Molecular Nanotechnology: Golden Mean as a Driving Force of Self-Assembly

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Abstract: In this paper we are considering self-assembly approach from nanobiology to molecular nanotechnology. Because the genetic code, as a most complex biomolecular system, is determined by Golden mean, we used it knowledge to study approaches to nanotechnology. Understanding protein self-assembly driving force and structure of clathrin and microtubules based on Golden mean we have found that fullerene C_{60} and nanotubes could be very useful materials for molecular nanotechnology. One possible solution as a sample is given.

Key-words: Golden mean, nanobiology, clathrin, microtubules, molecule C_{60}, nanotubes, molecular nanotechnology

1 Introduction

Beauty is a conspicuous element in the abstract completeness aimed at in the higher mathematics. Also, trough the symmetry law it is the goal of physics as it seeks to construe the order both elementary particules and the Universe. However, it ought to be the inspiration of genetic and molecular study of life.

Beauty is a word which has defied the efforts of philosophers to define in a way that commands general agreement. In mathematics it is mean ratio, golden triangle or Fibonacci golden series. In material science it is crystal state based on number of transformations of point symmetry groups. In molecular machines technology it could be driving force of self-assembly based on structure, energy and environmental properties.

2 Problem Formulation

Human organism is the most complex local Universe technology. In spite of that, structural information code (DNA) is based on only four elements, in form as an aperiodic crystal. [1] However, it has been shown that the genetic code is a Golden mean determined system. [2] On the other hand, the Golden mean is driving force of protein biomolecular machinery [3] For nannotechnology it is important to find biomolecules (proteins) as a systems which structure and energy properties are based on Golden mean. Based on nanobiology knowledge we can develop new materials with self-assembles properties for molecular nanotechnology. [4]

2.1 Golden Mean in Nanobiology:

Clathrin and microtubules are two main proteins which structure and energy properties are based on Golden mean. Clathrin was discovered in 1969 by two Japanise scientists, Kanaseki and Kadota [5], while microtubules at the first time was predicted and published by a 24-year-old Austrian cell biologist Sigmund Freud (well known psychologist) [6].

2.1.1 Clathrin

Clathrin- coated vesicles are cell structures found in all nucleated cells, from yeast to human. It is a protein with a molecular weight of 180,000 daltons (dalton: "D" is the equivalent of the weight of one hydrogen atom). Clathrins are the major components of coated vesicles, important organelles for intracellular material transfer including synaptic neurotransmitter release. Based on molecular weights, isoelectric points and antigenic determinants, two proteins, α- and β-tubulin subunits, have been found to be associated with coated vesicles in both bovine brain and chicken liver.

The basic form of clathrin is a *trimer* (three subunits), but the basic form of assembly protein, which associates with clathrin, is a *dimer*. Clathrin is highly conserved in evolution and is composed of three large polypeptide chains and three smaller polypeptide chains that together form a *triskelion.* A different number of *triskelions* assemble into a basket-like network with Golden mean properties based on 12 pentagons and various numbers of hexagons.

Clathrin as a truncated icosahedron is dominant in neurons, while clathrin with 30 hexagons is found in other types of cells (e.g. liver, etc.). Large clathrin of 60 hexagons with a diameter of about 120 [nm] have been found in fibroblasts. The number of amino acids with negative charges (aspartic acid and glutamic acid) is 378 per clathrin, while the number of amino acids with positive charges (histidine, lysine and arginine) is 201. This means that there are

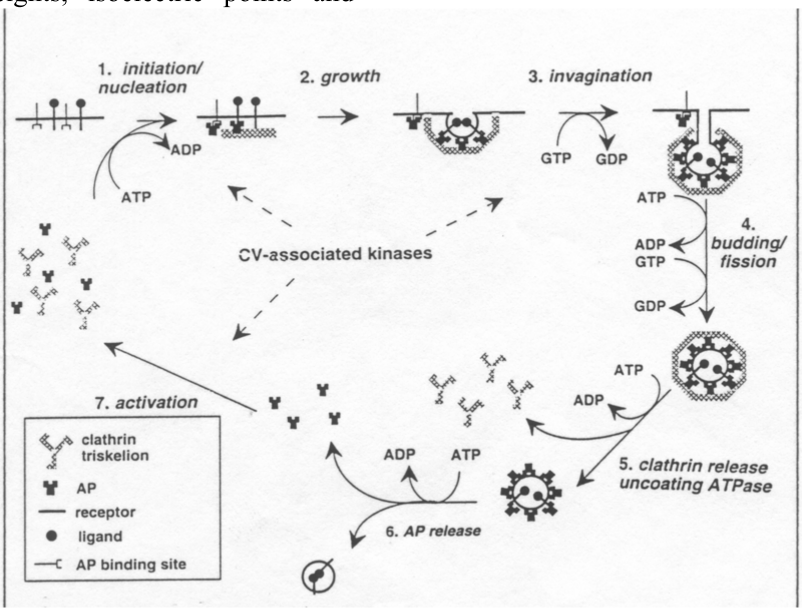
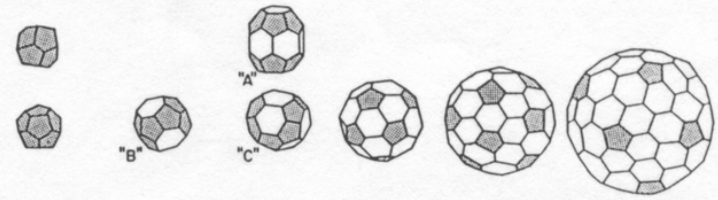


Figure 1: Clathrin self-assembly: Clathrin triskelions are the assembly units of the sphere lattice on the surface of coated pits and coated vesicles [4]

77 more electrons than positive charge per molecule, or per "cage" there are about 8.316 more electrons than positive charges.



	Dodecahe-dron	Type "B"	Types "A" and "C"	Truncated icosahedron (brain)	(Liver)	Full icosahedron (fibroblasts)
No. of hexagons	0	4	8	20	30	60
No. of vertices	20	28	36	60	82	140
Predicted diameter (nm)	40	50	60	76	90	120
Predicted weight (MD)	13	18	23	38	53	77
No. of "facets" in deep etch	3–4	4–5	7–8	10	14	24
No. of "spikes" in neg. stain	4–5	5–6	6–8	8	12	16–17

Figure 2: Neural cells (neurons) contain CV and clathrin with 12 pentagons and 20 hexagons with diameters of 70-80 nm [4]

2.1.2 Microtubules

Microtubules are biopolymers present in all eucariotic cells. They are involved in several specialized functions, including cell shape regulation, mitosis, intracellular translocation, cell motility, and secretion. Structurally, microtubules are hollow cylinders 25 nm in diameter which are composed of 13 linear chains (protofilaments) which consist of proten subunits called tubulin. Microtubules are composed of equimolar amount of the two globular 50 kD subunits, alfa and beta tubulin, each having a similar amino acid sequence and a similar overall shape.

Tubulin is a globular (spherical) protein composed of amino acids. α -tubulin subunits usually contain 450 amino acids, while β -subunits contain about 445 amino acids. There are about two times more negative charges (Asp and G1u) than positive charges (Lys, Arg and His). The diameter of tubulin subunits is about 4 nm. This heterodimer is the main building element of microtubules. Microtubules may exist from 7-17protofilaments, but usually (85%) a microtubule contains 13 protofilaments.

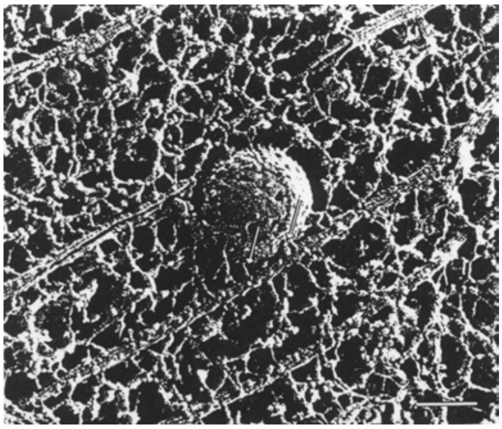


Figure 3: Most neuronal CV and clathrin are concentrated in synapses (where consciousness arise), some associated with microtubules (usually there are five CV per one microtubule). [4]

The subunits of tubulin molecules are assembled into long tubular structures with an average exterior diameter of 25-30 nm, capable of changes of length by assembly or disassembly of their subunits. Assembly/disassembly is sensitive to cold, high hydrostatic pressure, several specific chemicals such as colchicine and vinblastine, and other factors.

Since some experimental results link tubulin and microtubules to bioinformation processes such as memory, learning and consciousness microtubules have become the subject of intensive research. [7-9]

2.3 Golden Mean in Nanomaterials

2.3.1 Molecule C_{60}

The C_{60} molecule is the third known pure crystal form of carbon, in addition to graphite and diamond. It is predicted in 1970 by Japanise scientist Osawa, and synthesis in 1985 by Kroto/Smalley research team. The electronic structure is a complex, "many body" problem, because there are 360 electrons. Conversely, the C_{60} molecule has attributes of a "big atom", because it has a close spherical electronic shell and possesses unique icosahedral symmetry properties. In the truncated icosahedral structure there are two characteristic C-C bond lengths: C_5-C_5 in pentagons, C_5-C_6 double bonds in hexagons (or link between two pentagons).

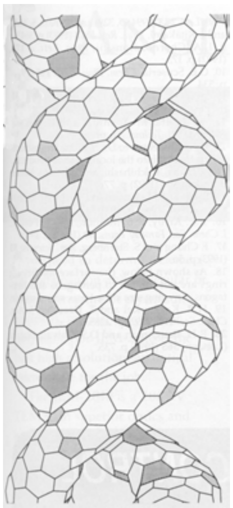


Figure 5: Nanotubes as a double-helix (proposed by Osawa [10]) could be very important basic element for molecular nanotechnology based on self-assembly.

There are sixty carbon p_z orbitals, each pointed along radial axes. If interactions among p_z orbitals belonging to carbon atoms on a certain pentagon are considered and interactions among orbitals located on different pentagons (there are 12 such pentagons) are neglected, then the five eigenstates based on K_h symmetry (spherical harmonics).

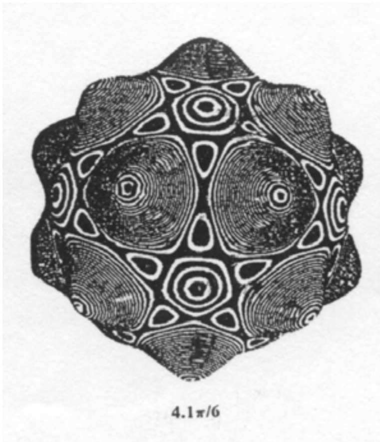


Figure 4: Golden mean surface energy state of molecule C_{60} [4]

There are three sets of orbitals which occur grouped together: ψ_0, $\psi_{1(+,-)}$, and $\psi_{2(+,-)}$. Interaction among 12 pentagons will split the twelve ψ_0 orbitals to $A_g + H_g + T_{1u} + T_{2u}$, while the 24 $\psi_{1(+,-)}$ orbitals, two per pentagon, will split into $T_{1g} + G_g + H_g + T_{1u} + G_u + H_u$, irreducible representations (or symmetries). The final 24 $\psi_{2(+,-)}$ orbitals, with the highest energy, will be split into T_{2g}, G_u, G_g, H_u, T_{2u} and H_g. Irreducible representations T_{1g}, T_{2g},T_{1u} and T_{2u} for symmetry elements C_5 and S_{10} possess Golden mean properties.[4]

2.3.2 Nanotubes

Nanotubes are similar to microtubules like C_{60} molecule is similar to clathrin. Nanotubes are quasi-1D structure, while C_{60} is quasi-0D entity; first crystallize around axis (1-dimension) and second crystallize around point (0-dimension). There are single-wall and multi-wall nanotubes with different physical properties. All types of nanotubes are intersting for nanotechnology, but helical one could be very intersting for molecular nanotechnology based on self-assembly.

3 Problem solution

We are proposing one possible approach to problem solution of molecular nanotechnology based on Golden mean. Nanomaterials will be fullerene molecule C_{60} with intelligent solvent and magnetic field with density of magnetic flux by Golden mean (Figure 6).

We plan to use knowledge from nanobiology (self assembly of clathrins and microtubules) to molecular nanotechnology (C_{60} and nanotubes) in sense like relationship between the flight of a bird and the flight of an aircraft: both use wings but in different manners. [11] However, molecular coding chain of spiral nanotubes, with C_{60} and endohedral M@C60 as basic elements, should exist.

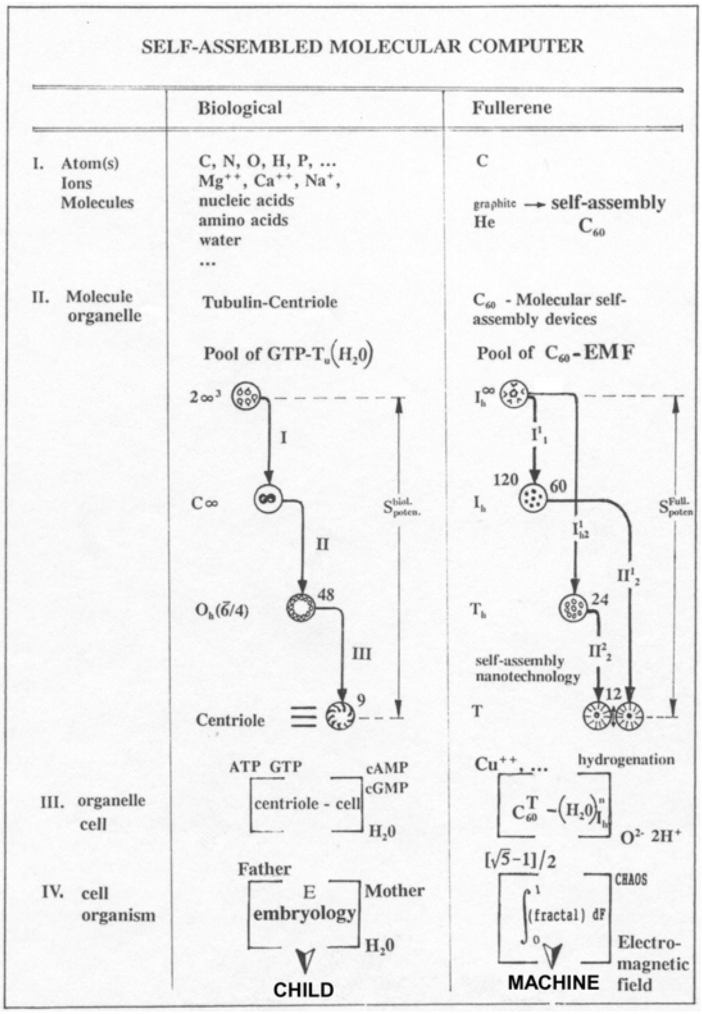


Figure 6: One possible approach of molecular nanotechnology based on Golden mean and symmetry reduction (from ∞ trough 48 to 9 and from ∞ trough 120, 60, 24 to 12 - adapt from reference [4]).

4 Conclusion

Golden mean is very powerful force of self-assembly in molecular biology (DNA and proteins). It is possible to take this knowledge from nanobiology and implement into molecular nanotechnology. Very promising nanomaterials for self-assembly approach based on Golden mean in molecular nanotechnology are fullerenes and carbon nanotunbes. Environment for self –assembly process should be intelligent solvent and internal pulsing magnetic field by Golden mean.

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