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The 19th Annual Meeting of the Israel Society for Astrobiology and the Study of the Origin of Life (ILASOL)

Book of Abstracts

Sunday, January 1, 2006

Botnar Auditorium, Belfer Building,

Weizmann Institute of Science, Rehovot

Avshalom Elitzur (BIU), Gideon Fleminger(TAU),

Barak Shenhav(WIS) and Doron Lancet (WIS)

Program

9:00-9:05	Doron Lancet (WIS)	Opening Remarks

Session 1 – Astrobiology (chair: Noah Brosch)

9:05-9:35	Akiva Bar-Nun (TAU)	Methane on Mars and Deep Impact Cometary Mission Updates
9:35-10:05	Nir Shaviv (HUJ)	Is Geological-scale Climate Variability Driven by Galactic Spiral Arm Passages?
10:05-10:35	David Eichler (BGU)	Optical Search for Extra-Terrestrial Intelligence

Session 2 – Genomic Insights (chair: Yitzhak Pilpel)

10:35-11:05	Oded Beja (IIT)	Environmental Genomics: New Ways to Harvest Light
11:20-11:50	Jerry Eichler (BGU)	Flowing Traffic - Moving Proteins Across Evolution
11:50-12:20	Emmanuel Tannenbaum (BGU)	An RNA-Centered View of Eukaryotic Cells
12:20-12:50	Ed Trifonov (UH)	Protein Chronology Scale - Generous Abiotic Start
12:50-13:20	Gad Yagil (WIS)	The Generation of Biocomplexity – an Attribute of the Evolution of Life

Session 3: Chemistry and Computing (chair: Gideon Fleminger)

14:00-14:30	Moshe Sipper (BGU)	Artificial Life: a Survey
14:30-15:00	Addy Pross (BGU)	On the Chemical Nature of Purpose – Teleonomy
15:00-15:30	Malcolm Schrader (HUJ)	Prebiotic Synthesis of RNA and Thermodynamic Feasibility

Session 4: Evolution (panel session, chair: Avshalom Elitzur)

15:30-16:00	Elia Leibowitz (TAU)	Overview of the Question of Intelligent Design
16:15-16:30	Arie Issar (BGU)	A Designer is Redundant Once Information is Regarded as a Dimension
16:30-16:45	Naomi Dar (UH)	Why Should the Origin of Life Be Studied? – Theological and Philosophical Aspects
16:45-17:00	Nakdimon Umiel (Volcani)	The Life-cycles of Life

Session 5: Exobiology

17:15-17:45	Emanuel Lottem (Editor, YNET encyclopedia)	Life's Origin and Diversity as Mirrored in Science Fiction
17:45-17:55	Noam Lahav (HUJ)	Concluding Remarks

Abstracts

Methane on Mars and Deep Impact Cometary Mission Updates

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The detection of methane in the Martian atmosphere at the 10ppb level prompted the suggestion that the methane is produced there by microorganisms. We show that it can be formed in the atmosphere by the photolysis of water in the presence of CO. Formaldehyde and methanol, which were also tentatively detected, are intermediates in the reaction which hydrogenates CO toCH_4.

The findings of the Deep Impact mission to comet Temple-1 will be presented and discussed.

Is Geological-scale Climate Variability Driven by Galactic Spiral Arm Passages?

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Recent evidence suggests that changes in the galactic cosmic ray flux are affecting the global climate through modulation of the tropospheric ionization. I will show here that the cosmic ray flux climate connection appears to exist also on geological time scales. In particular, the cosmic ray flux variability arising from our passages through the Milky Way's spiral arms seems to be responsible for the periodic appearance of ice-age epochs on Earth every 150 million years, while on longer time scales, glacial activity correlates with the Milky Way star formation history. I will discuss the ample evidence which supports this picture and mention other seemingly unrelated topics---from the demise of the dinosaurs to the trillion dollar question of global warming.

Optical Search for Extra-Terrestrial Intelligence

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We propose using large Air Cerenkov telescopes (ACTs) to search for optical, pulsed signals from extraterrestrial intelligence. Such dishes collect tens of photons from a nanosecond-scale pulse of isotropic equivalent power of tens of solar luminosities at a distance of 100 pc. The field of view for giant ACTs can be on the order of 10 square degrees, and they will be able to monitor 10-100 stars simultaneously for nanosecond pulses of about 6th magnitude or brighter. Using the Earth's diameter as a baseline, orbital motion of the planet could be detected by timing the pulse arrivals.

Environmental Genomics: New Ways to Harvest Light

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Environmental microbial genomics is a new emerging field that enables us to look at parts of the environment that were, until recently, masked to us. With present estimates suggesting that more than 99.8% of the microorganisms in most environments are not amenable to growth in pure culture, thus very little is known about their physiology and roles in the ocean. This problem is now bypassed by accessing the genomes of these microorganisms and identifying protein coding genes and biochemical pathways that will shed light on their physiological properties and ecological function.

My talk will be focused on recently identified pathways that help marine bacteria in harvesting light energy. These new mechanisms are different from the well-known photosynthesis system and are based on a single protein molecule. These rhodopsin molecules were identified only 5 years ago in a genome of uncultured bacteria and were a mere speculation till very recently. We now know that these proteins are found in different bacterial lineages including members of the SAR11 group (the most abundant bacteria on Earth). Moreover, there is now evidence that these proteins are indeed used to harvest light and transduce energy to the very nutrient-poor oceanic system.

Flowing Traffic - Moving Proteins Across Evolution

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One of the defining moments in the development of the cell came with the emergence of the lipid-based membrane. While the advent of the membrane served to create a distinct intracellular environment, the inability of molecules to readily cross this hydrophobic barrier required the formation of membrane-inserted proteins to mediate transfer across the membrane and the secretion of proteins outside the cell boundary to take advantage of conditions outside the cell. Today, such proteins fulfil a wide variety of functions, ranging from the generation of bio-energy to nutrient uptake to intercellular communication. To correctly localize these proteins, cells from the three domains of life, i.e. Bacteria, Archaea and Eukarya, have developed machineries responsible for identifying proteins destined to reside beyond the cellular cytoplasm, for targeting those proteins to sites of export in the membrane and finally, for delivery across the membrane. In realizing these aims, an evolutionarily conserved pathway is employed, although domain-distinct traits also exist. In addition to exporting proteins, eukaryal cells, containing multiple membrane-bound internal compartments, must also mediate internal protein transport. Accordingly, membranous vesicles serve as vehicles for the trafficking of proteins and lipids between the various intracellular compartments. In my presentation, I will give an evolutionary perspective of the different pathways used for moving protein within and beyond the cell membrane.

An RNA-Centered View of Eukaryotic Cells

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Emerging evidence suggests that the introns and intergenic sequences of the genomes of higher eukaryotes (the ``junk" DNA) codes for a vast, RNA-based, genetic regulatory network. It is believed that this network is responsible for the variety and complexity of terrestrial life. We conjecture that this regulatory network is more properly viewed as an RNA ``community", composed of a rich and largely unexplored biochemical web of RNA interactions. Viewed as an RNA-community, we hypothesize that the RNA regulatory network of higher eukaryotes can re-wire itself, and employ various and evolvable mutational strategies in response to external pressures. Thus, we argue that much evolutionary change is due to intracellular, RNA-mediated learning processes. Successful strategies and pathways are then recorded (hard-wired) into the DNA genome via reverse transcriptase. We present evidence which is consistent with this viewpoint, and make specific predictions which could be used to test the utility of our framework. If essentially correct, the RNA-community view of eukaryotic cells could reconcile measured point mutation and gene duplication rates with actual rates of evolutionary change. Futhermore, the RNA-community view of eukaryotic cells suggests that agent-based modeling techniques, used in mathematical economics, game theory, and neuroscience, will likely be as useful in understanding the functioning of eukaryotic cells as the pathway-based approaches of systems biology. We conclude this paper by arguing that a sufficient amount of biological knowledge has been accumulated to initiate a systematic program of experimental and computational studies of the origins and macroevolution of terrestrial life.

Protein Chronology Scale - Generous Abiotic Start

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Protein sequence conservation provides a global scale for time ordering and, potentially, actual chronology of major evolutionary events. Typical size of highly conserved peptide sequences is 6 to 9 amino acid residues. Ranking conserved octamers by the proportion of prokaryotic proteomes where they are found, from omnipresent ones (100% proteomes) down to 50% of the proteomes, may be considered as the evolutionary ordering of respective proteins in which the octamers are found. Inspection of the list of the proteins shows that amongst the very first, most ancient 30 proteins there is none of those enzymes that are involved in elementary syntheses of amino acids, sugars or bases. According to the time order by the sequence conservation the first synthesizing enzymes have been responsible for RNA components. Only at the level of conservation about 90% (step ~300) the amino acid synthesizing enzymes appeared. The reductases turning ribonucleotides to deoxy-ribonucleotides appear only at the level 50% (step ~1500). The order is consistent with commonly speculated scheme RNA early, DNA late. It also suggests that the early Life enjoyed rather generous abiotic supply of its elementary building blocks.

The Generation of Biocomplexity – an Attribute of the Evolution of Life

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A major attribute of living organisms is the presence of a set of coded instructions which orchestrate the formation and behavior of any living organism. Here we shall show, that these coded instructions are of a magnitude exceeding by far that of any inanimate assembly, leading to the conclusion that generation of a highly complex set of instruction is an essential step at some stage of the evolution of life.

A previously formulated procedure for the quantitative evaluation of system complexity is applied to assess the complexity of selected DNA segments. These segments include:

1. A typical *E. coli* gene (*lacz*), as an example of a DNA sequence which is as complex as possible (relative complexity=~1);
2. The telomere of a yeast chromosome, which has quite a number of regular features, and is indeed specified in a special short RNA code;
3. A segment of human DNA, gene p53, which has a number of regular features including 29 interspersed alu segments.

These cause a reduction of p53 gene complexity by 60%, but still with a complexity value exceeding by far anything encountered in the inanimate world. The overall conclusion is that coding sequences which serve as biotemplates are of the highest complexity encountered, and it will be a challenge to decipher the mechanism which creates the required highly complex template entities.

Yagil, G. (2000): Complexity and Order in Chemical and Biological Systems, In: Unifying Themes in Complex Systems, Y. Bar-Yam and T. Toffoli, Eds., Perseus Books, NY, pp.645- 654

Yagil, G. (2004): The over-representation of binary DNA tracts in seven sequenced chromosomes. BMC Genomics 5: 19-30

Yagil G. (In preparation): Quantitative Assessment of Structural Complexities

See also: http://www.weizmann.ac.il/~lcyagil

Artificial Life: a Survey

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Artificial Life, as defined by its main founder Chris Langton, "is the study of man-made systems that exhibit behaviors characteristic of natural living systems. It complements the traditional biological sciences concerned with the analysis of living organisms by attempting to synthesize life-like behaviors within computers and other artificial media. By extending the empirical foundation upon which biology is based beyond the carbon-chain life that has evolved on Earth, Artificial Life can contribute to theoretical biology by locating life-as-we-know-it within the larger picture of life-as-it-could-be."

My talk will provide an overview of the major open problems in artificial life, and an anecdotal survey of some interesting avenues being explored.

On the Chemical Nature of Purpose – Teleonomy

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Chemistry enables us to understand the properties of chemical systems based on their chemical structure. For example, we understand why water is soft, why ice is hard, and why metals conduct electricity and are shiny. However this kind of understanding is lacking for the basic properties of living systems. For example, one of living systems' most striking characteristics is their purposeful (teleonomic) character, but a chemical understanding of that character and, in particular, how it might have emerged, remains missing. In this talk we will explore the chemical nature of purpose within a general framework that attempts to further clarify the physico-chemical relationship between animate and inanimate systems. One key element of the analysis is our proposal that all living systems constitute a kinetic state of matter as opposed to the traditional thermodynamic states that dominate the inanimate world. We will attempt to demonstrate that the well-established concepts of kinetic and thermodynamic selection can help explain the emergence of biological systems with their striking properties – such as purpose - in relatively simple chemical terms.

Pross A. (In press): On the Chemical Nature and Origin of Teleonomy. Origins Life Evol. Biosphere

Pross A. (In press), Stability in Chemistry and Biology. Life as a Kinetic State of Matter, Pure Appl. Chem

Prebiotic Synthesis of RNA and Thermodynamic Feasibility

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Possible synthesis of RNA from the prebiotic atmosphere and earth is outlined. It is assumed that the atmosphere is "slightly reducing", consisting of nitrogen, carbon dioxide, water and traces of other gases. The source of energy initiating the process is assumed to be solar ultraviolet radiation. The traditional "reaction soup" approach, with its built-in problem of hydrolysis of products, is abandoned in favor of a flow system through a chromatographic adsorption-column type reactor. Enthalpy changes are tabulated for successive stages of the process. All significant changes are found to be negative or near zero in terms of chemical transformations.

Overview of the question of intelligent design

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Intelligent Design (ID) is a name of a trend in human culture that claims that there are phenomena in the observable universe, especially some that are related to the phenomenon of life, that are unaccounted for by the Darwinian, Evolutionary outlook of the world. This enforces the conclusion that the universe as a whole, or some important elements in it are manifestations of an Intelligent Design.

ID suffers from 5 major faults:

1. The attack on Darwinism is unwarranted by facts. This point will not be discussed in the lecture.
2. There are "holes" in the ID interpretation that are wider and deeper than those allegedly exist in Evolution.
3. The very question which the ID notion is supposed to answer is based on an Anti-Copernican point of view of the world.
4. Adopting the ID idea about the world cannot be regarded as acquiring useful knowledge about it. If ID has any value in human culture, it is akin to that of some forms of art.
5. There are undeniable logical consequences of Evolution that might be considered dangerous for the foundations of human Moral systems. At the beginning of the 21 century, however, the possible consequences of the ID outlook of the world on the future of mankind are no less dangerous.

The last part of the lecture show that the very same ID controversy took place 2000 years ago, between Jewish scholars that were debating the rules of how to light the Chanukah candles.

A Designer is Redundant Once Information is Regarded as a Dimension

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Lately, as a result of 'Darwin's Black Box', a book and a series of articles by Prof Michael Behe and his followers, a war of words rages between scientists about the question of the involvement of an Intelligent Designer (ID) in the evolution of living forms. Prof. Behe and his collaborators claim that the evolution is better explained as a process following an algorithm, designed by an intelligent mind, rather than by a process of random mutations just surviving the selection by the hostile environment.

The author, a geologist, claims that the evolution of the bio-world starting from the first organic molecule, which contained a self replicating program, indeed followed a design deciding its progress towards more and more intelligent forms of life. Yet, a designer is not needed. Moreover the observations brought up to support the theory of ID are, as a matter of fact, a verification of his theory that Information is a dimension like space-time (ST) intrinsic in the universe and the evolution of intelligence of the bio-world has progressed along space-time information dimensions. Once this conceptual model is accepted, a design without a designer crops out. Life and its evolution is a movement gaining nega-entropy i.e. opposing the arrow of universal entropy, along the coordinates of space-time-information continuum, which has eleven degrees of freedom (Spatial x,y,z, each of which has two degrees of freedom, Temporal, which has one degree of freedom from past to future and information with four degrees).

Why Should the Origin of Life Be Studied? – Theological and Philosophical Aspects

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The study of the origin of life is often regarded as a contradiction to the Biblical version of the creation of life. New developments in molecular biology (especially genetics and biochemistry) gave the impression, that the object of science was to establish the claim, that life originated from material processes, which is considered an alternative to the Biblical version of the origin of life.

The presumed contradiction between scientific research and the Biblical description of the origin of life does not have a solid philosophical support. The scientific research and the Biblical story do not refer to each other. At best, the two ways of description can be considered as complementary. The Bible roughly outlines God's responsibility for the creation of life, while science tries to explain how life could have originated from brute matter.

In the study of science, the relevance of the origin of life should be found within its philosophical assumptions. The main contribution of the origin of life to science is the establishment of the evolutionary theory and the general laws (such as natural selection) which are deduced from its framework. The generality of these laws can be preserved only if they are from the beginning applied to all stages of the development of life. Natural selection operates on all forms of life from the early pro-life entities to higher and more complicated forms of life. Despite the essential differences between life and non-life, the characterizations of living systems developed from the potential berried in "brute" mater.

The Life-cycles of Life

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Little is known of how, when or where life on Earth had started or if it was transported to Earth. Nevertheless, we know of only one type of life, the one presently dominating our home planet. The quantity of any life can be measured in many ways, among them also the total quantity of the replicator (e.g. DNA) in all living organisms, in mass (kg) or length (light-years).

A life-cycle is a measurement of quantity versus time. All life-cycles are starting by birth, followed by a growth period, maturation, decline and finally by death (or termination, or disappearance). The concept of life-cycle holds true for almost every thing in our Universe, from the life-cycle of the Universe itself (which we only partially know), to that of stars, or galaxies, or of each single insignificant cell or bacteria on Earth. If we agree that almost everything in the Universe have a life-cycle then we have to consider the possibility (or fact) that life itself have a life-cycle. Having a life-cycle means that at some point it had started and later on it will die and become extinct.

Any kind of life, the one we know and others we do not know, by definition, each must have its own life-cycle. Part of the known life-cycle (from its origin to the presence) of the "only life we know" is presented with some alternatives for the future parts of this life-cycle. From the features of the life we know, we can fairly generalize on some important features of the life-cycle of (some or all) other lives that might (had or will) exist elsewhere in the Universe, those that we still do not know.

Life's Origin and Diversity as Mirrored in Science Fiction

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Extraterrestrial life has long been thought of as the exclusive domain of science fiction; indeed, it may be regarded as one of the genre's defining features. It was only in recent years that life scientists and astronomers have begun to consider possible scientific scenarios for the existence of life outside our planet, and the new science of exobiology was born.

What can sci-fi contribute to this quest? Not as much as some may expect, it seems. Most aliens featured in sci-fi turn out to be but metaphors on human beings. Yet here and there alien life forms that have evolved elsewhere, under conditions much different than Earth's. Such stories serve, first and foremost, to highlight a fact often misconstrued by early origin of life theories: Life need not be earth life; it can be more diverse than that.

Another point, frequently raised in sci-fi, relates to panspermia, directed or otherwise. In order to tell a story involving humans and aliens, they have to have something in common. Is it just "intelligence," as currently defined on our mudball, or is there also a biological common denominator? Yet another series of issues raised by sci-fi concerns the super-intelligent beings. Where would the course of evolution take a civilization such as ours, in the fullness of time?

And finally, there is the pronouncement made by famous sci-fi author Sir Arthur C. Clarke: organic intelligence is but a stage in the evolution of machine intelligence. Thinks about that!