Energy Highway along Protein Strands

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A Northeastern research team has developed new technology that optimizes DNA sequencing using nanophysics and electric currents. [23]

Nevertheless, the accumulation of DNA damage is a cause of aging. A team of scientists based at CECAD at the University of Cologne is now trying to better understand the damage to the genome driving the aging process. [22]

By taking a different approach, however, researchers at Houston Methodist made a surprising discovery leading to the development of technology with the ability to rejuvenate human cells. [21]

The stiffness or elasticity of a cell can reveal much about whether the cell is healthy or diseased. Cancer cells, for instance, are known to be softer than normal, while asthma-affected cells can be rather stiff. [20]

Scientists at the University of Bonn have succeeded in observing an important cell protein at work using a method that measures structural changes within complex molecules. [19]

Scientists have now explored a modified form that can produce light-generated electrons and store them for catalytic hydrogen production even after the light has been switched off. They present this biomimetic photosynthesis approach in the journal Angewandte Chemie. [18]

Scientists at The Australian National University (ANU) have designed a nano crystal around 500 times smaller than a human hair that turns darkness into visible light and can be used to create light-weight night-vision glasses. [17]

Magnets instead of antibiotics could provide a possible new treatment method for blood infection. [16]

One of the biggest challenges in cognitive or rehabilitation neurosciences is the ability to design a functional hybrid system that can connect and exchange information between biological systems, like neurons in the brain, and human-made electronic devices. [15]

Wearable terahertz scanning device for inspection of medical equipment and the human body. [14]

Optical microscopy experts at Colorado State University are once again pushing the envelope of biological imaging. [13]

Researchers at the University of Melbourne have developed a way to radically miniaturise a Magnetic Resonance Imaging (MRI) machine using atomic-scale quantum computer technology. [12]

With one in two Australian children reported to have tooth decay in their permanent teeth by age 12, researchers from the University of Sydney believe they have identified some nanoscale elements that govern the behaviour of our teeth. [11]

When cryoEM images are obtained from protein nanocrystals the images themselves can appear to be devoid of any contrast. A group of scientists from the Netherlands have now demonstrated that lattice information can be revealed and enhanced by a specialized filter. [10]

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.

From the standpoint of physics, there is one essential difference between living things and inanimate clumps of carbon atoms: The former tend to be much better at capturing energy from their environment and dissipating that energy as heat. [8]

This paper contains the review of quantum entanglement investigations in living systems, and in the quantum mechanically modeled photoactive prebiotic kernel systems. [7]

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems.

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.

The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the

diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.

The diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the Relativistic Quantum Theory and making possible to understand the Quantum Biology.

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Author: George Rajna

Preface

Jeremy England, a 31-year-old assistant professor at the Massachusetts Institute of Technology, has derived a mathematical formula that he believes explains this capacity. The formula, based on established physics, indicates that when a group of atoms is driven by an external source of energy (like the sun or chemical fuel) and surrounded by a heat bath (like the ocean or atmosphere), it will often gradually restructure itself in order to dissipate increasingly more energy. This could mean that under certain conditions, matter inexorably acquires the key physical attribute associated with life. [8]

We define our modeled self-assembled supramolecular photoactive centers, composed of one or more sensitizer molecules, precursors of fatty acids and a number of water molecules, as a photoactive prebiotic kernel system. [7]

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

Improved model of energy highway along protein strands

Ever heard of polarons? They are a kind of quasi-particle resulting from electrons self-trapping in a vibrating crystal lattice. Polarons can be harnessed to transport energy under certain conditions related to the relative vibrations of the electrons and the lattice itself. The theory explaining how polarons carry energy in crystals can be applied to long molecules called polypeptides—which can fold into proteins.

In a new study published in EPJ B, Jingxi Luo and Bernard Piette from Durham University, UK, present a new mathematical model describing how polarons can be displaced in a directed way with minimum energy loss in linear peptide chains—which were used as a proxy for the study of proteins. The model therefore accounts for the energy transport mechanism explaining how energy generated inside a biological cell moves along transmembrane proteins towards the cell's exterior.

So how are polarons created? Regular crystal lattices display spontaneous vibrations. The presence of electrons produces localised distortions of these vibrations. When the electrons and the lattice experience a particular kind of electromagnetic interaction, or coupling, the energy potential for the electron is lowered, thus trapping it within the lattice. A similar coupling takes place between polarons and the peptide units in polypeptides.

Using simulations, the authors found that what determines the ability of polarons to transport energy is partly linked to the degree of symmetry of the electron interaction with the lattice. One prediction of their model is that a constant electric field, used in concert with random forces caused by heat in the cell environment, can initiate and sustain the motion of a polaron along a polypeptide chain. And this electric field matches the constant energy potential difference to be found across the membrane of a typical cell. [25]

New tools sift cancer sequences for microsatellite mutations

Two new computational tools, MSMuTect and MSMutSig, could help reveal how often mutations in common DNA features called microsatellites appear in, and contribute to, cancer.

Microsatellites—long stretches of short DNA repeats, such as TCGTCGTCG or ACACAC over and over—are common throughout the genome, both within and outside of genes. Researchers have linked inherited insertion and deletion mutations (also called "indels") in microsatellites to more than 40 inherited diseases, and clinical labs routinely test for spontaneous or acquired (a.k.a. somatic) indels in certain kinds of cancer. However, technical challenges have stymied efforts to use genome sequencing to systematically catalog cancer-relevant somatic microsatellite indel mutations.

In Nature Biotechnology, a team of researchers led by Yosef Maruvka and Gad Getz of the Broad Institute's Cancer Genome Computational Analysis group and Massachusetts General Hospital's Center for Cancer Research and Department of Pathology reveal two computational tools for detecting microsatellite indels in sequencing data from tumor cells. Dubbed MSMuTect and MSMutSig, the tools use statistical approaches to respectively a) identify microsatellite indels, and b) highlight genes harboring more of them than would be expected by chance.

Maruvka, Getz, and their collaborators tested the tools using whole exome sequence data from 6,747 tumors—representing 20 kinds of cancer—and matched normal tissues analyzed by The Cancer Genome Atlas. The two tools revealed more than 1,000 previously undescribed somatic microsatellite indels, as well as potential cancer-promoting indel "hotspots" within seven genes, including three not previously thought of as cancer drivers.

In addition, the team found that with MSMuTect they could correctly classify tumors based on their level of microsatellite instability (that is, a tumor's predisposition to developing microsatellite indels)—a feature of potential clinical importance.

MSMutTect and MSMutSig add to a large and still-growing sequence analysis toolkit developed by Getz and his colleagues for detecting and describing somatic mutations and other variations in cancer sequence data, including the original MutSig and MuTect (for characterizing point mutations), MutSigCV (which incorporates gene expression and other data to increase MutSig's accuracy), ABSOLUTE (for measuring a tumor sample's purity and looking for evidence of abnormal numbers of

chromosomes), and GISTIC (for hunting down genomic regions with significant copy number alterations). [24]

Biophysics study makes exciting advancements for the future of DNA sequencing

A Northeastern research team has developed new technology that optimizes DNA sequencing using nanophysics and electric currents. In a paper published in Nature Nanotechnology, Northeastern Professor of Biological Physics Meni Wanunu, in partnership with Pacific Biosciences, a biotechnology company with a focus on DNA sequencing, developed a method for loading DNA into sequencing wells with orders of magnitude higher efficiencies.

"Apart from being a multi-billion dollar a year market, DNA sequencing is one avenue where incremental improvements in research, like discovery of a new gene, for example, can have immediate clinical consequences," said Wanunu.

Our human DNA is a genome composed of 23 pairs of chromosomes, which breaks down into six billion pieces that all come together to give each person their unique characteristics and properties. While we have the ability to sequence important parts of the genome, the ability to know the entire sequence has the potential to make huge strides in the area of understanding and predicting disease, and more importantly, to personalize medicine.

"Right now, piecing together the entire sequence through traditional methods is like stitching together a giant puzzle, and the error rate can get so enormous that after the first few hundred bases, the sequence is gibberish," said Wanunu. "That's why there's a fundamental limit for second-generation sequencing methods, which we want to move past."

This is why technology has evolved to bring forward a new method for sequencing DNA: single-molecule sequencing.

Pacific Biosciences has developed an optical technology for single-molecule DNA sequencing that relies on nano-wells. These wells localize the sequencing signal and allow single molecule sequencing to be carried out. However, the methods used by the company to load the DNA into the wells favors shorter DNA molecules, rather than longer ones.

Wanunu's lab has redesigned the wells to incorporate nanopores at their bases, which allows them to attract larger segments of DNA using an electric field. By simply applying a voltage, the charged DNA molecules efficiently enter the wells, and longer DNA molecules become preferred over shorter ones.

"Large DNA molecules need just a small push to get into the sequencing volume, but once we apply this force, we can capture enormous sample fragments easily. The system will enable totally new sequencing experiments," said Joe Larkin, first author of this paper.

To further this research, Wanunu and his lab are working on preparing this technology for more large-scale use, specifically with equipment at Pacific Biosciences. The team is testing a porous substrate to replace the metal wells currently being used to attract and sequence DNA. As they

continue in this research, Wanunu hopes to even further increase the fundamental length of DNA that can be sequenced.

"We would like to have a platform, some day, that sequences every nucleic acid molecule in a single cell, without the need for making many copies of these molecules prior to sequencing, just reading the native DNA," Wanunu said. [23]

Fast-forward aging due to DNA damage

The heredity substance DNA is the blueprint of our life. Like an instruction manual it contains all the information needed for cells and the body to function properly. In the process, the DNA is always exposed to threats like UV light, pollutants and damage by metabolic byproducts. Many of those damages can be undone by sophisticated repair mechanisms. Nevertheless, the accumulation of DNA damage is a cause of aging. A team of scientists based at CECAD at the University of Cologne is now trying to better understand the damage to the genome driving the aging process.

For the study published in the journal Cell Reports, the researchers examined the nematode Caenorhabditis elegans. Because of its short life span of only twenty to thirty days, the worm is a popular model organism for aging research. When they exposed one-day-old worms to DNA damaging UV light, the team around Schumacher found that the young animals show surprising similarity to worms at old age. They compared comprehensively proteins, fatty acids, metabolism and signaling pathways. For Schumacher, the aha moment was when they found that the changes they knew to be occurring in old worms were now already unfolding in the young individuals within hours of inflicting the DNA damage. 'Everything was there, nearly the complete picture of the aging process. That way, we could show that the aged individuals re-program their biological processes in reaction to the increased damage in their DNA. Fast-forward aging, in a matter of speaking', says Schumacher.

In total, more than 5,000 different proteins and their connection via signaling pathways were examined: How are they connected, how are they interacting, do they regulate the same process? Like in a crossword puzzle, connections between metabolism, preservation of the DNA and proteins and signaling pathways determining the aging process became apparent. 'In the end, we found all the strings and junctions - that was impressive and even better than expected. What was looming in other studies could be shown by us in the whole picture', the researcher says.

Even though worm and human do not appear all that similar at first glance, their cellular processes are very similar and comparable. Many signalling pathways are identical, the metabolism alike, the quality control of proteins similar. That is what makes the worm so relevant for aging research. In the next step, the researchers want to take a closer look at the signalling pathways. The aim is to better understand the effects of DNA damage on the organism and to make healthy aging possible for humans. [22]

Researchers develop technology to make aged cells younger

Aging. We all face it. Nobody's immune and we've long tried to reverse it, stop it or just even slow it down. While advances have been made, true age-reversal at a cellular level remains difficult to achieve. By taking a different approach, however, researchers at Houston Methodist made a

surprising discovery leading to the development of technology with the ability to rejuvenate human cells. And that couldn't be more important for the small population of children who are aging too quickly - children with progeria.

John P. Cooke, M.D., Ph.D., department chair of cardiovascular sciences at Houston Methodist Research Institute, and his colleagues, describe their findings in a Research Letter titled "Telomerase mRNA Reverses Senescence in Progeria Cells," appearing online July 31 and in print Aug. 8 in the Journal of the American College of Cardiology, a leading medical journal in the field of cardiovascular disease.

Cooke studied cells from children with progeria, a rare condition marked by rapid aging that usually robs them of the chance to live beyond their early teens. They focused on progeria, because the condition tells them a lot about aging in general that's ultimately relevant to all of us.

"These kids are dying of heart attack and stroke at 13, 14, 15 years old," Cooke said. Although current therapies are useful, they only add a year or two, on average, to the child's life. We wanted to do something that would improve the children's quality of life and potentially allow them to live longer, so we set about studying their cells and seeing if we could improve the cell function."

Cooke and his team focused on something called telomeres, which are the timekeepers of cells and very important for the function of our chromosomes. They are found at the tip of each chromosome, like the tip of a shoelace, holding the chromosome together. As we get older, the telomere gets shorter, ticking off the time we have left.

He and his colleagues saw the telomeres were shorter in children with progeria and thought if they could restore the telomere length, then perhaps they could improve the cell function and its ability to divide and respond to stress.

"We all have telomere erosion over time, and many of the things that happen to these children at an accelerated pace occur in all of us," Cooke said. "What we've shown is that when we reverse the process of the telomere shortening in the cells from these children and lengthen them, it can reverse a lot of the problems associated with aging."

To do this, the researchers used a technology called RNA therapeutics. They were able to get the cells to produce a protein, called telomerase, that can extend and lengthen the telomere. They did this by delivering RNA to the cells that encodes this protein. Essentially, they gave the cells the information they needed to extend the telomere via an RNA delivery system and let the cells do the rest.

Having that protein expressed in a cell for just a few days was enough to have a substantial physiologically relevant and meaningful effect on the lifespan and function of the cells. Cooke said it was a surprise to have such an effect with one exposure to the RNA telomerase.

"What was most unexpected about our work was the dramatic effect the telomere-extending technology had on the cells," Cooke said. "We were not expecting to see such a dramatic effect on the ability of the cells to proliferate. They could function and divide more normally, and we gave them extra lifespan, as well as better function."

The research team also compared their approach at the cellular level to the current therapies available, and Cooke said it was night and day.

"We looked at many cellular markers of aging and weren't expecting to see such a dramatic effect on them. Our approach had a much greater effect on all the markers of cellular aging," Cooke said. "We markedly improved the ability of cells to multiply and reversed the production of inflammatory proteins. Those markers of cell aging we looked at were all reversed with the treatment in our study."

Cooke wants to see this approach turned into something useful and says they're going to do it quicker than expected within a few years.

"As a physician, many of the diseases I see are due to aging. It's a major risk factor for heart and vascular diseases," Cooke said. "About a third of the people in this country succumb to strokes and heart attacks. If we can fix that, we'll fix a lot of diseases."

Cooke's work is different from what others are doing in the progeria field, because most everyone else is focusing on the genetic mutation of progeria and the abnormal protein that results from that mutation. Cooke's team chose to focus instead on developing a method to extend the telomere in these children.

"When you see these kids, they're like every other kid. They want to play, they want to dream. They want to grow up and be something great," Cooke said. "But they can't do that. They don't have the chance. That, alone, is reason enough to pursue this approach."

While Cooke says aging is not irreversible, it is something their work can have a beneficial effect on.

"We can at least stall or slow down accelerated aging, and that's what we're working toward," he said. "Our next steps are to start moving this therapy toward clinical use. We plan to do so by improving existing cell therapies. I want to develop a therapy for these children. It's an unmet need." [21]

Fast, noninvasive technique for probing cells may reveal disease

The stiffness or elasticity of a cell can reveal much about whether the cell is healthy or diseased. Cancer cells, for instance, are known to be softer than normal, while asthma-affected cells can be rather stiff.

Determining the mechanical properties of cells may thus help doctors diagnose and track the progression of certain diseases. Current methods for doing this involve directly probing cells with expensive instruments, such as atomic force microscopes and optical tweezers, which make direct, invasive contact with the cells.

Now MIT engineers have devised a way to assess a cell's mechanical properties simply by observation. The researchers use standard confocal microscopy to zero in on the constant, jiggling motions of a cell's particles—telltale movements that can be used to decipher a cell's stiffness. Unlike optical tweezers, the team's technique is noninvasive, running little risk of altering or damaging a cell while probing its contents.

"There are several diseases, like certain types of cancer and asthma, where stiffness of the cell is known to be linked to the phenotype of the disease," says Ming Guo, the Brit and Alex d'Arbeloff Career Development Assistant Professor in MIT's Department of Mechanical Engineering. "This technique really opens a door so that a medical doctor or biologist, if they would like to know the material property of cell in a very quick, noninvasive way, can now do it."

Guo and graduate student Satish Kumar Gupta have published their results in the Journal of the Mechanics and Physics of Solids.

Stirring spoons

In his 1905 PhD thesis, Albert Einstein derived a formula, known as the Stokes-Einstein equation, that makes it possible to calculate a material's mechanical properties by observing and measuring the movement of particles in that material. There's just one catch: The material must be "in equilibrium," meaning that any particle motions must be due to the effect of the material's temperature rather than any external forces acting on the particles.

"You can think of equilibrium as being a hot cup of coffee," Guo says. "The coffee's temperature alone can drive sugar to disperse. Now if you stir the coffee with a spoon, the sugar dissolves faster, but the system is not driven solely by temperature any more and is no longer in equilibrium. You're changing the environment, putting energy in and making the reaction happen faster."

Within a cell, organelles such as mitochondria and lysosomes are constantly jiggling in response to the cell's temperature. However, Guo says, there are also "many minispoons" stirring up the surrounding cytoplasm, in the form of proteins and molecules that, every so often, actively push vibrating organelles around like billiard balls.

The constant blur of activity in a cell has made it difficult for scientists to discern, simply by looking, which motions are due to temperature and which are due to more active, "spoon-like" processes. This limitation, Guo says, has "basically shut the door on using Einstein's equation and pure observation to measure a cell's mechanical properties."

Frame by frame

Guo and Gupta surmised that there might be a way to tease out temperature-driven motions in a cell by looking at the cell within a very narrow timeframe. They realized that particles energized solely by temperature exhibit a constant jiggling motion. No matter when you look at a temperature-driven particle, it's bound to be moving.

In contrast, active processes that can knock a particle around a cell's cytoplasm do so only occasionally. Seeing such active movements, they hypothesized, would require looking at a cell over a longer timeframe.

To test their hypothesis, the researchers carried out experiments on human melanoma cells, a line of cancer cells they chose for their ability to grow easily and quickly. They injected small polymer particles into each cell, then tracked their motions under a standard confocal fluorescent microscope. They also varied the cells' stiffness by introducing salt into the cell solution—a process that draws water out of cells, making them more compressed and stiff.

The researchers recorded videos of the cells at different frame rates and observed how the particles' motions changed with cell stiffness. When they watched the cells at frequencies higher than 10 frames per second, they mostly observed particles jiggling in place; these vibrations appeared to be caused by temperature alone. Only at slower frame rates did they spot more active, random movements, with particles shooting across wider distances within the cytoplasm.

For each video, they tracked the path of a particle and applied an algorithm they had developed to calculate the particle's average travel distance. They then plugged this motion value into a generalized format of the Stokes-Einstein equation.

Guo and Gupta compared their calculations of stiffness with actual measurements they made using optical tweezers. Their calculations matched up with measurements only when they used the motion of particles captured at frequencies of 10 frames per second and higher. Guo says this suggests that particle motions occurring at high frequencies are indeed temperature-driven.

The team's results suggest that if researchers observe cells at fast enough frame rates, they can isolate particle motions that are purely driven by temperature, and determine their average displacement—a value that can be directly plugged into Einstein's equation to calculate a cell's stiffness.

"Now if people want to measure the mechanical properties of cells, they can just watch them," Guo says.

The team is now working with doctors at Massachusetts General Hospital, who hope to use the new, noninvasive technique to study cells involved in cancer, asthma, and other conditions in which cell properties change as a disease progresses.

"People have an idea that structure changes, but doctors want to use this method to demonstrate whether there is a change, and whether we can use this to diagnose these conditions," Guo says. [20]

Researchers watch biomolecules at work

Scientists at the University of Bonn have succeeded in observing an important cell protein at work using a method that measures structural changes within complex molecules. The procedure makes it possible to elucidate such processes in the natural environment. The researchers are also providing a tool kit, which allows a wide range of molecules to be measured. Their study has been published in Angewandte Chemie International Edition.

To open a Christmas season walnut, we usually use a nutcracker. The simplest of them consists of two arms that move against each other around a joint and can thus exert pressure on the shell.

Cellular molecules also alter their spatial structure as they work – similar to the nutcracker, which has arms that open or close. These conformational changes tell experts a great deal about the way in which the molecule fulfills its job. Unfortunately, it is very difficult to measure these kind of movements because they occur on a very small length scale. This complicates the observation of structural changes in the natural cellular environment, where countless simultaneous processes make it very hard to isolate any specific information from the general noise.

The working group from the Institute for Physical and Theoretical Chemistry at the University of Bonn has now succeeded in doing this. To this end, the scientists further developed a method that has been used for many years to measure distances within large molecules. "However, this normally only works in a test tube," explains the head of the study, Prof. Olav Schiemann. "In contrast, our technique can also be used in cells."

The researchers used what is known as electron paramagnetic resonance spectroscopy (EPR) for their measurements. The molecule to be measured is usually given a magnetic marker at two different sites. Through radiation with microwaves, the polarity of one of these mini magnets is reversed. The magnetic field emitted by it is thus changed, which in turn influences the second mini magnet. This influence is greater the closer both markers are to each other.

"We now measure how strongly the second magnet reacts to the reverse polarity of the first," explains Schiemann. "From this, we can ascertain the distance between both markers." If – metaphorically speaking – both arms of the nutcracker are marked in this way, their movement against each other can be understood.

Magnetic ruler measurements

In principle, the technique is not new. "However, we have succeeded in producing a new kind of label with which we can mark a wide range of biomolecules in a site-specific way", explains Schiemann's staff member Jean Jacques Jassoy. Usually, these labels consist of radicals – which are chemical compounds that carry a single free electron. The electron acts as a magnet during the measurement. The problem here: single electrons are highly reactive – they try to form pairs of electrons as quickly as possible. The chemists at the University of Bonn thus used a very stable radical in their work – a so called trityl group. They created various derivatives of this trityl radical. Each of these magnetic markers is designed to target specific sites within biomolecules and thus enables several approaches for the structural analysis of different biomolecules.

In their study, the researchers used this methodological advance to investigate a protein from the cytochrome P450 group. These proteins occur in almost all living beings and fulfill important tasks, for instance during oxidation processes in the cell. "With our method, we were able to precisely measure the distance between two areas of the cytochrome to a fraction of a millionth of a millimeter," emphasizes Schiemann´s staff member Andreas Berndhäuser.

The procedure is suitable for making biomolecule conformational changes visible in the cell. At the same time, it also generally facilitates the clarification of molecular structures. Schiemann: "We are thus providing researchers with a new tool kit that could help answer many biochemical questions." [19]

Hydrogen from sunlight—but as a dark reaction

The storage of photogenerated electric energy and its release on demand are still among the main obstacles in artificial photosynthesis. One of the most promising, recently identified photocatalytic new materials is inexpensive graphitic carbon nitride. Scientists have now explored a modified form that can produce light-generated electrons and store them for catalytic hydrogen production even after the light has been switched off. They present this biomimetic photosynthesis approach in the journal Angewandte Chemie.

Nature has split photosynthesis into a light reaction generating electrons and holes from solar energy, and a dark reaction generating the actual "fuels" or chemicals that transport and store this energy. This second, time-lagged process is independent of the primary energy source, the sunlight, and thus ensures that fuel is continually produced over the entire diurnal cycle. This contrasts with current man-made systems, which suffer from an annoying disruption of energy production during the night.

In photovoltaic systems, solar cells generate electrons for either local use or to feed them into the public grid. Storage of electric energy is usually performed in batteries or by electrochemical conversion into fuels such as hydrogen or methane. Mimicking Nature's photosynthesis in a process known as "artificial photosynthesis" would imply using a material that is able to store the electrons right after their light-induced generation and release them on demand. Such a material was explored by Bettina V. Lotsch at the Max Planck Institute for Solid State Research, Germany, and collaborators in Zurich and Cambridge. It was obtained from "melon", an ordered carbon nitride polymer, which is currently heavily investigated for its photocatalytic and semiconducting properties.

The as-modified graphitic nitride is a yellow solid, which changes color upon exposure to light. "This polymer turns blue when photo-irradiated in the presence of certain electron donors in an oxygen-free environment," said the scientists. This "blue radical" state contains trapped electrons. The scientists found out that when the light was switched off and a hydrogen-evolution co-catalyst was added, the polymer turned yellow again while producing hydrogen by releasing the stored electrons. Thus it is possible to decouple the generation of photoinduced electrons from their use, for example, in fuel production, within one single, inexpensive material. This could be a significant advance for the production of storable solar fuels independent of the intermittency of solar irradiation. [18]

ANU invention to inspire new night-vision specs

Scientists at The Australian National University (ANU) have designed a nano crystal around 500 times smaller than a human hair that turns darkness into visible light and can be used to create light-weight night-vision glasses.

Professor Dragomir Neshev from ANU said the new night-vision glasses could replace the cumbersome and bulky night-vision binoculars currently in use.

"The nano crystals are so small they could be fitted as an ultra-thin film to normal eye glasses to enable night vision," said Professor Neshev from the Nonlinear Physics Centre within the ANU Research School of Physics and Engineering.

"This tiny device could have other exciting uses including in anti-counterfeit devices in bank notes, imaging cells for medical applications and holograms."

Co-researcher Dr Mohsen Rahmani said the ANU team's achievement was a big milestone in the field of nanophotonics, which involves the study of behaviour of light and interaction of objects with light at the nano-scale.

"These semi-conductor nano-crystals can transfer the highest intensity of light and engineer complex light beams that could be used with a laser to project a holographic image in modern displays," said

Dr Rahmani, a recipient of the Australian Research Council (ARC) Discovery Early Career Researcher Award based at the ANU Research School of Physics and Engineering.

PhD student Maria del Rocio Camacho-Morales said the team built the device on glass so that light can pass through, which was critical for optical displays.

"This is the first time anyone has been able to achieve this feat, because growing a nano semi-conductor on a transparent material is very difficult," said Ms Camacho-Morales from the Nonlinear Physics Centre at ANU.

The research is published in Nano Letters and is being presented by Dr Rahmani at the Australian Institute of Physics Congress in Brisbane this week. [17]

Using magnets instead of antibiotics as a new treatment method for blood infection

Magnets instead of antibiotics could provide a possible new treatment method for blood infection. This involves the blood of patients being mixed with magnetic iron particles, which bind the bacteria to them after which they are removed from the blood using magnets. The initial laboratory tests at Empa in St. Gallen have been successful, and seem promising.

Blood poisoning is still fatal in more than 50% of cases, but can be cured if treated at an early stage. The highest priority is therefore to act quickly. For this reason, doctors usually administer antibiotics even in the event of a suspicion of blood poisoning, without first ascertaining whether it is actually a bacterial sepsis, which in turn greatly increases the risk of resistance to antibiotics developing. It is therefore important to identify and develop a fast and effective therapy, if possible without the need to use antibiotics.

An antibody for everything

Empa researcher Inge Herrmann and her team are developing a solution in collaboration with modelling expert Marco Lattuada from the Adolphe Merkle Institute and doctors from the Harvard Medical School. The idea for the treatment is the magnetic purification of blood. The principle is, at least in theory, quite straightforward. Iron particles are coated with an antibody that detects and binds the harmful bacteria in the blood. As soon as the iron particles are attached to the bacteria, they are removed from the blood magnetically.

However, there is (still) a small catch: So far, it has only been possible to coat the iron particles with antibodies that recognise one type of bacteria – but many different types of bacteria may be involved, depending on the species causing the blood poisoning. Using blood analysis, doctors must therefore first determine which bacteria is causing the poisoning before the appropriate antibodies can be used. "This blood analysis is time-consuming and time plays a vital role in the treatment of blood poisoning," explains Herrmann. This is also the reason for magnetic dialysis rarely having been used to date.

But a team at the Harvard Medical School led by Gerald Pier has now developed an antibody that can bind almost all the bacteria that can trigger blood poisoning - so if there is a suspicion of sepsis,

the magnetic treatment could be started immediately, regardless of which pathogen is in the blood. This "allrounder" antibody to succeed in isolating pathogenic bacteria - similar to using dialysis.

How harmful are the iron particles?

The method is not yet sufficiently mature to be used on patients. In a next step, Herrmann wants to carry out tests with various other germs and find out whether the Harvard antibody can actually bind additional bacteria to itself. The nature of the iron particles is also not to be underestimated. It may be the case that some particles remain in the blood after the magnetic extraction has been carried out. The requirements for these carriers are thus clear: they must not harm the human body. But Herrmann's team already has a solution ready in this regard. The tiny iron particles are assembled into larger clusters and are thus more responsive to the magnet. In addition, the researchers have been able to demonstrate, in an in vitro simulation, that the iron particles are broken down completely after only five days.

Further experiments still to come

In the future, it should therefore no longer be strictly necessary to administer antibiotics as soon as there is a suspicion of sepsis. Blood will be taken from the patient for analysis, and the patient connected to a dialysis machine to cleanse the blood, no matter what bacteria are in it. As soon as the doctors have the detailed blood values, an antibiotic therapy tailored to the pathogen can be introduced, if necessary.

This idea is currently just a future ambition, as there are still numerous issues that need to be clarified. Firstly, it is imperative that this method is used in the initial stage of sepsis, when the damage has not yet spread from the blood to the organs or bodily functions, and there is also the issue of how well this treatment will work in unstable patients or patients with pre-existing conditions. But Herrmann and her team are optimistic - and also a step closer to achieving a new and more gentle treatment for sepsis. [16]

Interdisciplinary approach makes linking biological materials and electronic devices possible

One of the biggest challenges in cognitive or rehabilitation neurosciences is the ability to design a functional hybrid system that can connect and exchange information between biological systems, like neurons in the brain, and human-made electronic devices. A large multidisciplinary effort of researchers in Italy brought together physicists, chemists, biochemists, engineers, molecular biologists and physiologists to analyze the biocompatibility of the substrate used to connect these biological and human-made components, and investigate the functionality of the adhering cells, creating a living biohybrid system.

In an article appearing this week in AIP Advances, the research team used the interaction between light and matter to investigate the material properties at the molecular level using Raman spectroscopy, a technique that, until now, has been principally applied to material science. Thanks to the coupling of the Raman spectrometer with a microscope, spectroscopy becomes a useful tool for investigating micro-objects such as cells and tissues. Raman spectroscopy presents clear advantages for this type of investigation: The molecular composition and the modification of subcellular compartments can be obtained in label-free conditions with non-invasive methods and under

physiological conditions, allowing the investigation of a large variety of biological processes both in vitro and in vivo.

Once the biocompatibility of the substrate was analyzed and the functionality of the adhering cells investigated, the next part of this puzzle is connecting with the electronic component. In this case a memristor was used.

"Its name reveals its peculiarity (MEMory ResISTOR), it has a sort of "memory": depending on the amount of voltage that has been applied to it in the past, it is able to vary its resistance, because of a change of its microscopic physical properties," said Silvia Caponi, a physicist at the Italian National Research Council in Rome. By combining memristors, it is possible to create pathways within the electrical circuits that work similar to the natural synapses, which develop variable weight in their connections to reproduce the adaptive/learning mechanism. Layers of organic polymers, like polyaniline (PANI) a semiconductor polymer, also have memristive properties, allowing them to work directly with biological materials into a hybrid bio-electronic system.

"We applied the analysis on a hybrid bio-inspired device but in a prospective view, this work provides the proof of concept of an integrated study able to analyse the status of living cells in a large variety of applications that merges nanosciences, neurosciences and bioelectronics," said Caponi. A natural long-term objective of this work would be interfacing machines and nervous systems as seamlessly as possible.

The multidisciplinary team is ready to build on this proof of principle to realize the potential of memristor networks.

"Once assured the biocompatibility of the materials on which neurons grow," said Caponi, "we want to define the materials and their functionalization procedures to find the best configuration for the neuron-memristor interface to deliver a full working hybrid bio-memristive system." [15]

Wearable terahertz scanning device for inspection of medical equipment and the human body

Scientists at the Tokyo Institute of Technology have developed a portable and wearable terahertz scanning device using arrays of carbon nanotubes for non-invasive inspection of three-dimensional objects without requiring bulky peripheral optical components. The device is expected to have wide-ranging applications including noninvasive inspections of medical and drug delivery equipment such as syringes, as well as imaging cancer cells, blood clots, sweat glands and teeth. The findings are published in Nature Photonics, November 2016.

Imaging devices based on terahertz waves show promise for noninvasive inspection of solid objects and soft tissues of the human body. However, terahertz waves have difficulty in imaging and reproducing the curved contours of three-dimensional objects. Furthermore, terahertz devices currently used for whole-body scans at airports must rotate 360 degrees around the human body, and are thus large, bulky, and non-portable. In addition, the materials used to fabricate conventional terahertz systems are not flexible, and the terahertz detectors must be cooled in order to achieve high detection sensitivity.

Therefore, researchers seek terahertz imaging systems that are portable, flexible, and operate efficiently at room temperature. To address these challenges, Yukio Kawano and colleagues at the Laboratory for Future Interdisciplinary Research of Science and Technology, Tokyo Institute of Technology, have demonstrated a terahertz imaging device fabricated with arrays of carbon nanotubes (CNT). Notably, CNTs have previously been used for the fabrication of photodetectors that operate in the visible, infrared, and terahertz regions of the electromagnetic spectrum.

The Tokyo Tech team fabricated a flexible, wide-band terahertz scanner by integrating 23 CNT detector elements into a single array. The mechanical strength of the CNT film used in the detector could be readily bent over a wide range of angles, unlike conventional semiconductor materials that are fragile and break under stress. Importantly, the CNT films also absorb electromagnetic radiation over a broad terahertz range, which eliminates the need for planar antennas to scan objects. The terahertz scanner developed by Kawano and his team was successfully used for active imaging of flat and curved samples; multiview scanning of cylindrical samples; and passive wearable imaging of a human hand.

In the future, the research team expects that the applications of their terahertz scanner will enhance the capability of noninvasive inspections in pharmaceuticals, food quality control, and medical monitoring. These applications are possible because the terahertz scanner is wearable, portable, and can scan 3-D objects without requiring complex optics or equipment. [14]

Fluorescent holography: Upending the world of biological imaging

Optical microscopy experts at Colorado State University are once again pushing the envelope of biological imaging.

Jeffrey Field, a research scientist in electrical engineering and director of CSU's Microscope Imaging Network, has designed and built a fluorescence-detection microscope that combines three-dimensional and high-resolution image processing that's also faster than comparable techniques.

The work, with co-authorship by Randy Bartels, professor of electrical and computer engineering, and former postdoctoral researcher David Winters, has been published in Optica, the journal of the Optical Society of America. They named their new microscope CHIRPT: Coherent Holographic Image Reconstruction by Phase Transfer.

Imaging tradeoffs

Field and other optics scientists work in a world of tradeoffs. For example: an advanced deep-tissue imaging technique called multiphoton fluorescence microscopy employs a short, bright laser pulse focused tight to one spot, and the fluorescence intensity from that one spot is recorded. Then, the laser moves to the next spot, then the next, to build up high-resolution 3D images. The technique offers subcellular detail, but it's relatively slow because it illuminates only one tiny spot at a time.

Other techniques, like spinning disk confocal microscopy, are faster because they shine light on multiple spots, not just one, and they scan simultaneously over a larger area. But unlike multiphoton, these techniques require collecting an image with a camera. As a result, fluorescent

light emitted from the specimen is blurred on the camera, leading to loss in resolution, and with it, subcellular detail.

Call them greedy, but Field and colleagues want it all.

Breaking established boundaries

Their goal is working around each of these limitations - speed, resolution, size of field - to break through established boundaries in light microscopy.

Field and Bartels' new microscope builds upon a previously published technique, and permits digital re-focus of fluorescent light. It illuminates not one point, but multiple points by harnessing delocalized illumination spread over a large area. The physical principles they are using are similar to holography, in which scattered light is used to build a 3-D image.

Using a large illumination field, followed by back-end signal processing, the microscope can define distinct light modulation patterns of many points within the field of view. It builds up a 3-D image by combining the signals from all those distinct patterns.

"The idea is that you have a fluorophore at any point in the specimen, and the temporal structure of its fluorescence will be distinguishable from all others," Field said. "So you can have this huge array of fluorophores, and just with this single-pixel detector, you can tell where every one of them is in that 2D field."

3D, deep-tissue images

So what does this new technique allow? Deep-tissue images in three dimensions, with better depth of field than comparable techniques. Depth of field, like in photography, means background images are in sharp focus along with the main image. And the CSU researchers can work at 600 frames per second, which is many times faster than established techniques.

With their new microscope, images can also be post-processed to remove aberrations that obscure the object of interest. It's akin to being able to focus a picture after it's been taken.

The CHIRPT microscope could allow biomedical researchers to produce sharp, 3-D images of cells or tissue over a much larger volume than conventional fluorescence microscopy methods allow. It could lead to things like imaging multicellular processes in real time that, with a conventional light microscope, could only be seen one cell at a time. [13]

Atomic-scale MRI holds promise for new drug discovery

Researchers at the University of Melbourne have developed a way to radically miniaturise a Magnetic Resonance Imaging (MRI) machine using atomic-scale quantum computer technology.

Capable of imaging the structure of a single bio-molecule, the new system would overcome significant technological challenges and provide an important new tool for biotechnology and drug discovery.

The work was published today in Nature Communications, and was led by Prof Lloyd Hollenberg at the University of Melbourne, working closely with researchers at the ARC Centre of Excellence for Quantum Computation and Communication Technology (CQC2T) to design the quantum molecular microscope.

The team propose the use of atomic-sized quantum bits (qubits) normally associated with the development of quantum computers, but here would be employed as highly sensitive quantum sensors to image the individual atoms in a bio-molecule.

"Determining the structure of bio-molecules such as proteins can often be a barrier to the development of novel drugs," said Prof. Lloyd Hollenberg, Thomas Baker Chair in Physical Biosciences at the University of Melbourne.

"By using quantum sensing to image individual atoms in a bio-molecule, we hope to overcome several issues in conventional biomolecule imaging, " Prof Hollenberg said.

State-of-the-art techniques create a crystal of the molecule to be studied and use X-ray diffraction to determine the molecules' average structure. However, the crystalisation and averaging processes may lead to important information being lost. Also, not all bio-molecules can be crystalised - particularly proteins associated with cell membranes, which are critical in the development of new drugs.

"Our system is specifically designed to use a quantum bit as a nano-MRI machine to image the structure of a single protein molecule in their native hydrated environments," added Prof Hollenberg.

"As part of our research in quantum computing we have also been working on the nearer-term applications of atomic-based quantum technology investigating the use of a single quantum bit as a highly sensitive magnetic field sensor," says Prof. Hollenberg.

Atomic qubits can be made to exist in two states at the same time, a disturbingly strange property that not only underpins the power of a quantum computer, but also the sensitivity of qubits as nano-sensors.

"In a conventional MRI machine large magnets set up a field gradient in all three directions to create 3D images; in our system we use the natural magnetic properties of a single atomic qubit," says University of Melbourne PhD researcher Mr. Viktor Perunicic, who was the lead author on the paper.

"The system would be fabricated on-chip, and by carefully controlling the quantum state of the qubit probe as it interacts with the atoms in the target molecule, we can extract information about the positions of atoms by periodically measuring the qubit probe and thus create an image of the molecule's structure." says Mr. Peruncic.

"The system could be constructed and tested relatively quickly using diamond-based qubits. However, to capture really high resolution molecular images in the longer term, CQC2T's silicon-based qubits might have the advantage because they have very long quantum coherence," said Prof. Hollenberg.

"The construction of such a quantum MRI machine for single molecule microscopy could revolutionise how we view biological processes at the molecular level, and could lead to the development of new biotechnology and a range of clinical applications." [12]

Researchers identified some nanoscale elements that govern the behavior of our teeth

With one in two Australian children reported to have tooth decay in their permanent teeth by age 12, researchers from the University of Sydney believe they have identified some nanoscale elements that govern the behaviour of our teeth.

Material and structures engineers worked with dentists and bioengineers to map the exact composition and structure of tooth enamel at the atomic scale.

Using a relatively new microscopy technique called atom probe tomography, their work produced the first-ever three-dimensional maps showing the positions of atoms critical in the decay process.

The new knowledge on atom composition at the nanolevel has the potential to aid oral health hygiene and caries prevention, and has been published today in the journal Science Advances.

Professor Julie Cairney, Material and Structures Engineer in the Faculty of Engineering and Information Technologies, said:

"The dental professionals have known that certain trace ions are important in the tough structure of tooth enamel but until now it had been impossible to map the ions in detail.

"The structure of human tooth enamel is extremely intricate and while we have known that magnesium, carbonate and fluoride ions influence enamel properties scientists have never been able to capture its structure at a high enough resolution or definition."

"What we have found are the magnesium-rich regions between the hydroxyapatite nanorods that make up the enamel.

"This means we have the first direct evidence of the existence of a proposed amorphous magnesium-rich calcium phosphate phase that plays an essential role in governing the behaviour of teeth. "

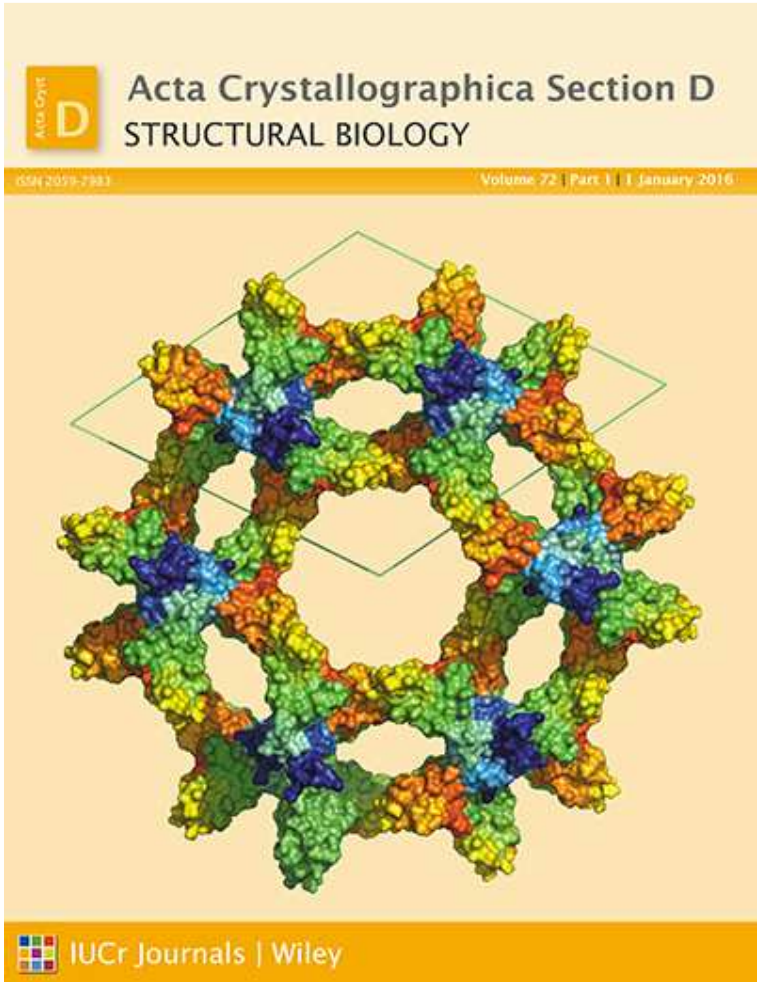
Co-lead researcher on the study, Dr Alexandre La Fontaine from the University's Australian Centre for Microscopy and Microanalysis, said:

We were also able to see nanoscale 'clumps' of organic material, which indicates that proteins and peptides are heterogeneously distributed within the enamel rather than present along all the nanorod interfaces, which was what was previously suggested.

The mapping has the potential for new treatments designed around protecting against the dissolution of this specific amorphous phase.

The new understanding of how enamel forms will also help in tooth remineralisation research." [11]

Digital enhancement of cryoEM photographs of protein Nanocrystals



The procedure described by van Genderen et al. [(2016). Acta Cryst. D71, 34-39] paves the way towards full three-dimensional structure determination at high resolution for protein crystals. The authors report on how lattice information can be enhanced by means of a wave finder in combination with Wiener-type maximum-likelihood filtering. The lattice filter is a very powerful tool for selecting and analysing extremely low contrast cryo-images of three dimensional protein/peptide nanocrystals. It confirms that the three-dimensional crystals are made up from multiple domains that are slightly differently oriented. Indeed, the algorithm can comfortably deal with multiple crystals with very different orientations, unit cells and/or space groups.

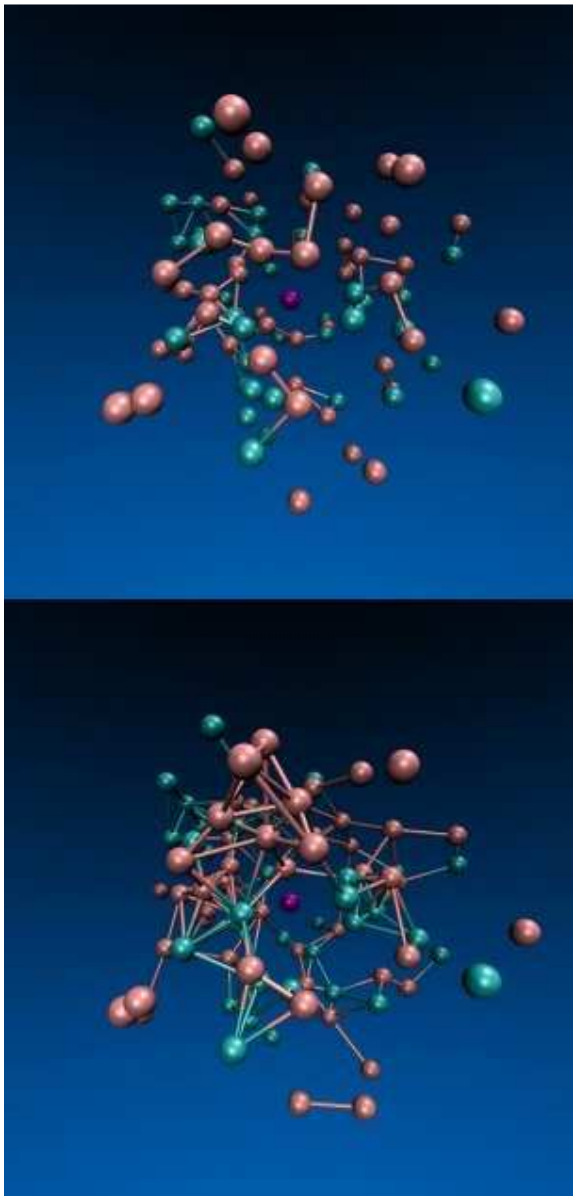
The authors of the paper propose the new lattice filter as a powerful tool for processing very noisy images with crystal factors (and thus the phase information) hidden within them. The filter is able to discriminate between noise images and the very noisy images with very low contrast which contain crystal-like structures. The lattice filter retains the shape of the spots in Fourier space and also retains any phase gradients within the Bragg spots (which determine the domain structure within the crystal). Thus, it retains all of the significant information from the Bragg spots. This will open the way to combining the phases acquired from stationary, two-dimensional images with intensities of rotation diffraction data taken from the same type of crystals. In this way, the authors expect to be able to phase the diffraction information of protein and peptide crystals. [10]

This Physicist Has a Groundbreaking Idea about Why Life Exists

"You start with a random clump of atoms, and if you shine light on it for long enough, it should not be so surprising that you get a plant," England said.

England's theory is meant to underlie, rather than replace, Darwin's theory of evolution by natural selection, which provides a powerful description of life at the level of genes and populations. "I am certainly not saying that Darwinian ideas are wrong," he explained. "On the contrary, I am just saying that from the perspective of the physics, you might call Darwinian evolution a special case of a more general phenomenon."

At the heart of England's idea is the second law of thermodynamics, also known as the law of increasing entropy or the "arrow of time." Hot things cool down, gas diffuses through air, eggs scramble but never spontaneously unscramble; in short, energy tends to disperse or spread out as time progresses. Entropy is a measure of this tendency, quantifying how dispersed the energy is among the particles in a system, and how diffuse those particles are throughout space. It increases as a simple matter of probability: There are more ways for energy to be spread out than for it to be concentrated.



A computer simulation by Jeremy England and colleagues shows a system of particles confined inside a viscous fluid in which the turquoise particles are driven by an oscillating force. Over time (from top to bottom), the force triggers the formation of more bonds among the particles.

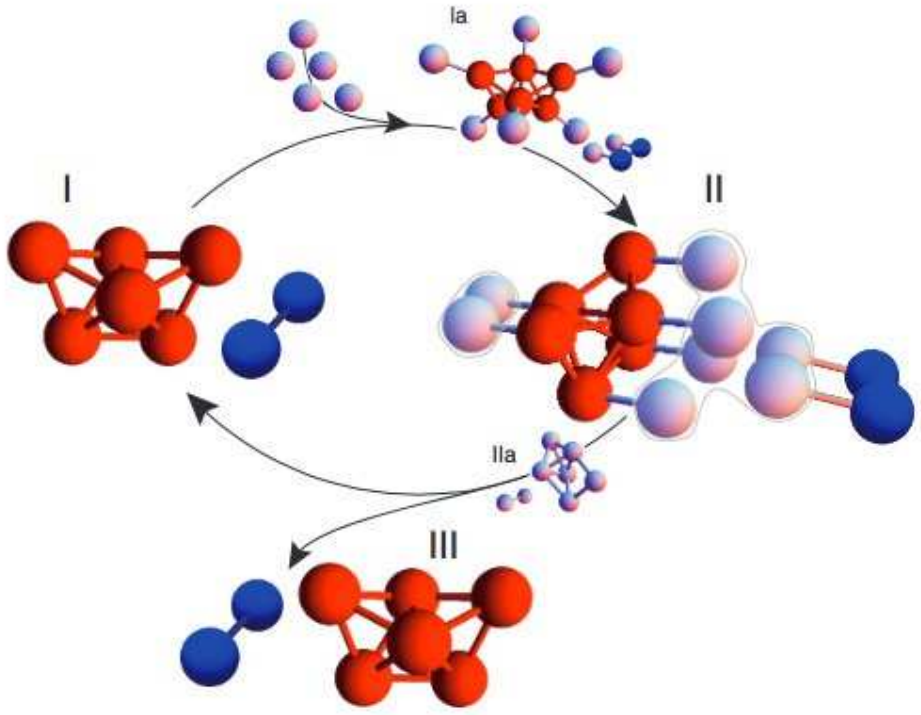
Thus, as particles in a system move around and interact, they will, through sheer chance, tend to adopt configurations in which the energy is spread out. Eventually, the system arrives at a state of maximum entropy called “thermodynamic equilibrium,” in which energy is uniformly distributed. A cup of coffee and the room it sits in become the same temperature, for example.

Although entropy must increase over time in an isolated or “closed” system, an “open” system can keep its entropy low — that is, divide energy unevenly among its atoms — by greatly increasing the entropy of its surroundings. In his influential 1944 monograph “What Is Life?” the eminent quantum physicist Erwin Schrödinger argued that this is what living things must do. A plant, for example, absorbs extremely energetic sunlight, uses it to build sugars, and ejects infrared light, a much less

concentrated form of energy. The overall entropy of the universe increases during photosynthesis as the sunlight dissipates, even as the plant prevents itself from decaying by maintaining an orderly internal structure.

Self-replication (or reproduction, in biological terms), the process that drives the evolution of life on Earth, is one such mechanism by which a system might dissipate an increasing amount of energy over time.

As England put it, “A great way of dissipating more is to make more copies of yourself.”



Self-Replicating Sphere Clusters: According to new research at Harvard, coating the surfaces of microspheres can cause them to spontaneously assemble into a chosen structure, such as a polytetrahedron (red), which then triggers nearby spheres into forming an identical structure.

Scientists have already observed self-replication in nonliving systems. According to new research led by Philip Marcus of the University of California, Berkeley, and reported in Physical Review Letters in August, vortices in turbulent fluids spontaneously replicate themselves by drawing energy from shear in the surrounding fluid. And in a paper in Proceedings of the National Academy of Sciences, Michael Brenner, a professor of applied mathematics and physics at Harvard, and his collaborators present theoretical models and simulations of microstructures that self-replicate. These clusters of specially coated microspheres dissipate energy by roping nearby spheres into forming identical clusters. “This connects very much to what Jeremy is saying,” Brenner said. [8]

Photoactive Prebiotic Systems

We propose that life first emerged in the form of such minimal photoactive prebiotic kernel systems and later in the process of evolution these photoactive prebiotic kernel systems would have produced fatty acids and covered themselves with fatty acid envelopes to become the minimal cells of the Fatty Acid World. Specifically, we model self-assembling of photoactive prebiotic systems with observed quantum entanglement phenomena. We address the idea that quantum entanglement was important in the first stages of origins of life and evolution of the biospheres because simultaneously excite two prebiotic kernels in the system by appearance of two additional quantum entangled excited states, leading to faster growth and self-replication of minimal living cells.
The quantum mechanically modeled possibility of synthesizing artificial self-reproducing quantum entangled prebiotic kernel systems and minimal cells also impacts the possibility of the most probable path of emergence of photocells on the Earth or elsewhere. We also examine the quantum entangled logic gates discovered in the modeled systems composed of two prebiotic kernels. Such logic gates may have application in the destruction of cancer cells or becoming building blocks of new forms of artificial cells including magnetically active ones.

Significance Statement

Our investigated self-assembly of molecules towards supramolecular bioorganic and minimal cellular systems depends on the quantum mechanics laws which induce hydrogen and Van der Waals bindings (Tamulis A, Grigalavicius, M, Orig Life Evol Biosph 41:51-71, 2011).

In the work presented here, quantum entanglement takes the form of a quantum superposition of the active components in synthesized self-assembling and self-replicating living systems. When a quantum calculation of an entangled system is made that causes one photoactive biomolecule of such a pair to take on a definite value (e.g., electron density transfer or electron spin density transfer), the other member of this entangled pair will be found to have taken the appropriately correlated value (e.g., electron density transfer or electron spin density transfer). In our simulations, the separation distance of supramolecular bio systems changes took place during geometry optimization procedures, which mimic real-world intermolecular interaction processes.

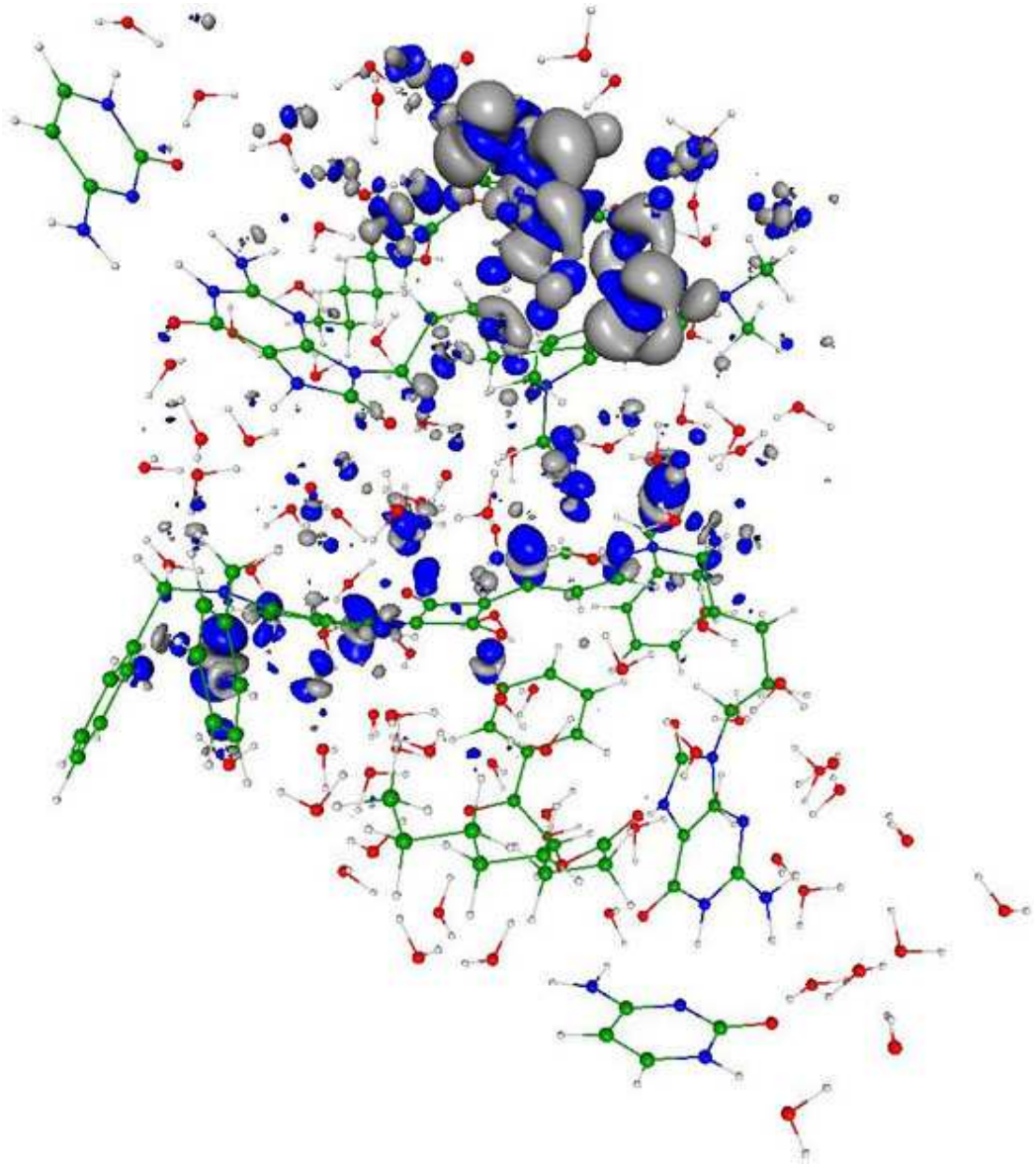
Our discovered phenomenon of the quantum entanglement in the prebiotic systems enhance the photosynthesis in the proposed systems because simultaneously excite two prebiotic kernels in the system by appearance of two additional quantum entangled excited states (Tamulis A, Grigalavicius M, Baltrusaitis J, Orig Life Evol Biosph 43:49-66, 2013; Tamulis A, Grigalavicius M, Krisciukaitis S (2014) , J Comput Theor Nanos, 11, 1597-1608, 2014; Tamulis A, Grigalavicius M, 8:117-140, 2014.). We can propose that quantum entanglement enhanced the emergence of photosynthetic prebiotic kernels and accelerated the evolution of photosynthetic life because of additional absorbed light energy, leading to faster growth and self-replication of minimal living cells.

We can state that: Livings are self-assembled and self-replicating wet and warm stochastically moving supramolecular systems where quantum entanglement can be continuously generated and destroyed by non-equilibrium effects in an environment where no static entanglement exists; quantum entanglement involve the biomolecule inside one living or between other neighboring livings.

This warm quantum coherence is basic for the explanation of DNA stability and for the understanding of brain magnetic orientation during migration in more than 50 species of birds, fishes and insects. Exists experimental evidence for quantum-coherent is used for more efficient light-harvesting in plant photosynthesis. Quantum entanglement exists in supramolecules determining the sense of smell and in the brain neurons microtubules due to quantum vibrations.

In the work presented here, we started to design and quantum mechanical investigations of the molecular logical devices which are useful for construction of nano medicine biorobots against the molecular diseases such a cancer tumors, and against the new kinds of synthesized microorganisms and nano guns.

Figure legend



You can see in the enclosed figure the quantum entanglement phenomenon in the closely self-assembled two synthesized protocell system due to the photo excited electron charge transfer from one protocell to another that leads to closer self-assembly and exchange of energy and information.

Visualization of the electron charge tunneling associated with the 6th (467.3 nm) excited state. The transition is mainly from squarine molecule of the first protocell situated in the bottom of this bi cellular system to precursor of fatty acid (pFA) molecule of the second subsystem (in the top) and little from the 1,4-bis(N,N-dimethylamino)naphthalene molecule (in the top-right) to the same pFA molecule of the second subsystem (in the top). The electron cloud hole is indicated by the dark blue color while the transferred electron cloud location is designated by the gray color.

As a result, these nonlinear quantum interactions compressed the overall molecular system resulting in a smaller gap between the HOMO and LUMO electron energy levels which allows enhanced tunneling of photo excited electrons from the sensitizer squarine and (1,4-bis(N,N-dimethylamino)naphthalene) to the pFA molecule resulting in its cleavage. The new fatty acid joins the existing minimal cell thus increasing it in size. After reaching some critical size, the minimal cell should divide (i.e. self-replicate) into two separate smaller minimal cells. [7]

Quantum Biology

Researchers have long suspected that something unusual is afoot in photosynthesis. Particles of light called photons, streaming down from the Sun; arrive randomly at the chlorophyll molecules and other light-absorbing 'antenna' pigments that cluster inside the cells of every leaf, and within every photosynthetic bacterium. But once the photons' energy is deposited, it doesn't stay random. Somehow, it gets channeled into a steady flow towards the cell's photosynthetic reaction centre, which can then use it at maximum efficiency to convert carbon dioxide into sugars. Quantum coherence in photosynthesis seems to be beneficial to the organisms using it. But did their ability to exploit quantum effects evolve through natural selection? Or is quantum coherence just an accidental side effect of the way certain molecules are structured? [6]

Quantum Consciousness

Extensive scientific investigation has found that a form of quantum coherence operates within living biological systems through what is known as biological excitations and biophoton emission. What this means is that metabolic energy is stored as a form of electromechanical and electromagnetic excitations. These coherent excitations are considered responsible for generating and maintaining long-range order via the transformation of energy and very weak electromagnetic signals. After nearly twenty years of experimental research, Fritz-Albert Popp put forward the hypothesis that biophotons are emitted from a coherent electrodynamics field within the living system.

What this means is that each living cell is giving off, or resonating, a biophoton field of coherent energy. If each cell is emitting this field, then the whole living system is, in effect, a resonating field-a ubiquitous nonlocal field. And since biophotons are the entities through which the living system communicates, there is near-instantaneous intercommunication throughout. And this, claims Popp, is the basis for coherent biological organization -- referred to as quantum coherence. This discovery

led Popp to state that the capacity for evolution rests not on aggressive struggle and rivalry but on the capacity for communication and cooperation. In this sense the built-in capacity for species evolution is not based on the individual but rather living systems that are interlinked within a coherent whole: Living systems are thus neither the subjects alone, nor objects isolated, but both subjects and objects in a mutually communicating universe of meaning. . . . Just as the cells in an organism take on different tasks for the whole, different populations enfold information not only for themselves, but for all other organisms, expanding the consciousness of the whole, while at the same time becoming more and more aware of this collective consciousness.

Biophysicist Mae-Wan Ho describes how the living organism, including the human body, is coordinated throughout and is "coherent beyond our wildest dreams." It appears that every part of our body is "in communication with every other part through a dynamic, tunable, responsive, liquid crystalline medium that pervades the whole body, from organs and tissues to the interior of every cell."

What this tells us is that the medium of our bodies is a form of liquid crystal, an ideal transmitter of communication, resonance, and coherence. These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [5]

Information – Entropy Theory of Physics

Viewing the confined gas where the statistical entropy not needs the information addition is not the only physical system. There are for example quantum mechanical systems where the information is a very important qualification. The perturbation theory needs higher order calculations in QED or QCD giving more information on the system as in the chess games happens, where the entropy is not enough to describe the state of the matter. The variation calculation of chess is the same as the perturbation calculation of physics to gain information, where the numbers of particles are small for statistical entropy to describe the system. The role of the Feynman graphs are the same as the chess variations of a given position that is the depth of the variations tree, the Information is the same as the order of the Feynman graphs giving the Information of the micro system. [9]

Information – Entropy Theory of Life

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that

is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction. The living biological systems have also entropy lowering and information growing direction by building more complicated or entangled molecules, governed by the quantum mechanics and the general weak interaction. On the other hand there is the arrow of time; the entropy growing is lowering the information by dissipating these entangled or otherwise connected biomolecules, aging the living systems.

Creating quantum technology

Another area of potential application is in quantum computing. The long-standing goal of the physicists and engineers working in this area is to manipulate data encoded in quantum bits (qubits) of information, such as the spin-up and spin-down states of an electron or of an atomic nucleus. Qubits can exist in both states at once, thus permitting the simultaneous exploration of all possible answers to the computation that they encode. In principle, this would give quantum computers the power to find the best solution far more quickly than today's computers can — but only if the qubits can maintain their coherence, without the noise of the surrounding environment, such as the jostling of neighboring atoms, destroying the synchrony of the waves. [6]

Quantum Entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by

linearly increasing the way they take every next time period because this accelerated motion. The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly: $ds/dt = at$ (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate).

Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would

reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the

proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.
The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.
We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change. There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

Fermions and Bosons

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

Van Der Waals force

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will

have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

Electromagnetic inertia and mass

Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

The frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv/c^2$ that is the m depends only on the v frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [2]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive

charges they need 2 photons to mediate this attractive force, one per charges. The Bing Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate Mp=1840 Me. In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the T_{max} change and the diffraction patterns change. [2]

Higgs mechanism and Quantum Gravity

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

Conclusions

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
Prentiss, who runs an experimental biophysics lab at Harvard, says England's theory could be tested by comparing cells with different mutations and looking for a correlation between the amount of energy the cells dissipate and their replication rates. [8]
Exists experimental evidence for quantum-coherent is used for more efficient light-harvesting in plant photosynthesis. Quantum entanglement exists in supramolecules determining the sense of smell and in the brain neurons microtubules due to quantum vibrations.
In the work presented here, we started to design and quantum mechanical investigations of the molecular logical devices which are useful for construction of nano medicine biorobots against the molecular diseases such a cancer tumors, and against the new kinds of synthesized microorganisms and nano guns. [7]
One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .
The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]
The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing.
The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]
These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [5]
Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions also.

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