Irreducible Design Complexity in Physical Animate Creation
A Case Study of Photosynthesis in Purple Bacteria
(Rhodopseudomonas acidophila - strain 10050)
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Irreducible Design Complexity is loosely defined as a single system or ordered structure which is composed of several interacting parts that contribute to the basic desired function, and where the removal of any one of the parts causes the system or structure to effectively cease the function under examination. In the case of photosynthesis, the failure of this mechanism can result in cellular death, in organisms dependent upon it for their own energy production.

There are several factors in the marvelous operation of photosynthesis that can be easily overlooked and are often unappreciated. First of all, photosynthesis is a very efficient process of changing light energy to chemical energy. The efficiency of photosynthesis is clearly over 50% and thought to be around 85%. This is necessary because the available energy of visible light in the range of 3500 to 8500 Angstroms is on the range of 3.5 to 1.46 electron volts, about twice the energy required to produce a charge separation across a cellular membrane which is then utilized to create charged ions which permit useful cellular chemical synthesis to occur.

The overall process occurs with extreme rapidity, since light advances about 1.18 hundred thousands of an inch or 2998 Angstroms per femtosecond (10-15 second), on the scale of very large molecular structures. The chlorophyll molecule, itself some 80 to 120 Angstroms in size, is only stable for some nanoseconds (10-9 seconds) when excited so all useful work must be done during this interval to transfer energy and fix it into potential chemical energy.

A recent Dutch research project "Deutsche Forschungsgemeinschaft (DFG) Project Le729/2-2 titled "IIe.8 Femtosecond dynamics of primary processes in photosynthesis [ref]" is a look into the still relatively unknown high speed chemistry of photosynthesis and the molecular structures that enables this chemistry to proceed with such efficiency.

This investigation provides a strong hint that significant design is incorporated into these molecular structures. The investigators own words stated "The bacterial photosynthetic antenna LH2 for example is a masterpiece of nature to study the physics of excitonic coupling in circular aggregates and to compare this with linear J-aggregates. Also photosynthetic antennas are a models for nanostructures with extraordinary nonlinear optical properties." (Author's own emphasis).

In this instance, the object of research is to elucidate the femtosecond-dynamics in and among definite subsystems of photosynthesis in terms of the general correlation between structure and function. In other words, how does photosynthesis work, when examining the molecular structures?

The researchers have found certain purple photosynthetic bacteria very amendable for research in this area due to the simplicity of their structures. From the researcher's WebPages [ref] one finds that the photosynthetic apparatus in these bacterium is broken down into three or four regions. The first is the reaction center (RC) which requires energy. This is obtained either by direct adsorption of a photon of light, or by energy transfer process facilitated by a chain of light-harvesting complexes called LH1, LH2, and sometimes LH3.

The researchers found to their delight that the light harvesting centers of these purple bacteria have a remarkable circular structure that enables the funneling of energy down to the reaction center. These complexes act like an antenna funnel or light wave guide, so that energy is caught, directed and transferred to the reaction center.

Quoting from the web page "This modulation results in a downward gradient of energy levels from LH3 - LH2 - LH1. Energy absorbed by any molecule in this antenna array is funneled down into LH1 which feeds the RC. The bacteria synthesize enough LH2 to satisfy the RC, this is directly dependent on the ambient light intensity, the number of BChla per RC rises to 250 or more in low light cases." In other words the bacteria adjusts its light funnel to the current conditions, creating more LH2 substance to capture energy when light is dim thus meeting a certain minimum requirement.

A full scientific description of the LH2 complex is described for the technically inclined person at http://www.chem.gla.ac.uk/protein/LH2/olh2.html

In studying the chemical structure of these light-harvesting centers, the researchers discovered several important items. The bacteria had only one major chlorophyll pigment. Only one of the several possible electron transfer chains of the Reaction Center is utilized. The researchers marveled about the light guides, and wondered how the bacteria managed to arrange the spectral qualities of their pigments in such a way as to create an efficient gradual adsorption of energy.
The researchers' own words capture what they felt. "The complex captures photon energy and passes it very rapidly and efficiently to the 'core' particle; comprising LH1 (the primary antenna), and Reaction Centre - where charge separation takes place." In layman's terms, the bacteria harvested light by their very cleverly designed light guides or antennas.

One only needs to look at the proposed design structure for LH2 to realize that the nine protomers making up the structure possess a wonderfully remarkable design structure that captures light so efficiently. Could this have been an accident?

There are significant design issues in chemistry and molecular structure that have to be solved here. (The reader may be interested to reread the mechanism of photosynthesis as outlined by Cornell University [ref] which shows current research into this area, and the remarkable picosecond chemistry which must take place to allow successful photosynthesis to occur.)

In considering design structure, several considerations must be met. First the bacteria have to come up with the basic circular antenna waveguide structure to begin with, in order to harvest light. Next they have to adjust the light adsorption of the tunnel, so as to transfer energy along the light guides efficiently. This is similar to how man adjusts the impedance of microwave horns by changing their size so as to facilitate the directing and control of microwave radiation. The bacteria did not utilize several available electron transfer chains, but depended instead upon only one! Finally the light antennas have to be situated over the reaction centers themselves, so that useful charge separation work can occur. Additionally the bacteria apply a "quenching" process when the light is too intense. Finally the whole electron transfer path seems to avoid leaky entropic channels that would diminish the efficiency of this whole conversion process.

What is so understated in all this analysis is at what speed this energy transfer occurs. In just a few parts of 1,000,000,000,000,000th of a second, energy is transferred. This is due to the fact that light is traveling over 186,282 miles per second, and takes very little time to transverse a chlorophyll molecule.

The following (incomplete listing of) elements of design are exhibited:

1. Electromagnetic waveguide structures and resonant atomic structures of the Light-harvesting complexes
2. Spectral modulation of adsorption coefficients of the LH pigments to obtain desired optical impedances
3. Utilization of only one electron transfer chain despite several being available
4. Utilization of only one chlorophyll pigment, despite several being available
5. Femtosecond transfer rates of the LH-structure, to pass energy along from molecule to molecule and concentrate it into the reaction center
6. Production of more light harvesting complexes depending upon ambient light conditions. This necessitates some type of light measuring system and feedback mechanism, so that increased levels of pigment are called for when light levels decrease.
7. Picosecond (10-12 sec) chemistry of the reaction center itself and the selection of the proper type and arrangement of atoms so at to facilitate a charge separation.
8. Proper sequencing of the timing with regard to process durations, so as to facilitate an ordered progression of energy transfer events along the antenna complexes into the reaction centers.
9. Measurement of light intensity, with regard to regulation of lumen input.
10. Proper selection of electron transfer paths, to minimize entropy leakage.

Items #1 and #2 above exhibit knowledge of electro-optical dispersion properties of atoms and molecular complexes and knowledge of electromagnetic waveguide structures on the scale of nanostructures. Not any atom or molecule will do, certain arrangements are mandatory for deriving the desired adsorption coefficients and waveguide guiding. Items #3 & #4 strongly suggests that the bacteria have pared down to just one process from many, rather than attained the one process by a trial and error mechanism. Item #5 requires knowledge of atomic orbital dynamics along molecular structures, still not simulated today in any completeness by supercomputers. Item #6 suggests a very fruitful area of future molecular biological research. Item #7 suggests that someone knowing energy level transfers of molecular arrangements and electron volt levels of visible light decided that useful work could occur by adding light energy to certain chemical biological structures. Item #8 strongly suggests that a unified approach to the whole process of photosynthesis had to be used, to successfully complete the function, otherwise the whole scheme would fail. (Not to mention the disastrous results to the bacteria themselves). Item #9 is another area of future research. Item #10 suggests extreme efficiency of choice, even though scientific studies admit that structures in #1 and #2 are not from a common origin.

For those who want to continue to argue that a gradual naturalistic evolution process of chance combinations of amino acid peptides led to the creation of life, the remarkable molecular structure and femtosecond chemistry that these lowly purple bacteria exhibit should provide a sanity check upon offering such foolish ideas. While such explanations might suit popular naturalistic theories currently in scientific vogue, they are mathematically and logically indefensible. The timing issue involving energy transport and the peculiar electron transfer structures that have to be in place in order to support this energy transfer are so critical as to their structural design and timing sequence, due to the femtoseconds chemistry allotted to the process, that the mathematical possibility of cellular mechanisms evolving this structure by chance alone is so low as to be non-existent. Additionally, the concurrance of the factors #1-10 listed above is not a chance occurrence, since each, in itself, is the product of several contingencies.

In other words, this structure did not evolve; it was created this way and genetically programmed into the cellular DNA. Just making one mistake in any part of this photosynthesis process renders the whole superfluous. Remove one electron transport chain and the reaction centers cannot work. Genetically mutate the one pigment too much and the cell cannot capture light. Change the LH2 structure and energy is not transferred. Change the adsorption bands of the chromophores, and no gradual energy transfer can occur. Invert the antenna structure and no light funneling takes place to the critical Reaction center. Change the order and timing of electronic energy transport and charge separation ceases. Forget to diminish the light intensity and irreversible damage occurs. Employ a leaky process, and the electron escapes without doing any useful work. The removal of any of these factors kills the cell since it loses chemical energy necessary to support its own life.

It should not be necessary to point out again that if anything goes wrong in the general design of this remarkable molecular structure these bacteria will die and not reproduce. What is so extraordinary is that this structure accomplishes its goal in just a few femtoseconds of time allotted to it. Such a complexity of structure should impel the thoughtful and introspective reader to conclude that physical life very strongly exhibits design characteristics and is not the result of evolved fortuitous accidents. Further mathematical analysis and consideration of the atomic physics and chemistry involved in the photosynthesis mechanism renders an explanation by causal agency necessary and allows no alternatives.

This is just one example; perhaps a few more experimental samples might be necessary to establish the design hypothesis as required by the scientific method.

Further References: http://metallo.scripps.edu/PROMISE/LH2PB_REV.html