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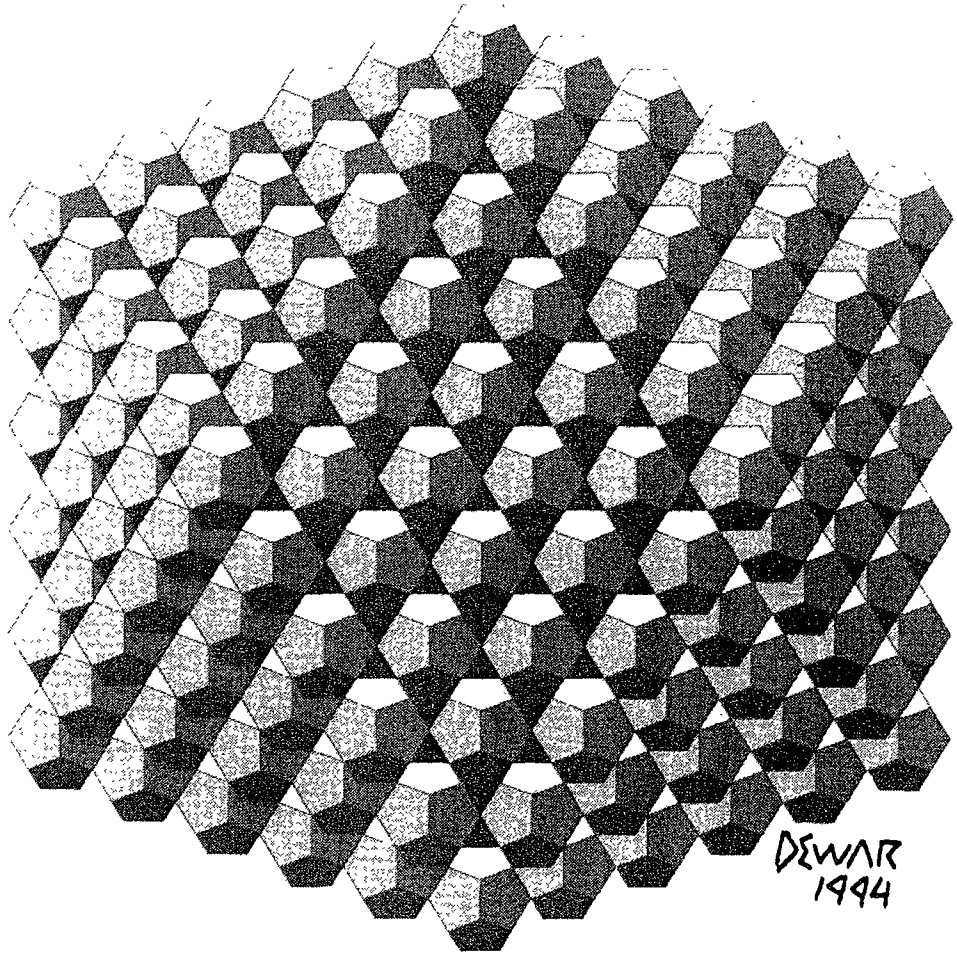

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THE ORIGIN OF SYMMETRY IN THE ADENOVIRUS: IS IT NATURAL OR ARTIFICIAL?

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My poster design for the first ISIS-Symmetry Symposium, titled "Structure of Symmetry", was based on an *elegant* tiling of Penrose rhombuses that I shaded to create a 3-dimensional illusion. Roger Penrose wrote: "Elegance ... has to do with unexpected simplicity, where one imagines that things are going to be complicated but suddenly they turn out to be much simpler than expected.", (Penrose 1974). The illusion led me to discover that the tiling is a true orthographic projection of a 3-dimensional model which forms an icosahedral shell. Figure 1 is made out of rhombic triacontrahedra joined face to face and Figure 2 is its dual, formed out of dodecahedra joined edge to edge. Icosahedra can also be used to make a dual and it has perfect *geometric hierarchical symmetry.*

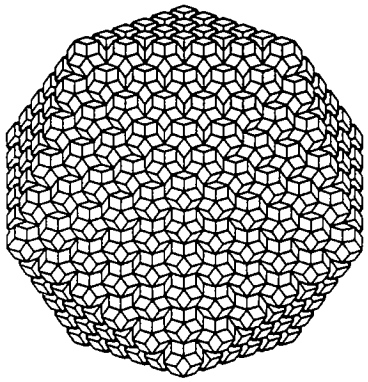

Figure 1. Rhombic triacontrahedronite

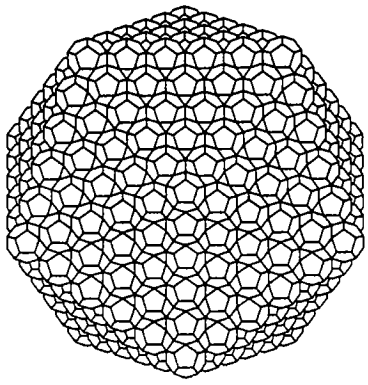

Figure 2. Dodecahedronite

A *6-frequency dodecahedronite model* means that 6 dodecahedra are joined along each edge of the icosahedral form as shown in Figure 3.

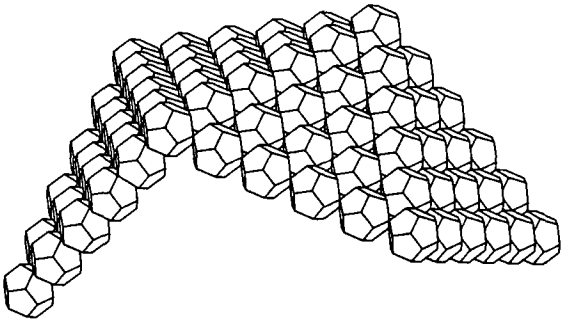

Figure 3. Detail of 6-frequency dodecahedronite model showing edge to edge connections

My design, (Figure 4), for the 1995 ISIS-Symmetry Congress poster is based on the 2-fold symmetry view of a 6-frequency dodecahedronite model because it is similar to electron micrographs, (Figure 5), of the adenovirus capsid, i.e., the icosahedral shaped protein casing of the virus. It would be interesting to superimpose the 6-frequency dodecahedronite model over the 3-D voxel data of the adenovirion, (Stewart, et. al. 1993), and compare the ARTIFICIAL geometry to the NATURAL data. Such a *symmetry bridge* constructed as a 3-dimensional computer model may lead to new understanding of the ultra-structure of the virus.

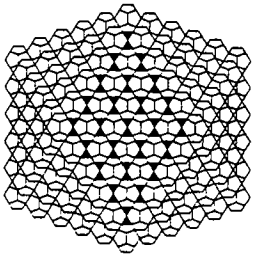

Figure 4. 2-Fold view of dodecahedronite model

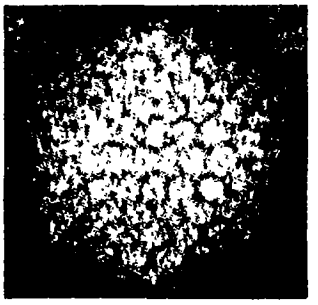

Figure 5. EM of adenovirus capsid

The dodecahedronite model may also form a *symmetry bridge* to other disciplines as well. It might be used as the geometric principle of a roof (truss) structure in architecture as an alternative to the geodesic dome principle. Engineers may find it useful in satellite design where strength and modularity are important issues.

The dodecahedronite symmetry bridge may also be useful in explaining the evolution of the virion itself. Why is it that the adenovirus evolved to have an icosahedral shell? The answer can be found in the carbon chains which form the back bones of the structural polypeptides.

In 1977 I had an idea about carbon atoms that I now call my *carbon/icosahedron hypothesis*, (Dewar, 1982). I imagined that a carbon atom was like a molecule of hydrogen atoms in the form of a stable triangulated icosahedron. Figure 6 shows how an ethane molecule, C_2H_6, would look in this system. The ethane hydrogen atoms are located at the vertices of the tetrahedra which are connected to the faces of the icosahedra. The ethane wireframe computer model is constructed with an empirical Leonard-Jones type of Force Potential, (Figure 7). Formulas of this type are used to deform wireframe models in computer graphic animations, (Szeliski and Tonnesen, 1992).

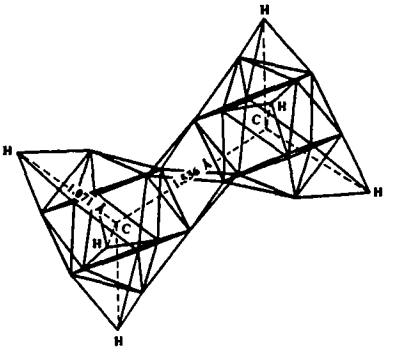

Figure 6. Carbon/icosahedron model of C_2H_6

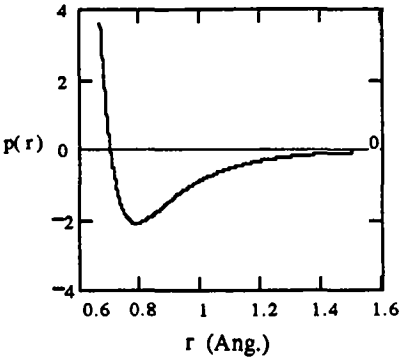

Figure 7. Leonard-Jones Potential formula

Icosahedral shaped carbon atoms in the polypeptide chains will align to the same orientation no matter which way the molecule twists and turns. This gives the polypeptide molecule a crystal-like tendency to develop 5-fold symmetry facets. Thus mutant polypeptides will always have an inherent tendency to develop icosahedral shaped virus capsids according to the principles of geometric hierarchical symmetry.

The adenovirus is like an egg, i.e., it has a shell and inside there is DNA material; and its host cell is like a surrogate mother. Which came first? How did life evolve in the universe? I believe that 5-fold symmetry is the *symmetry of life* because *life* is carbon based. Icosahedral shaped structures of nucleons (carbon atoms) form naturally when the universe cools off after the Big Bang, because the nucleon potential energy spheres are soft which allows tetrahedral packing to predominate. This accounts for the abundance of carbon in the universe. Therefore, I believe that 5-fold symmetry geometric principles (ARTIFICIAL) favor the evolution of large biological macromolecules (NATURAL) such as the adenovirus, and that much can be learned by comparing one with the other.

References:

Dewar, R. E. (1982), Sculptures of Polyhedral Networks based on an Analogy to Crystal Structures Involving Hypothetical Carbon Atoms, *Leonardo*, Vol. 15, No. 2, pp. 96-103, 1982

Penrose, R. (1974), The Role of Aesthetics in Pure and Applied Mathematical Research, *Bull Institute of Mathematics and its Applications*, Vol. 10, No. 7/8, pp. 266-271, 1974

Stewart, P. L. (1993), Difference imaging of adenovirus: bridging the resolution gap between X-ray crystallography and electron microscopy, *The EMBO Journal*, Vol. 12, No. 7, pp. 2589-2599, 1993

Szeliski, R. and Tonnesen, D. (1992), Surface Modeling with Oriented Particle Systems, SIGGRAPH '92 Conference Proceedings, Vol. 26, No. 2, pp. 185-194, 1992