The Arrow of Entropy

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The FQXI question is how does physics relate to direction, aims and intentions? It asks whether there a uniform theme to nature that suggests its goals? The arrow of entropy (information) is fundamental to these questions, especially in biological systems.

The idea that nature originates as a series of separations is an old idea, for example, recall that Genesis contains the words "So God made the expanse and **separated the water** under the expanse from the ... as **Genesis** 1:7 ends with the phrase 'from the **water** above it [the expanse]'.

Separation of some information from other information is a theme throughout nature. Separations determine the information level and its direction but important properties are maintained and are thought to be initial conditions. The appendix contains a list of separations and complementary property preservations. Consider a beginning with zero energy and probability 1. This avoids the endless argument that things are made of other things, ad infinitum. The energy parts come into existence at the same time but represent zero overall. What about probability 1? Understanding this involves correlating data in a different way. Information (N) is defined by the negative natural logarithm of probability (N= - ln P) [Shannon] but the key equation is the relationship between energy and information. The equation is E=e0*exp(N) where e0 is an energy constant and N is found by correlating data from high energy labs [3]. Separation occurs between N for mass (plus kinetic energy) and N for field energy in a neutron and these are further separated into components of the neutron [12]. With mass plus kinetic energy positive and field energy negative, energy is zero but separation of N causes an individual neutron to very improbable. For example if the neutron mass components and field components both total N=90, each has probability P=1/exp(90). The probability of a neutron with improbable energy *and* fields is 1/exp(180). Probability one is preserved by the creation of an enormous number of neutrons. N= neg ln(1/exp(180))=180 represents a huge amount of information. Information gain is very rare in nature and normally it is lost (9). If we can find the source of the initial value 180 we will make progress in understanding nature.

Neutrons/protons are mostly structural but there are functional parts of nature that help us address the FQXi question regarding direction, aim and intent. Quantum mechanics underlies a process leading to perception. The equation of interest for light absorption is a wave function for a system that has an internal freedom that varies back and forth between frequency (f) values.

Psi=mu e/h (1-exp i (f-F) t/ (f-F))

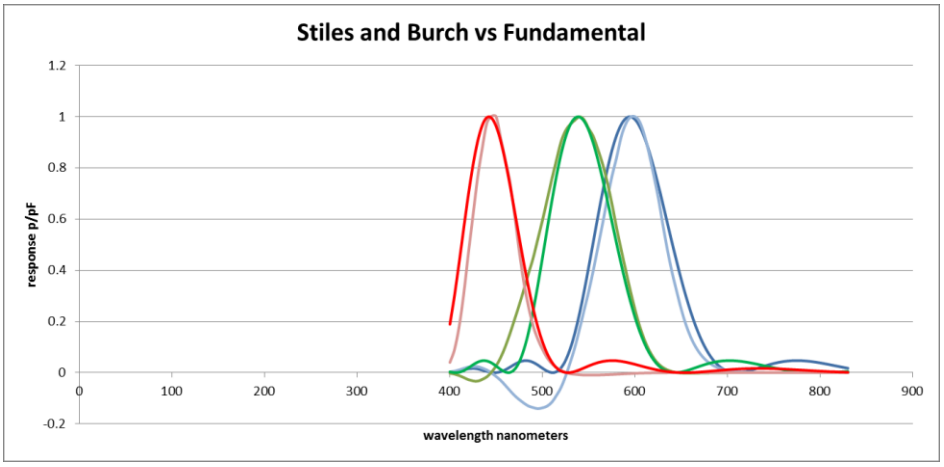
The solution to this quantum mechanical equation is found in The Feynman Lectures on Physics, Volume III page 9-13 [2]. The basic equation for a probability pf can be divided by pF to form a ratio normalized to make the peak response equal to unity at the peak frequency, F.

pf/pF=(sin((f-F)t/2))^2/((f-F)t/2))^2 Where f=frequency and t=time interval.

The function above peaks at unity when the wavelength approaches 591. Our eye is tuned to absorb light. The information (N) value series 0, 0.0986, 0.197, *0.296*, 0.394 (1, 2, 3, and 4 times 0.0986) is important. N=3*0.0986 is exactly N for the electromagnetic field, E=2.02e-5*exp(0.296)=2.72e-5 MeV.

Series N	Energy MeV	P=e0/E e0=2.02e-5	Meanin	Color (nm)
0.000	2.02472E-05	1	→	652.05
0.099	2.23456E-05	0.906094	→	590.82
0.197	2.46614E-05	0.821006	→	535.34
0.296	2.72173E-05	0.743909	→	485.07
0.394	3.0038E-05	0.674051	→	439.52

Stiles and Burch (UCSB)[1] measured the response of the eye to colored light. The graph below plots the Feynman equation pf/pF for the three color peaks 591, 535 and 439 nanometers. It compares favorably with measurements. The associated width series is 61, 55 and 41nanometers respectively for red, green and blue responses based on differences between the primary wavelengths. This links internal observations with information and is a clue regarding signaling and response in our brain's neural networks. It indicates that quantum level interactions are operational in the eye and brain.



The fundamental calculations are the lighter colors and the dark colors are Stiles and Burch.

Molecules absorbing light in the retina initiate a neuronal action potential. Rather than four distinct pf/pF responses, we see colored images and this indicates that vision is based on a network adding responses together. Hues are combinations of these curves without full spectrums.

It is well known that neurons send signals through various levels of processing. Once the signals reach the long ganglion neurons that connect to the visual cortex, the signals are electromagnetic spikes. Scientists are attempting to understand the spikes and communications in neural networks. The author believes as many others do that the brain is primarily a neural network based processing machine. However, the model of color vision indicates there is something occurring at the molecular level because it uses a quantum mechanics equation (Feynman) and

information values belonging to electromagnetic field energy. The challenge is to understand what is taking place at the synaptic junction. From what we know about retinal, rhodopsin and its relationship with transducin, a photon initiates the action potential. Glutamic acid is a neurotransmitter that opens ion channels and allows the action potential to progress to neuron postsynaptic connections. The most common neuro-receptor AMPA is known to be involved in long term memory and LTP (long term potentiation). Neurons are inside the body and can't directly absorb light but a relayed electromagnetic spike could be absorbed by AMPA similar to the way rhodopsin absorbs light. A pf/pF spike occurs in the neuro-receptor when the electromagnetic spike is absorbed. When the neural junction receives pf/pF spikes a network is completed and information gain occurs. The overall response of millions of neural interactions throughout the brain leads to perception. A network as large as the brain can process and amplify the information to the large scale. This is of interest to the question of how quantum level interactions become large scale observations.

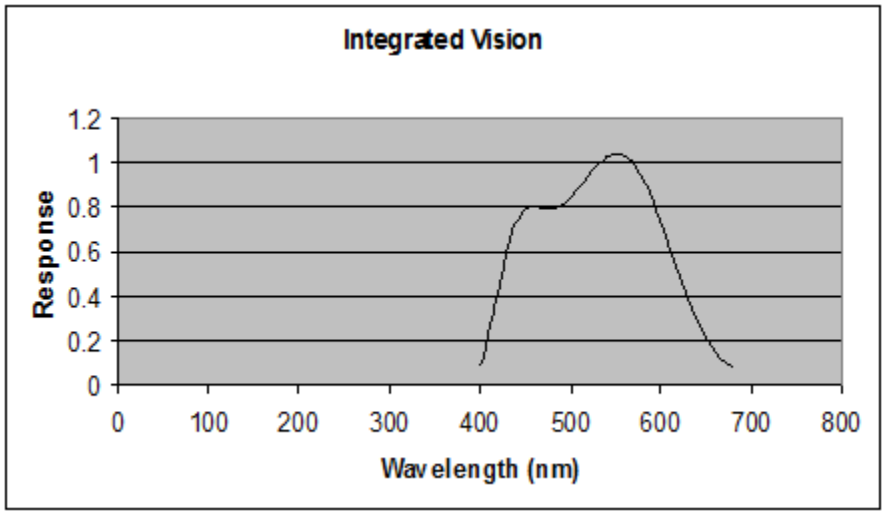
Functional information networks

A computer program works because instructions written in a standard language can be processed by a machine into an output. The language of nature is probability [8][quantum mechanics]. There are repetitive patterns throughout nature that suggest many levels of organization. For example, protons form atoms with electronic structures that fit together nicely in chemicals. This leads to functional structures, not just building blocks like protons. A network has nodes and branches. There is a probability for each branch and it is known that neural networks have feedback loops that adjust the probabilities based on expectations (similar to fuzzy logic). Internal information is produced by adding the pf/pF responses. The information gain along the path the action potential takes can be quantified. In the example below the probability of each path is 0.71 but four nodes are reached with pF signals that code for red, green, scotopic and blue light. Probabilities along the path multiply and if nodes are improbable, the information (N) value can be quite large. Many possible pathways are stored and improved but their function is to provide information.

	network information gain					
		normalized	information	meaning		
		signal	in raw signal		normalization factor	
node	prob of signal	pf/Pf	n=-ln(p)		1/(prob of signal)	
1	0.71	1	0.35	591		
2	0.71	1	0.35	535		
3	0.71	1	0.35	485		
4	0.71	1	0.35	439		
	0.25	1	1.39		4	

Above, a signal pathway was completed with 4 sequential nodes. Information in the final signal was added and greater than 1. The pf/PF signal is close to 1 since perception is normalized (for example many photons increase the intensity but our visual system adjusts to keep our internal response relativity constant). The neural junction receives a composite colored dot. Each network node could represent a particular multiple of 0.0986 and wavelength from the table above. For example m= 2, 4, 1, 3 fire together in the network shown above. The sum of the

pf/pF functions is normalized by the number four. The output of the network is white light with the following spectrum.



Information gain

There are many networks like the one above in operation. Much of the information entering the visual cortex is from the cerebral cortex. This helps process signals and presents an image to our visual cortex. Absorption of light or electromagnetic spikes increases information, something that cannot be over-emphasized. Thermodynamic entropy is a process that destroys information but information gain is unique in nature. Thermodynamic entropy applies overall but an electrochemical structure with information about the things around it can exploit its environment. An organism that can recognize patterns has a higher probability of survival. It will survive and evolve if it can replicate itself. DNA is stored evolutionary information that codes for the body, brain and sense components of the nervous system. As the body, brain and its senses evolve there are many opportunities. Memory provides a vast array of potential perceptions that enhance survivability.

The information we get about the world around us is where light, sound, taste, touch, etc. comes from relative to our position. Our eyes gather light energy but our brain gathers information. This produces consciousness and it is reasonable to suspect that our evolved brain integrates information and enhances reality. We produce an internal reality that replicates by trial and error what we believe is external reality but we must be cautious about assuming it is a perfect replica. For example there are parts of nature like dark matter that we do not detect. Also, we need to separate pre-existing information from results we achieve with thought. Life as we know it did not exist for billions of years after the big bang. It is reasonable to believe that we are late comers able to interact with an information source through imperfect perception.

Is nature a network?

Finding out what caused the huge beginning information value N=180 is a new challenge but our minds create information and this could be a clue. It appears that all neutron/protons came from one information separation, and if so they can be considered to be part of a network. The protons have been combined into new things (like us) but must participate in the network to satisfy the

zero energy and probability one condition. We could be creative participants in a network that we do not fully perceive.

proton network

node	Probability	Pf/pf	Information n=-ln(P)	meaning	normalization
1	1		0	1 neutron	exp(180)
2	0.5		0.693147	1 proton	
3	0.3		1.203973	fusion to atoms	
4	1.2E-38		87.31591	biological molecules	
5	0.0001	1	9.21034	light capture by molecules	
6	4.53999E-05	1	10	neural networks	
	8.17199E-48	1	108.4234	protons involved in thought	

Obviously the probability values above are rough estimates but the idea is that a functional network produces information. Thinking seems normal to us because the complex neural signal Pf/pf has been normalized to 1. A network that results in thought is highly improbable, but we know this occurs. This means information was created; in this case information N= –ln(P)=108 (a paltry value compared to 180). You may agree that complex biological molecules formed neural networks but what connections exist between protons? I believe a partial answer is related to preserving initial conditions. Probability 1 was separated and preserved. Energy zero was separated and preserved. Perception is an imperfect internal process based on light from particles and what we think they represent. The preserve part of the energy operation is invisible to us and the preserve part of the information operation is invisible to us. There are reliable experiments that deal with this. One of the experiments goes by the initials EPR (Einstein, Podolsky and Rosen) but much more work is needed.

Conclusions

Information separation can be interpreted as a theme that underlies nature's physical laws and determines the entropy arrow. It normally makes things more similar and robs information. However laws allow biological molecules to absorb light, form networks and become more complex. Information gain, molecular cooperation and niche exploitation across deep time leads to earth's thriving and replicating network of life. This should be surprising to us and we can imply intent. It is reasonable to explore the possibility that nature is a network because it might explain the high information initial state.

Appendix Nature's separations

Each separate below can be considered an information/energy operation. Some preserve operations normalize information to unity. Other preserve operations normalize overall energy or other properties to zero. Life and thought increases information.

Information level 180 separate 180 [3][12]

P=1/90*1/90=1/exp(180) 90 separate 90

m+ke separate field e preserve 0 energy

Neutrons=exp(180) (mass+kinetic energy equal and opposite and field energy)

EXP(180)/EXP(180)=1 6 neutron components separate information but preserve total 90

preserves information=1

mass	field1
ke	field2

[10][12]

6 neutron components preserve energy 0

result: nested orbits with m+ke in fields

Expansion separates [13][14]

Kinetic plus potential energy preserved [12]

Neutrons separated into protons+ and electrons- [4]

Energy preserved as fusion heat is released [5][11]

Mass density assembled by gravitational accumulation [9]

Non-life molecules separate potential life molecules [6][7]

light transmitted — light captured [12]

neural network — neural response

information increased — brain

information preserved — memory

non-survival separate survival

preserve dna — body

separate dna — clone

environment separates niches

evolution preserves survivors

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