both the "experience" of the divine from a personal point of view for those who have had such experiences and can't deny them, and for scientific explanation as well. God alone could divine the basis and method of divine perception. The basis of human perception remains locked into the neuron-*dharma*, systems within systems of brain cells that pulse or don't pulse, require sugar and oxygen to survive, and which cannot be damaged or starved or they will die, and incidentally take us with them.

This perspective on the nature of consciousness goes beyond detailing the biological limits of the human brain. It is equally provocative to both religion and science. On one hand, it may dim the attraction of seeking perfection to realize that we can't describe it in any detail using the human mental system. Clearly, if nobody can adequately describe it, we certainly couldn't tell anyone what to look for. It seems we may have to "know" it when and if we find it because it may exist only in the realm of experience, unrecognizable to anyone but ourselves and dependent on the time in our life as well as the space we were in at the given moment. Still, science fares no better. If we deprive the brain of oxygen and witness our life flash before us are we in another time and space, or are we in brain failure? How can we ever know anything for certain unless our "knower" is standardized so we can be sure it's working all right today? We know all human brains differ slightly from each other. Even worse, at the molecular level, every thought affects our brain a tiny bit. Werner Heisenberg's classic uncertainty principle states we can't find anything without pushing it a little with whatever we use to find it, even a photon from a flashlight. We never really locate anything quite exactly because we just moved it by finding it. If we can't think about anything without modifying a few thousand neurons each time, what does that have to say, ultimately, about any search for ultimate answers? Won't the questions change as the questioner 's mind changes in the process of working out answers? Or is our mental journey the answer itself?

Questions like this are bound to arise as we start to explore some of the operational aspects of our biological lens of perception. Just as the incomparable is unthinkable, our sense of time itself is probably a fairly recently evolved capability. If we could neither recall the past nor project the future in any detail we might never wonder what happens after death until it was far too late. In fact it seems highly likely that early humans couldn't even conceptualize most, if not all, of the hard questions requiring religious answers. Recent discoveries indicate that the ability to sequence time, generate abstractions, and understand speech all require structures evolved within a very recent time frame. The first humans with larynxes like ours, for instance, didn't even appear until after 150,000 BCE.

For Adam to hear God's commands, or speak with Eve, he needed a well-developed speech cortex. Clearly, any historic Eden had to appear at least past that point in brain evolution. As far as religions are concerned, not one is more than 5,000 years old. It is a rather recent phenomenon, just as we ourselves are. In fact, without many recently evolved neurological capabilities, we would not have had the consciousness to know either natural law or divine intent. And even if we did, we could not have written it, read it nor spoken about it to anyone else. If there were any religions on earth before we developed speech, certainly no one ever mentioned it.

A Colorful Line of Thought: Synthesis and Sunsets

After much heavy reading, it's time to unwind with our inner vision, our own imagination. This chapter started with sight. It ends with a sunset. We're are seated on a bluff overlooking a rocky California beach a little north of Santa Cruz, looking out over the Pacific. It's a warm Sunday afternoon, the last part of the day with the sun low on the horizon. The day was hotter than we'd expected because we notice a slight sunburn our the neck. The warmth lingers, but the breeze is picking up. With the day cooling off it's time to just relax, sit on the grass and watch the sun go down.

There were showers in the afternoon and a last gathering of dark clouds are scudding slowly off to the west. Blocking the sun, they let its dying rays pierce through, here and there, as it sinks toward the sea. Then, for a moment, the lower edge of the sun begins to drop slowly from the bottom of the lowest cloud. Glowing at the edge of the sea, it suddenly brightens, bathing the bluffs and the waving sea grasses in that unique horizontal yellow light that we all have seen when the heavens are gray and the sun is blazing out from the horizon. The world is suddenly magical and glowing.

For a moment the sun rests there, suspended, glowing in deep oranges, and then slowly sinks into the sea. Waves hiss up the sand as twilight descends, the pink cotton candy clouds rolling to magenta and fading in gentle deep purples. Shadows begin to wrap the rocks in deepening darkness, while the silver slice of a crescent moon, shining against the cobalt blue sky, begins its climb towards an evening star. The breeze is getting a little chilly now. It's time to get up and head back to the house, the windows alight from inside, glowing against the last twilight of a soft evening as the night slowly cloaks the shore.

The brain remains in silence and in darkness. Sixteen million fibers are pouring cataracts of information over an infinite grid as our mind fills with the sunset, and we are surrounded by it in all ways. We can never be aware of those billions and trillions of ones and zeroes; we can never hope to see them although they outnumber the stars in the sky. It all happens so fast and so neatly that all we see is the sunset, and only that sunset, in a depth and color possible only for our human eyes to perceive and a beauty only a human mind could know.