

Are Carbonate Solutions Alive?

Bicarbonate aqueous systems, the necessary constituents of all biological liquids, exhibit a sustained non-equilibrium state and sensitivity to cosmic events.

by V.L. Voeikov, Do Minh Ha, N.D. Vilenskaya, S.I. Malishenko, and E.V. Bouravleva



Ian Britton

Solutions of bicarbonates, such as ordinary baking soda, show life-like properties.

The authors are from the Lomonosov Moscow State University, Faculty of Biology, in Moscow and can be reached via e mail at v109028v1@yandex.ru .

A version of this article appeared in the Italian publication La Medicina Biologica, Oct.-Dec. 2010, pp. 45-53. Additional figures have been supplied by V.L. Voeikov.

Carbonates (bicarbonate, carbonic acid, and CO_2) are the necessary constituents of cell cytoplasm and of all biological liquids. The bicarbonate content is strictly maintained in the organism. Its deficiency results in impaired cell and tissue respiration, followed by the development of a variety of pathological states. Both normal and healing drinking waters are usually bicarbonate solutions, and supplementation with bicarbonate is a universal healing method in complementary medicine. However, the true mechanism of action of carbonates is still a matter of debate.

We discovered that the addition of iron oxide Fe(II) salts to bicarbonate solutions induces a wave of photon emission. The intensity of the wave is boosted in the pres-

ence of luminol, the probe for the reactive oxygen species (ROS), indicating that spontaneous chain reactions with the participation of reactive oxygen species take place continuously in aqueous bicarbonate solutions. The addition of hydrogen peroxide (H_2O_2) in sub-millimolar (mM) concentrations to 1-5 mM bicarbonate solutions initiates a process accompanied by spontaneous low-level photon emission, which is amplified with luminol.

Hermetically sealed test-tubes containing activated bicarbonate solutions continue to emit photons for many months when kept in complete darkness. Drastic changes in photon emission from both plain and activated bicarbonate solutions were observed during and after solar and lunar

eclipses, indicating a very high sensitivity of these highly non-equilibrium, and yet stable, systems to extremely low-intensity natural factors.

Such properties of bicarbonate aqueous systems imply that they have a complex dynamic structure, that they acquire a continuous supply of energy from the environment, and that they may be sensitive to extremely low-intensity resonant factors. The behavior of these systems agrees with the theory of coherent domains developed by G. Preparata and E. Del Giudice.

The mechanism to explain the long-lasting effects of solar and lunar eclipses on photon emission from aqueous systems can be considered only hypothetically at this point. Both events represent special cases of gravitational influence upon the Earth. It is clear that the direct effect of variations in the gravitational attraction upon water samples is practically negligible. However, the total effect on such a massive body as the Earth may result in changes in the parameters of manifold physical fields associated with it, which, in turn, may trigger changes in the behavior of non-equilibrium aqueous systems. It should be noted that cosmic events may influence the behavior of practically all non-equilibrium aqueous systems on the Earth, including water in living organisms, and may produce long-lasting effects in them.

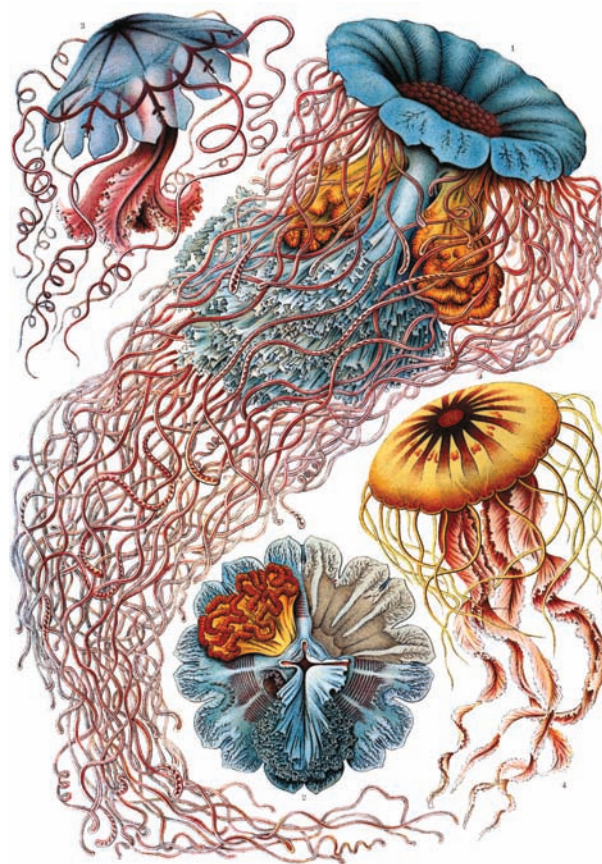
Introduction

According to Ervin Bauer's major principle of theoretical biology, the Principle of Stable Non-equilibrium:

Living systems are unique in that they are never at equilibrium. They perform work against equilibrium, ceaselessly, and in a manner demanded by the physical and chemical laws appropriate to the actual external conditions.¹

In other words, in order to maintain the stability of its non-equilibrium state, a living system transforms *all* of its free energy into work aimed at sustaining or changing its parameters in response to changing conditions. The non-equilibrium state of matter, in the sense of Bauer's principle, is an excited state, in which the structure of matter and its properties differ significantly from those characteristic of the equilibrium (ground) state of the same matter. Stable non-equilibrium is displayed at all levels of organization of a living system, including the molecular one.

Water is, by far, the dominant molecular constituent of all living systems. On a molar basis, water constitutes more than 99 percent of the molecules of any living cell and of the extracellular matrix. Biological molecules can exert their functions only in aqueous milieu; no biological processes can occur in a system whose water content is below a certain threshold.^{2,3} Thus, water should participate directly both in keeping living matter



Drawings by Ernst Haeckel of four medusa-like organisms, Discomedusae, a subclass of jelly fish. There may be as many as 2,000 molecules of water for every molecule of "living" carbon in organisms like these.

in the excited state, and in the performance of its work against equilibrium.

Living systems belong to the class of *confined open systems* (the term coined by Prof. E. Tiezzi⁴). The term *open* means that they are able to exchange energy and matter with their environment, and to receive information about changes in their environment and react to this information by adaptation of their internal processes. Basically, all vital processes may be seen as processes of energy gain and transformation: The conversion of different forms of potential energy into free energy and of the latter into the work against equilibrium which is "demanded by the physical and chemical laws appropriate to the actual external conditions."

The term *confined* means that a system has boundaries and is segregated from its environment. Vital processes take place in the confined space of living systems. The internal space of living systems represents a gel-like aqueous phase⁵ (more precisely multiple aqueous phases) formed by the indissoluble union of organic molecules and the water in which they are imbedded.

1. E.S. Bauer, 1935. *Theoretical Biology*. (Moscow-Leningrad: VIEM Publishing House). (see also V.L. Voeikov, E. Del Giudice, 2009. "Water Respiration—The Basis of the Living State," *WATER; A Multidisciplinary Research Journal*, Vol. 1, No. 1 (July), pp. 52-75.)

2. J.S. Clegg, A.C. Zettlemoyer, H.H. Hsing, 1978. "On the residual water content of dried but viable cells." *Experientia*, Vol. 34, No. 6, p. 734.

3. N. Marchettini, E. Del Giudice, V. Voeikov, E. Tiezzi, 2010. "Water: A medium where dissipative structures are produced by a coherent dynamics" *J. Theoret. Biology*, doi:10.1016/j.jtbi.2010.05.02

4. E. Tiezzi, G. Cecconi, N. Marchettini, 2010. "Confined ontic open systems." *Int. J. of Design and Nature and Ecodynamics*, Vol. 5, No. 1, pp. 3-9.

5. G.H. Pollack, 2001. *Cells, Gels and the Engines of Life: A New Unifying Approach to Cell Function*. (Seattle: Ebner and Sons).

The major organic molecules responsible for structuring the internal space of living systems are the acidic polysaccharides and collagen-like proteins. In some cases (for example, in medusa-like animals, such as jellyfish) these substances may bind up to 2,000 parts of water per 1 part of organic carbon,⁶ and this “living water” exhibits the same vitality as in any other organism. Thus, living systems may be provisionally defined as *organic (carbonaceous) aqueous systems* in a persistent state of energy transformation.

Although we encounter an enormous diversity of living systems expressing an overwhelming complexity of dynamic structure and vital activities, the fundamental principles of their structure and mechanisms of activity should be common to all. We believe that these principles can be traced to confined aqueous systems containing carbonaceous compounds, in the simplest case, inorganic carbonates. Here we present evidence that aqueous bicarbonate solutions represent stable non-equilibrium systems. Further, one of the intrinsic properties of living systems is their ability to react to extremely low-intensity external factors—“informational stimuli.” Indeed, we have observed changes in the “behavior” of non-equilibrium bicarbonate solutions in response to cosmic events, in particular to lunar and solar eclipses.

The Non-equilibrium State of Water

Any “real” water sample is never a homogenous collection of water molecules interacting exclusively with each other. Rather

6. M.R. Reeve, M.A. Syms, P. and Kremer, 1989. “Growth dynamics of a ctenophore (Mnemiopsis) in relation to variable food supply, I. Carbon biomass, feeding, egg production, growth and assimilation efficiency,” *J. Plankton Res.*, Vol. 11, p. 535-552.



St. David Spring, near Moscow, which is enriched with bicarbonates of magnesium and calcium.

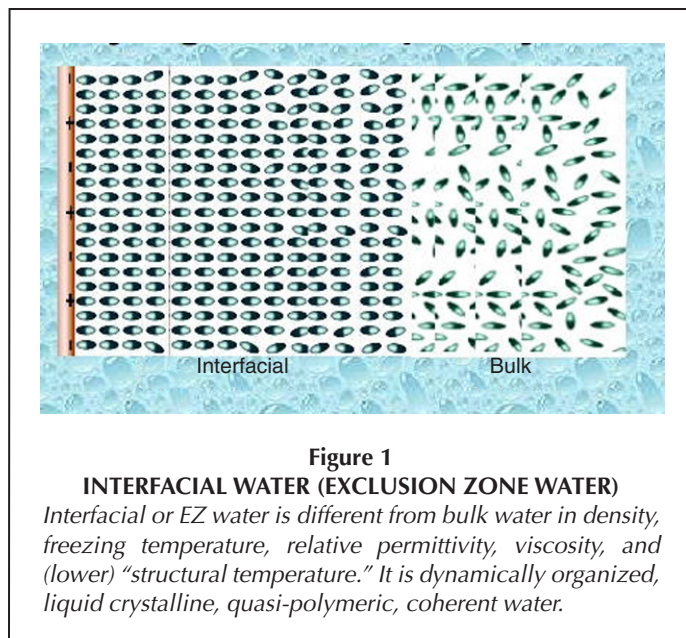


Figure 1
INTERFACIAL WATER (EXCLUSION ZONE WATER)
Interfacial or EZ water is different from bulk water in density, freezing temperature, relative permittivity, viscosity, and (lower) “structural temperature.” It is dynamically organized, liquid crystalline, quasi-polymeric, coherent water.

it represents an *aqueous system* that is intrinsically heterogeneous for at least two reasons.

The first reason is that liquid water always resides in a vessel. Some water is adjacent to the boundaries of the vessel, and to the water-air (gas) interface; other water molecules are located at a certain distance from the boundaries. Recently, G.H. Pollack and his group have demonstrated convincingly that water near the boundaries forms a peculiar phase with many properties different from that of the “bulk” water at a distance from

these surfaces.⁷ Depending upon the properties of the wetted surface, the thickness of this phase may reach hundreds of microns.

The second reason is that even ultra-pure water always contains impurities. These may include the gases dissolved in it, ionic and molecular species, and the products of water dissociation (H_3O^+ and OH^-). During a long history of water research, it has been shown that even the tiniest impurities can significantly change the colligative properties of water. Recently, direct visualization has demonstrated the presence of stable-water-clusters of tens of nanometers to micron size in very dilute sodium chloride solution.⁸

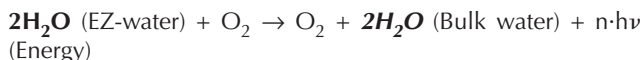
The common feature of the interfacial aqueous phase (named “Exclusion Zone” water, or EZ-water, by Pollack), and the stable water clusters visualized by Lo et al., is that both possess negative electrical potential, reaching fractions of volts, in respect to “bulk” water. (See Figure 1.) That means that any

7. J.M. Zheng, W.C. Chin, E. Khijniak, E. Khijniak, Jr., and G.H. Pollack, 2006. “Surfaces and interfacial water: Evidence that hydrophilic surfaces have long-range impact,” *Adv. Colloid Interface Sci.*, Vol. 23, pp. 19-27.

8. S.Y. Lo, X. Geng, and D. Gann, 2009. “Evidence for the existence of stable-water-clusters at room temperature and normal pressure,” *Physics Letters A*. Vol. 373, pp. 3872-3876.

“real” water is a non-equilibrium system in which high electrical and other gradients always exist between different aqueous phases. It is important to stress here that such properties of aqueous systems have been predicted by G. Preparata and E. Del Giudice, in their Quantum Electrodynamics coherence theory of the condensed state of matter.⁹ If the conditions for the flow of electrons from negatively charged water to electron acceptors are present, potential energy may be released as free energy, and work may be performed both within the system and in its surrounding environment.

A natural electron acceptor whose reduction gives the highest yield of free energy is oxygen. It is always present in water, even if in minute quantities, because under relatively mild conditions water can split and produce oxygen.¹⁰ Many “impurities,” such as nano- and micro-bubbles, nanoparticles, and ions facilitate this process. Thus, EZ-water in contact with bulk water containing dissolved oxygen represents a donor-acceptor pair, and, under appropriate conditions, the complete oxygen-reduction reaction may proceed within it:



Although the molecular species on the left and right sides of this equation are the same (water and oxygen), a high-grade, highly condensed energy of electron excitation (a total of up to 8 eV per O_2 molecule) may be donated by this reaction. Water

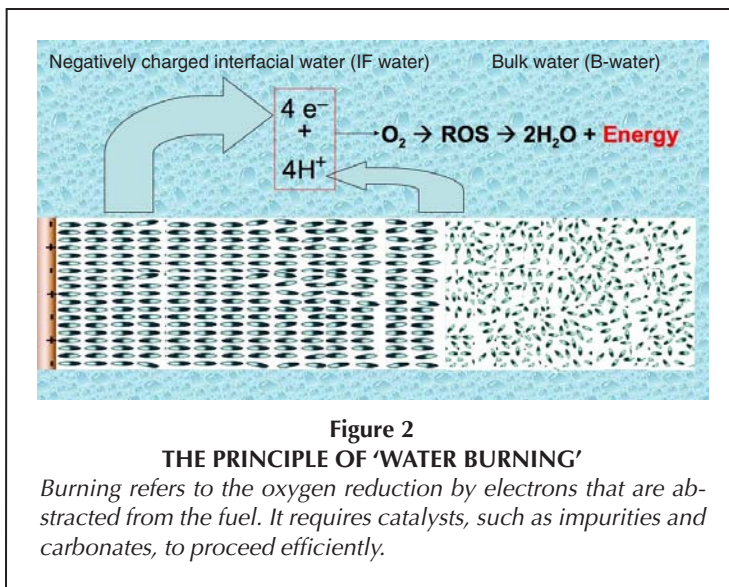


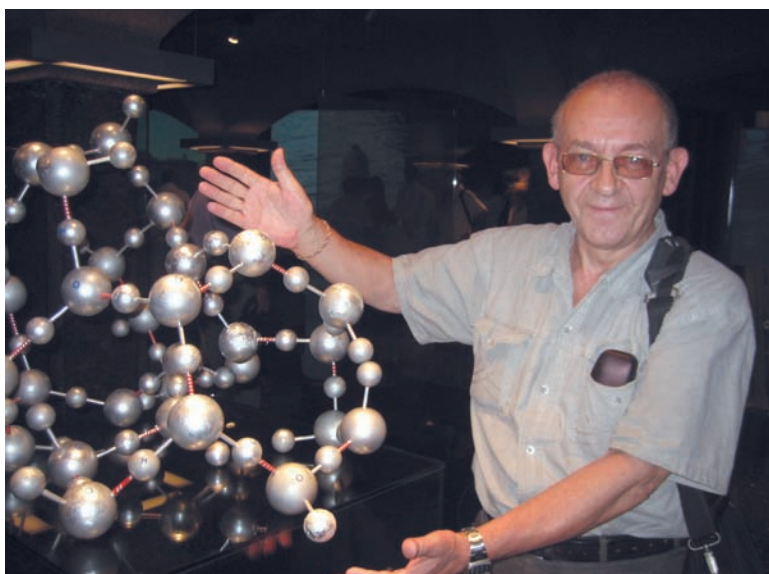
Figure 2
THE PRINCIPLE OF ‘WATER BURNING’
Burning refers to the oxygen reduction by electrons that are abstracted from the fuel. It requires catalysts, such as impurities and carbonates, to proceed efficiently.

on the left side of the equation (in bold) belongs to a stable non-equilibrium (excited) structure, that is, EZ-water. Water on the right side of the equation is ground-state (bulk) water. It is the “structural energy” of EZ-water that is released when water molecules belonging to this stable, non-equilibrium structure revert to ground-state water molecules.

The process of EZ-water “burning” (meaning oxygen reduction by electrons extracted from the “fuel”) outlined in the equation in Figure 2 shows some ideal situation that probably cannot be realized in “pure” water. Certain catalysts are needed for the process of water “burning” to proceed efficiently. The most common “impurities” that may serve as catalysts for the processes related to water splitting and burning are the members of the carbonate family:

9. R. Arani, I. Bono, E. Del Giudice, G. Preparata, 1995. “QED Coherence and the Thermodynamics of Water,” *Int. J. Modern Phys.* Vol. B9, pp. 1813-1841.

10. V.L. Voeikov, 2006. “Biological significance of active oxygen-dependent processes in aqueous systems.” *In Water and the Cell*, eds. G. Pollack, I. Cameron, and D. Wheatley (The Netherlands, Springer Press, pp. 285-298).



Author Voeikov (left) and his collaborator Do Minh Ha at the Lomonosov Moscow State University. Voeikov is pictured with a molecular model of “structured hexagonal water” (ice). The large balls are oxygen, the small ones are hydrogen. The red sticks depict hydrogen bonds.



Luminol ($C_8H_7N_3O_2$) exhibits chemiluminescence, giving off a blue glow when it is mixed with an oxidizing agent. Presence of Luminol boosted the intensity of the photon emission-wave in the bicarbonate solutions.



Carbonates are present in practically all aqueous systems, because of the very high solubility of CO_2 in water and the wide distribution of carbonates in nature. More and more experimental data are demonstrating a very important functional role for carbonates, particularly bicarbonates, in a variety of biochemical reactions, including the fundamental processes of photosynthesis¹¹ and respiration.

Carbonates Promote Respiration

According to textbook knowledge, cellular respiration is the process of energy gain caused by the oxidation (burning) of sugars and fats by oxygen. In this process, organic molecules serve as donors of “hot” electrons; oxygen accepts them, turning into water; and the energy released is used to propel vital functions. However, even when fuel and oxygen are not limited, respiration may be halted if the living system is severely deficient of carbonates. Thus, carbonates present in water may participate in (bio)energetic processes based on respiration on a very fundamental level.

At the end of the 19th Century, the Swiss biologist Friedrich Miescher discovered that the intensity of physiological respiration (breathing) depended much more strongly on small changes in the CO_2 content in alveolar air, than on the oxygen content in the inhaled air. He described this in a poetic phrase: “Carbon dioxide spreads its protective wings over the body’s oxygen supply—especially as it cares for the brain. . . .”¹²

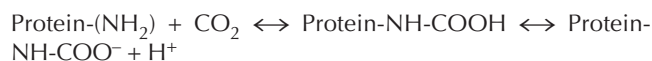
11. P.A. Castelfranco, Y.-K. Lu, A.J. Stemler, 2007. “Hypothesis: the peroxycarbonic acid cycle in photosynthetic oxygen evolution,” *Photosynth. Res.*, Vol. 94, pp. 235-246.

12. F. Miescher, 1885. “Bemerkungen zur Lehre von den Athembewegungen,” *Arch. Anat. Physiol. Physiol. Abth.* 3555. 1885.

Later, prominent physiologists Christian Bohr, John Haldane, and Yandell Henderson confirmed that carbonates are no less vital to life than oxygen. Bohr and Haldane discovered that carbon dioxide regulates oxygen binding to hemoglobin, and *vice versa*. Henderson claimed that CO_2 (and carbonates in general) is the major hormone of the body; that it is produced in every tissue and exerts its effects on all the tissues; and that a decrease of carbonates below some critical level, especially in the brain, may result in fatigue and death due to cessation of respiration.¹³

Henderson supposed that the effect of carbonates is mediated by their regulation of acid-base balance, but he also noted that carbonates may exert some more specific action upon molecular targets.

In fact, it was demonstrated that CO_2 and bicarbonates support respiration in isolated leucocytes,¹⁴ and are necessary for DNA replication and cell division in primary cultures of eukaryotic cells.^{15,16} There are multiple mechanisms for the action of carbonates on the cellular level. One of them may be related to the reaction of CO_2 with the amino groups in peptides and proteins, forming unstable carbamino adducts:



Generally, the activity and stability of modified proteins are increased.¹⁷

In light of what was said above about interfacial water, it is interesting to speculate that the net increase in the negative charge of carbamylated proteins may promote the building up of additional layers of EZ-water around them, resulting in the energizing of such an aqueous system.

Another important property of carbonates is less acknowledged. Carbonates modulate oxidation, peroxidation, and nitration both *in vivo*, and *in vitro*. The carbonates possess such a property because they react with the active oxygen species, and turn into relatively long-living and more selectively acting free radicals¹⁸ and peroxy-carbonates.¹⁹ In particular, they exert striking effects on the activity of the enzymes involved in the metabolism of the reactive oxygen species.

13. Y. Henderson, 1938. *Adventures in Respiration: Modes of Asphyxiation and Methods of Resuscitation* (Baltimore: Williams & Wilkins).

14. W. Bicz, 1960. The influence of carbon dioxide tension on the respiration of normal and leukemic human leukocytes. I. Influence on endogenous respiration,” *Cancer Res.*, Vol. 20, pp. 184-190.

15. T. Mitaka, G.L. Sattler, H.C. Pitot, 1991. “The bicarbonate ion is essential for efficient dna synthesis by primary cultured rat hepatocytes,” *In Vitro Cell. Dev. Biol.*, Vol. 27A, pp. 549-556. 0

16. R.S. Chang, H. Liepius, M. Margolish, 1961. “Carbon dioxide requirement and nucleic acid metabolism of HeLa and conjunctival cells,” *Proc. Soc. Exp. Biol. Med.*, Vol. 106, pp. 149-152.

17. J.S. Morrow, P. Keim, F.R. Gurd, 1974. CO_2 adducts of certain amino acids, peptides, and sperm whale myoglobin studied by carbon 13 and proton nuclear magnetic resonance,” *J. Biol. Chem.*, Vol. 249, pp. 7484-94.

18. D.B. Medinas, G. Cerchiaro, D.F. Trindade, O. Augusto, 2007. “The carbonate radical and related oxidants derived from bicarbonate buffer. Critical review,” *IUBMP Life*, Vol. 59, pp. 255-262.

19. M.G. Bonini, S.A. Gabel, K. Rangelova, K. Stadler, E. DeRose. “Direct magnetic resonance evidence for peroxy-monocarbonate involvement in the Cu, Zn superoxide dismutase peroxidase catalytic cycle.” <http://www.jbc.org/cgi/doi/10.1074/jbc.M804644200>

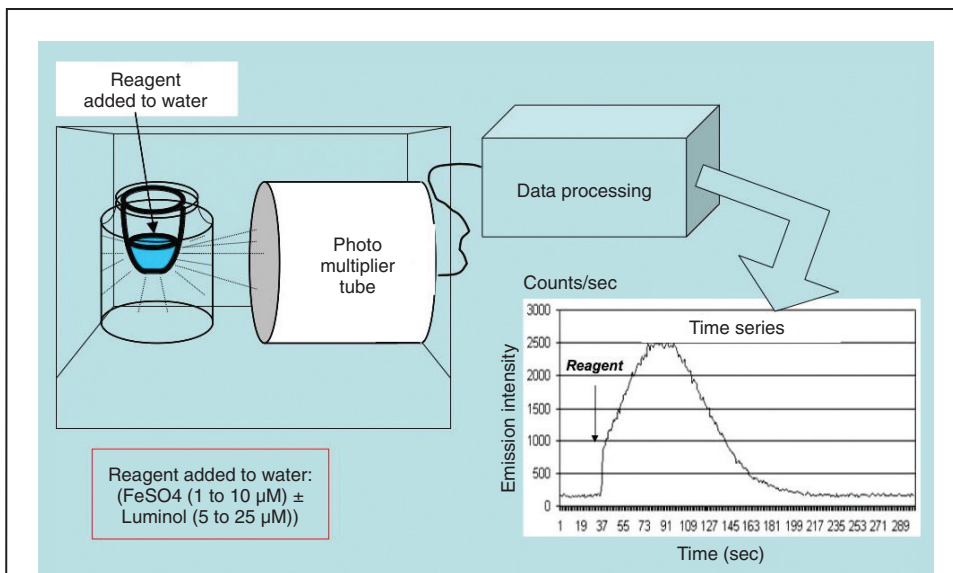


Figure 3
PHOTON EMISSION IN BICARBONATE WATERS

Shown here schematically is the addition of iron oxide, Fe II, salts in catalytic quantities to bicarbonate water, which results in the development of a wave of Luminol-amplified photo emission from the water. This indicates that processes in which reactive oxygen species participate go on continuously in bicarbonate waters.

The least, but probably not the last, is the ability of carbonates to participate directly in the synthetic reactions which give rise to the organic compounds, and in the processes in which (bio)polymers originate.²⁰

Thus, carbonates are needed for multiple vital processes, and especially for the most basic one—respiration, both on the organismal and cellular levels. Inasmuch as a significant part of consumed oxygen is reduced by one electron, and spent for combustion, and since water in principle may be used as a fuel, it can not be excluded that carbonate solutions may themselves “respire.”

Intrinsic Activity of Aqueous Bicarbonate Solutions

‘Plain’ Bicarbonate Solutions. Using sensitive single photon counters we found that a wave of photon emission in the visible range of the electromagnetic spectrum may be initiated in bicarbonate artesian waters and in aqueous bicarbonate solutions, following the addition of Fe(II) salts (FeSO_4 or FeCl_2) in concentrations as low as $5 \mu\text{M}$ (micromoles). The intensity of the photon emission-wave was increased in the presence of luminol, the probe for the reactive oxygen species (Figure 3). The development of a luminol-amplified photon emission-wave from bicarbonate solutions of Fe(II) salts, indicated that spontaneous chain reactions with the participation of reactive oxygen species continuously take place in aqueous bicarbonate solutions. The amplitude of the wave and its duration was dependent upon bicarbonate concentration. The addition of Fe(II) to a bicarbonate solution, after the decay of the first pho-

ton emission-wave, could induce the appearance of a new photon emission-wave, with the same or even higher intensity as the previous one; this effect could be reproduced many times.

Just after the bottle with bicarbonate artesian water was opened, the amplitude of photon emission-waves was low. But provided that the water was in contact with the surrounding air, the wave amplitude increased and reached a quasi-stationary level, displaying circadian variations (Figure 4). However, in the experiment illustrated in Figure 4, when the activity of the water was monitored several times a day for 11 days, a strong decline in the amplitude of the induced photon-emission-wave was observed after 6 days.

The minimal amplitude of the photon emission-wave coincided with the time of the New Moon (16:00-18:00 hours on Aug. 8, 2002), but two days later the amplitude returned to the same level as before.

Bicarbonate Solutions Activated with Hydrogen Peroxide. When hydrogen peroxide (H_2O_2) was added to 1-5 mM bicarbonate solutions in final concentrations as small as 0.001-

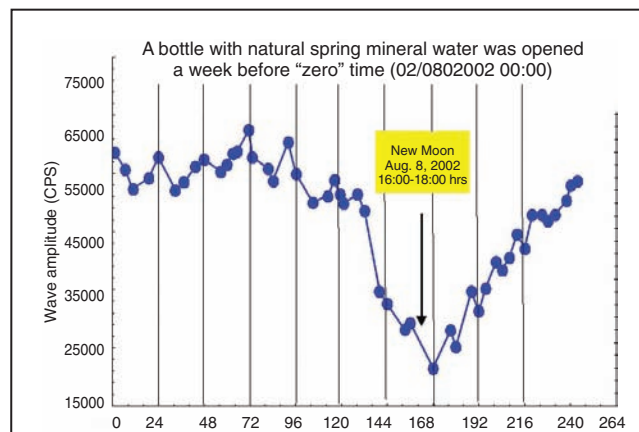
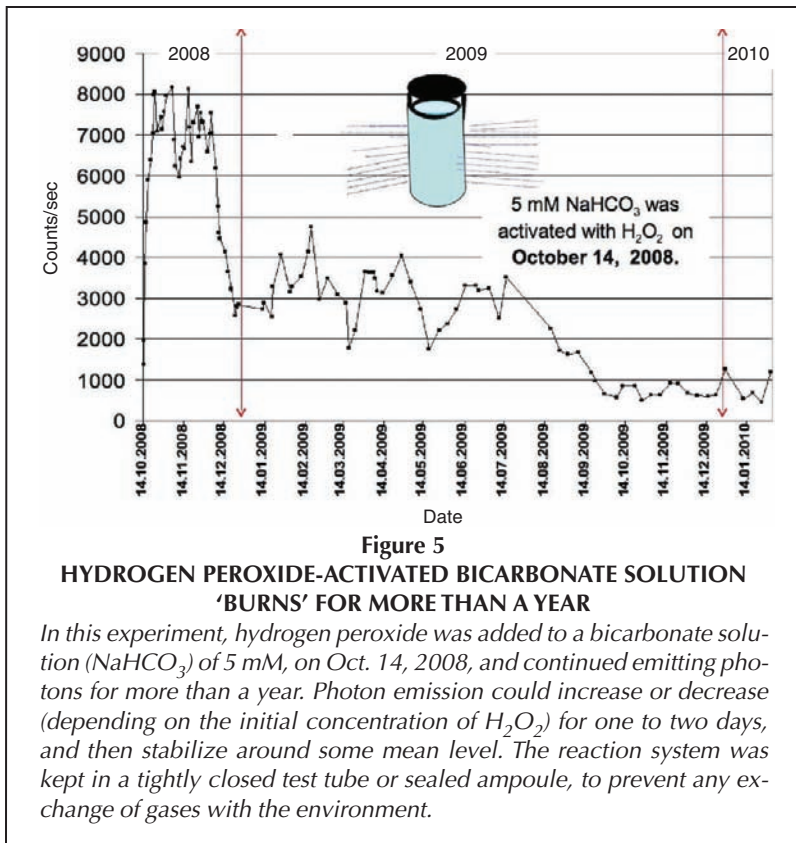


Figure 4
CHANGES OF SPRING WATER PROPERTIES
COINCIDE WITH NEW MOON

Long-term monitoring of spring water with the addition of Fe(II) and Luminol reveals circadian rhythms and strong changes of water properties coinciding with the New Moon. A bottle with natural spring mineral water was opened a week before “zero” time, Aug. 8, 2002 at 00.00.

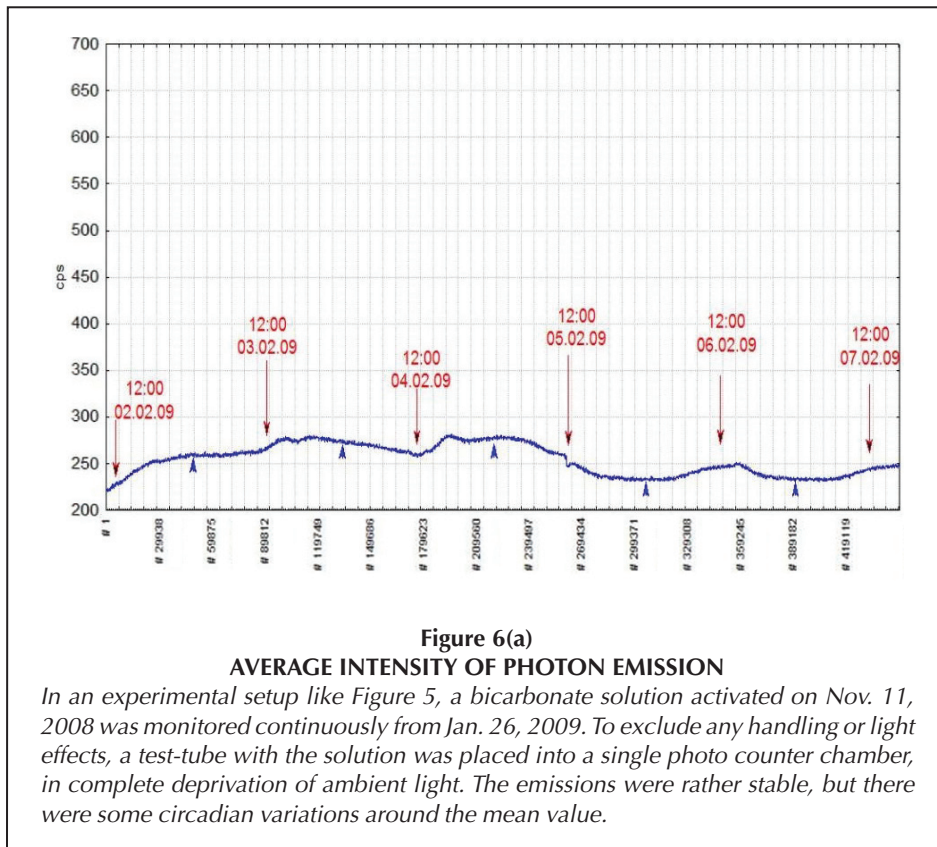
20. M.F. Guly, D.A. Melnichuk, 1978. “The role of carbon dioxide in the regulation of metabolism in heterotrophic organisms,” *Naukova Dumka*, Kiev.



0.0005 percent, stable luminol-amplified photon emission could be observed even in the absence of a metal. Depending on the initial concentration of the H_2O_2 , the photon emission could increase or decrease for 1-2 days, before stabilizing around some mean level. Figure 5 illustrates that a test-tube with 1 ml of 5-mM NaHCO_3 in distilled, deionized water can serve as a source of photon emission for more than one year.

It should be mentioned that the reaction systems were kept in tightly closed test tubes or sealed ampoules, to prevent any exchange of gases with the environment. Although photon emission intensity obviously declined after 15 months of observations, it was still 25- to 50-fold higher than the dark current of the photomultiplier.

In the experimental setup illustrated in Figure 5, occasional measurements of photon emission were performed during the period of observations. To exclude the effects of handling the samples and their exposure to ambient light between measurements, a test-tube containing the active solution was placed into a single photon counter chamber, and continuous measurement of the photon emission was performed for several weeks. Under conditions of complete deprivation of ambient light, the average intensity of photon emission from the active solution was rather stable, although some circadian variations around the mean value could be observed (Figure 6a).



However, during the next week, drastic changes in the photon emission patterns from the same sample were observed (Figure 6b). These changes correlated with specific time points characteristic of the lunar eclipse that started in Moscow on Feb. 9, 2009, at 17:34 P.M. The photon emission intensity began to increase exactly at this moment of time. At 19:38, at the moment of totality, a spike on the kinetic curve was observed (see first insert in Figure 6b). After the end of the lunar eclipse, the photon emission intensity did not decrease to its initial values, but oscillated in a pronounced circadian pattern with the intensity exceeding the previous one by two- to three-fold. Two days after the start of the Moon's eclipse, the photon emission

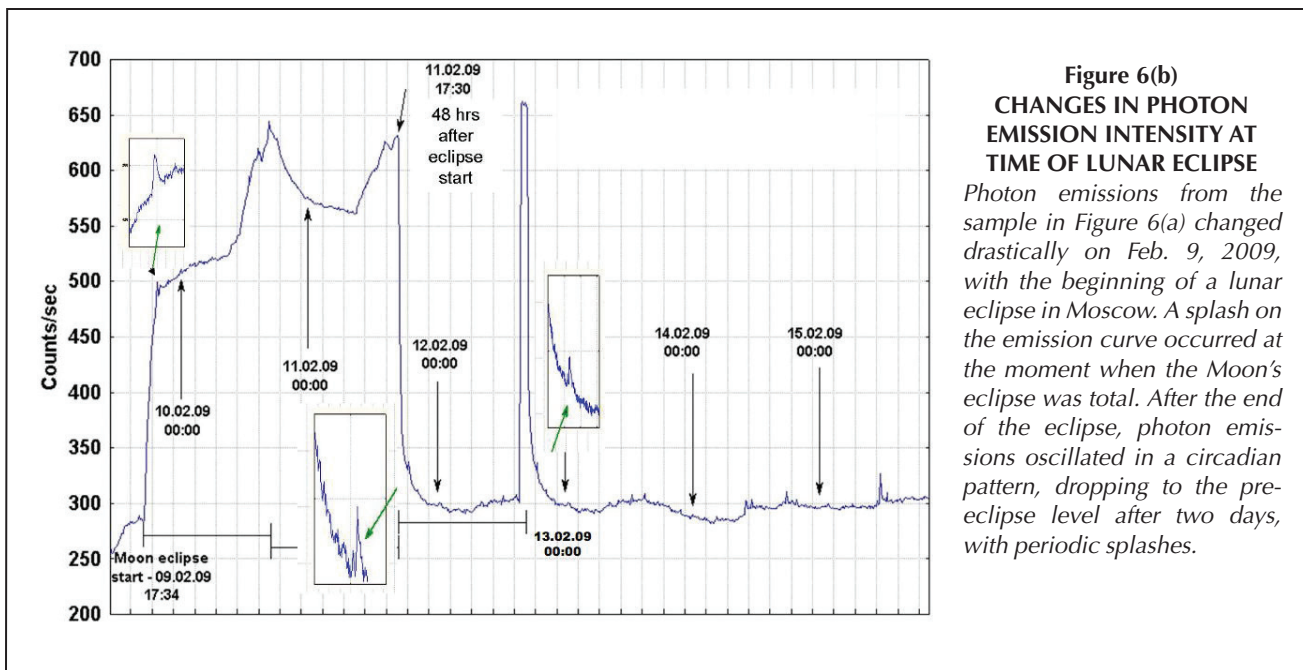


Figure 6(b)
CHANGES IN PHOTON EMISSION INTENSITY AT TIME OF LUNAR ECLIPSE
Photon emissions from the sample in Figure 6(a) changed drastically on Feb. 9, 2009, with the beginning of a lunar eclipse in Moscow. A splash on the emission curve occurred at the moment when the Moon's eclipse was total. After the end of the eclipse, photon emissions oscillated in a circadian pattern, dropping to the pre-eclipse level after two days, with periodic splashes.

dropped to the level preceding the eclipse.

It is notable that exactly 48 hours after totality, at 19:38 on February 11, a spike similar to the one observed at the moment of total eclipse again appeared on the curve (see second insert in Figure 6b, and Figure 6c). Three days after the Moon's eclipse, the photon emission intensity again rose more than two-fold, and two hours later it fell back to the initial level. During the next three days, occasional spikes were observed on the kinetic curve.

A reaction of activated bicarbonate solution to the solar eclipse was also registered (Figure 7). This time, the H₂O₂-activated bicarbonate solution was prepared in a 10-mm × 10-mm × 40-mm glass cuvette. The cuvette was installed in a thermostatic jacket that was fixed in the chamber of a single photon detector. The jacket was kept at constant temperature (~20°C ±0.1°C), with the help of flow-through water. For continuous temperature measurements, a thermosensor (a germanium diode) was placed in the solution. Photon emission from the active bicarbonate solution and the signal from the Ge-diode were recorded simultaneously.

It can be seen in plots presented in Figure 7 that the average temperature in the solution, after its equilibration with

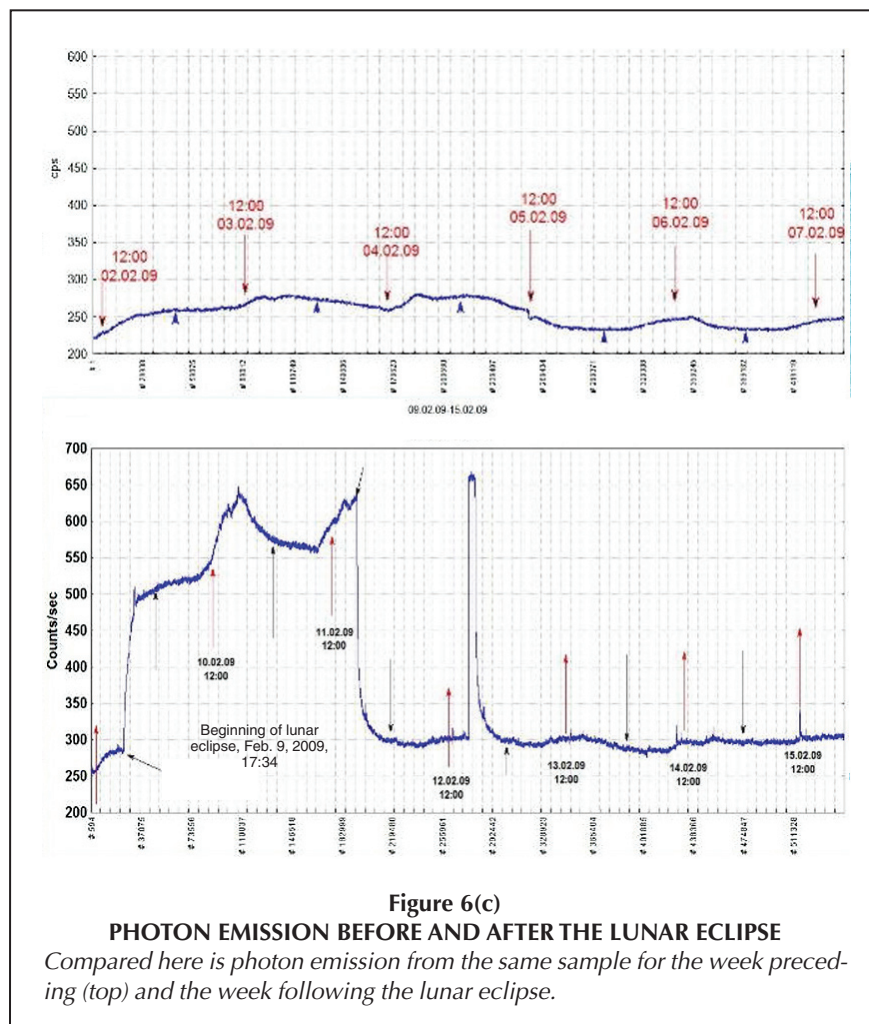


Figure 6(c)
PHOTON EMISSION BEFORE AND AFTER THE LUNAR ECLIPSE
Compared here is photon emission from the same sample for the week preceding (top) and the week following the lunar eclipse.

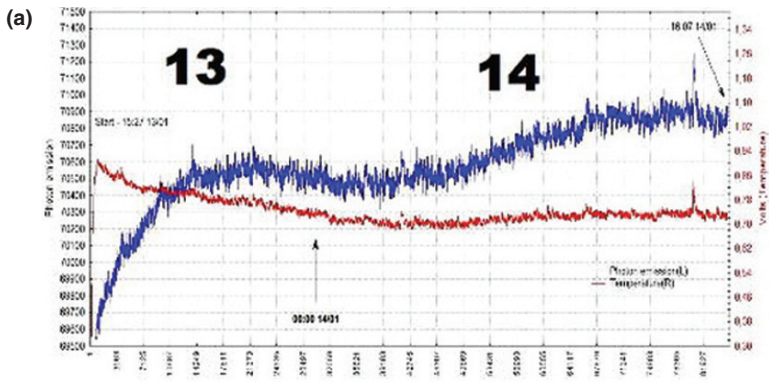
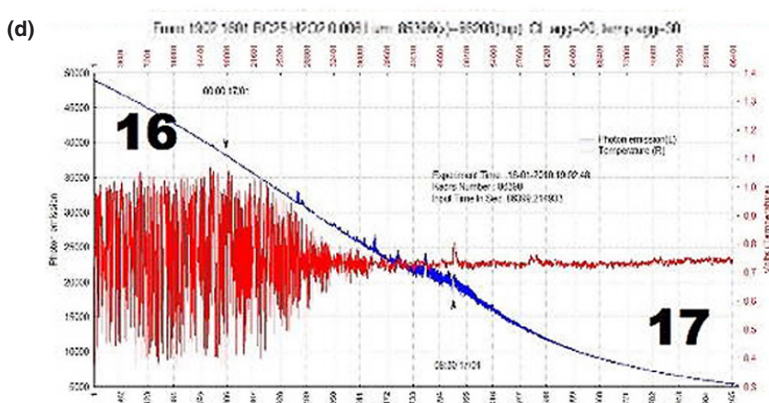
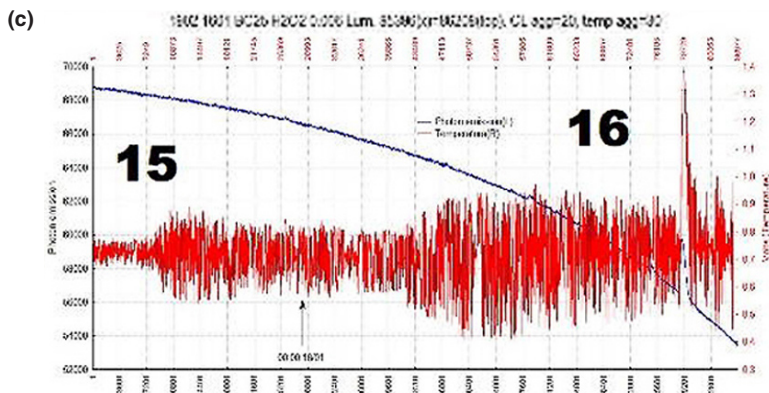
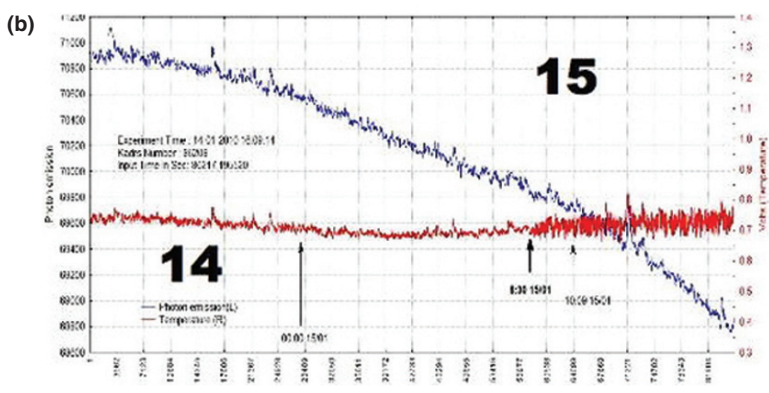


Figure 7 (a-d)
BEHAVIOR OF BICARBONATE SOLUTION BEFORE, DURING, AND AFTER THE ANNULAR SOLAR ECLIPSE ON JAN. 15, 2010

In this experiment an H₂O₂-activated carbonate solution was prepared in a glass cuvette, which was then installed in a thermo-static jacket fixed in the chamber of a single photon detector. The temperature of the jacket was kept constant, and temperature fluctuations were measured with a thermo-sensor. Both photon emissions (blue) and temperature (red) increased at the start of the annular solar eclipse.



the jacket temperature (Figure 7a), was rather stable (~20°C) during the whole period of observation (January 13-17, 2010). Temperature fluctuations around the set value were rather small during the first 40 hours and the last 10-13 hours of monitoring, although occasional temperature splashes coinciding with the splashes in photon emission were observed.

The pattern of temperature variations changed suddenly at 08:30 on January 15 (Figure 7b). It is notable that on Jan. 15, 2010, there was an annular eclipse of the Sun in the equatorial region of the Earth. Although it was not observed in Moscow, a full eclipse at Moscow's longitude (37.5° E) took place at 05:30 universal time (08:30 Moscow time). Exactly at this moment, the amplitude of fluctuations of the signal from the Ge-probe began to elevate. The swing of the signal from the Ge-diode increased during the next two days, and by the evening of January 16 and night of January 17, the amplitude of oscillations reached values equivalent to consecutive heating and cooling of the solution in the range of 4.2°C! (Figure 7d)

Close to two days after their emergence, the fluctuations in the signal disappeared. It is interesting to note here that the increase in photon emission intensity from the active bicarbonate solution also lasted for about two days after the lunar eclipse (Figure 6b).

Since the periods of typical fluctuations of the Ge-probe signal were in the range of 1-1.5 minutes (see, for example, Figure 8),

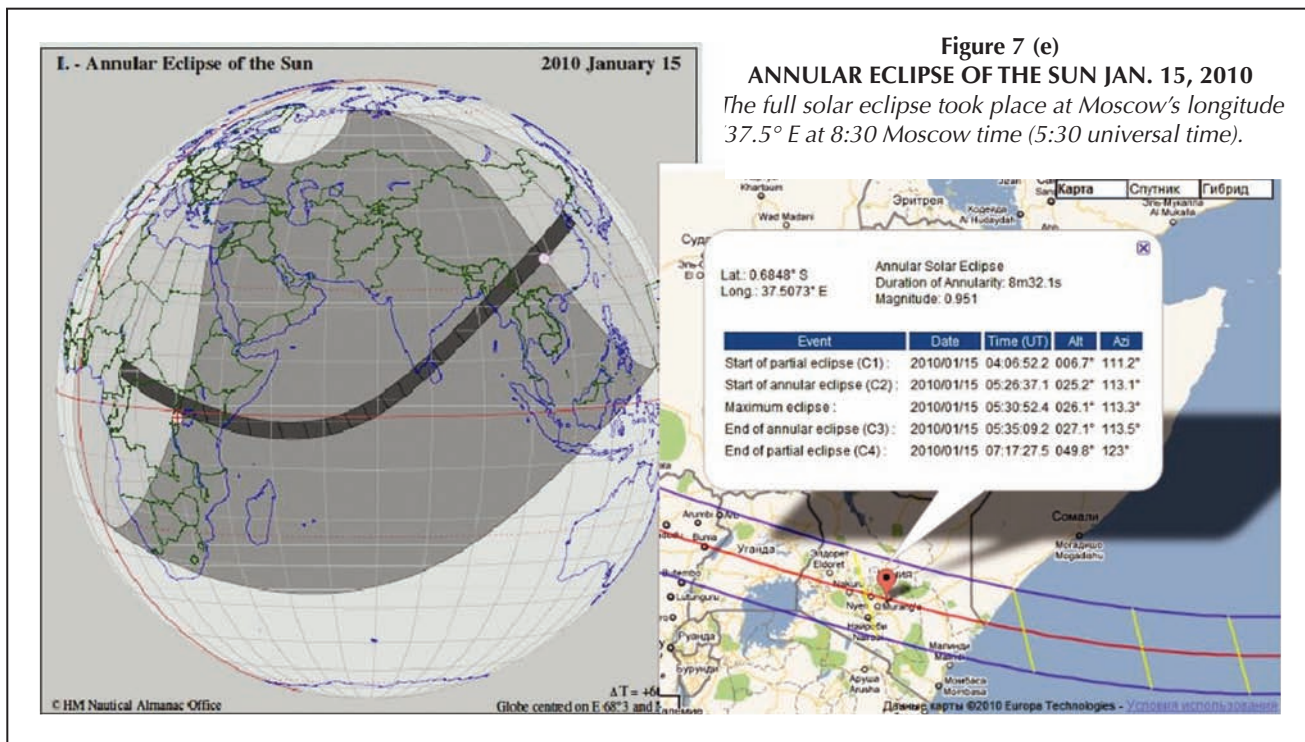


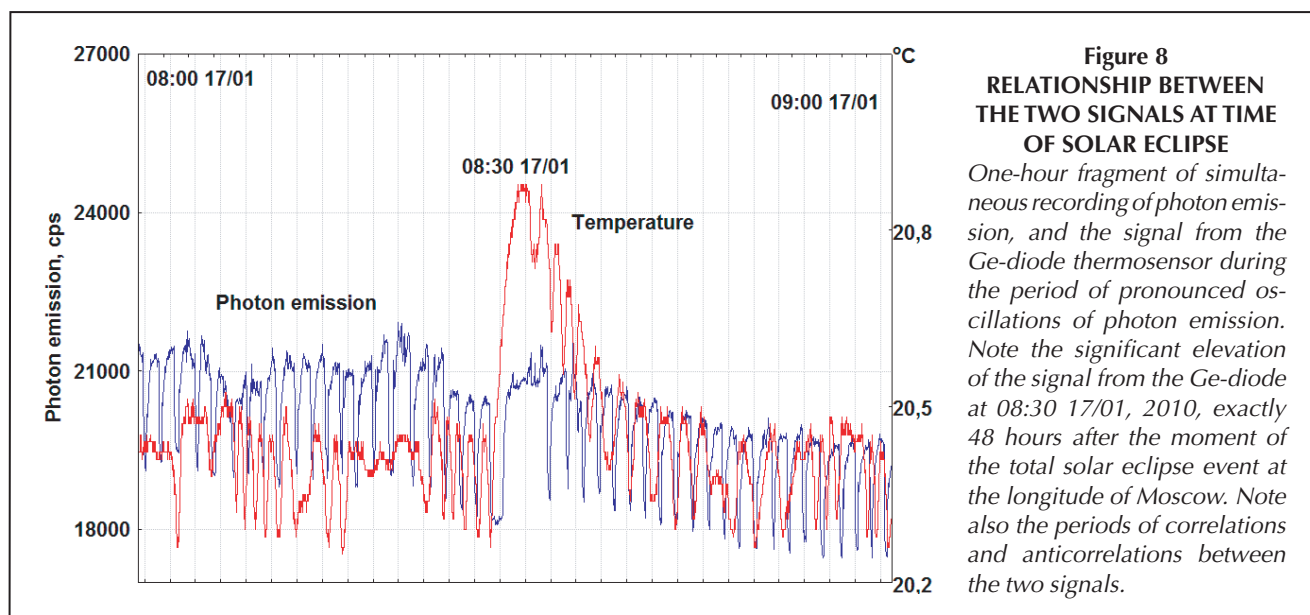
Figure 7 (e)
ANNULAR ECLIPSE OF THE SUN JAN. 15, 2010
The full solar eclipse took place at Moscow's longitude 37.5° E at 8:30 Moscow time (5:30 universal time).

with the fastest fluctuations lasting for only 20 seconds, they are very unlikely to reflect the cycles of heating and cooling of the solution in the thermostatted cuvette, because a water thermostat is unable to produce such fast temperature variations. On the other hand, one should take into account that the Ge-diode commonly used as a temperature sensor is in fact a photodiode, sensitive to the near-infrared part of the electromagnetic spectrum. In this part of the electromagnetic spectrum, water is the nearly exclusive absorber (and, obviously, emitter) of photons.

Having this in mind, it is interesting to speculate that the pro-

found fluctuations of the Ge-diode signal observed in Figure 7 are marking variations in near-infrared radiation in the vicinity of this probe. Such variations may originate from collective excitations and de-excitations of water domains, if they have dimensions comparable to the dimensions of the germanium probe (at least, fractions of a millimeter).⁷⁻⁹

That the oscillations of the signal are artifacts from the Ge-diode is unlikely, because in some cases these temperature oscillations coincided with photon emission oscillations, while in others there was no such correlation. Indeed, as may



be observed in Figure 7(a-d), splashes of signals from the Ge-diode coincided with the splashes of photon emission during the calm periods (January 13, 14, and 17). However, the most pronounced correlations (and anti-correlations) between the two signals were observed during the period of decay of fluctuations of the Ge-diode signal (Figure 8).

Here one can see both the profound, more or less regular fluctuations of photon emission intensity and synchronous fluctuations of the signal from the Ge-diode. It should be stressed that such fluctuations in photon emission intensity may be registered only if the processes resulting in photon emission go on collectively in the whole volume of the solution, because the photon emission is registered not at a local site, but from the whole surface of the cuvette facing the photomultiplier.

Coincidences in the oscillations of both signals probably indicate that energy in the form of photons is released both in the visible and near-infrared ranges of the spectrum, more or less coherently.

Non-Equilibrium and Water 'Burning'

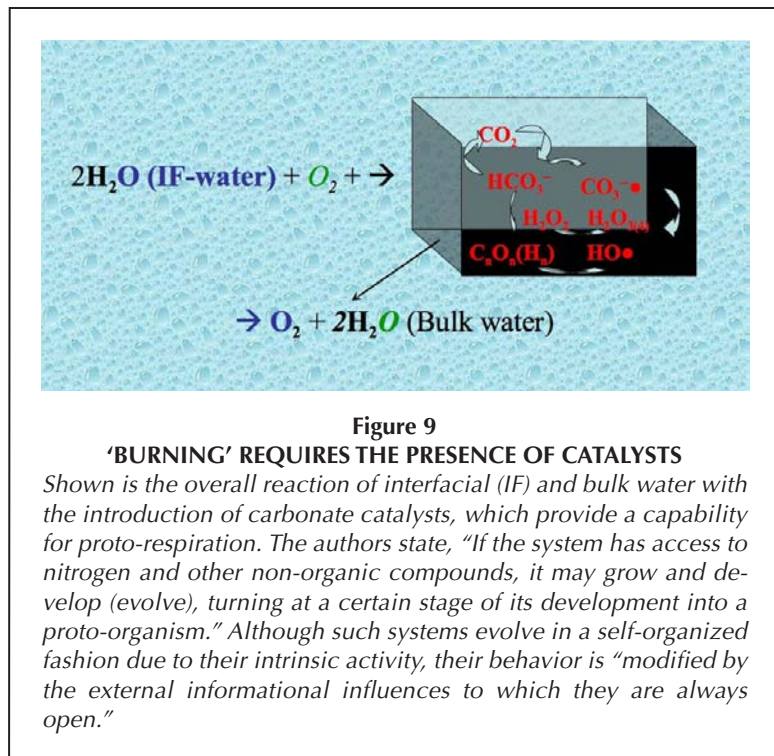
Our data indicate that even "common" bicarbonate solutions display stable, non-equilibrium properties, which can be revealed by the appearance of a wave of photon emission occurring after the addition of a small quantity of an electron donor, Fe(II). Bicarbonate aqueous solutions activated with small quantities of hydrogen peroxide (H_2O_2) demonstrate stable non-equilibrium much more impressively.

There are many known chemiluminescent systems in which free radical reactions proceed. However, in the vast majority of cases luminescence fades out as the reagents are exhausted. The activated bicarbonate solutions described here preserve the capability for spontaneous photon emission for many months, in complete darkness, and under conditions when exchange of matter (oxygen, water vapor, volatile reaction products) with the environment does not occur. That means that the processes accompanied by the generation of energy of electron excitation proceed continuously, and in a cyclic-like manner in these systems, without irreversible consumption of any reagents.

Further, the system can accumulate the high-density energy that it generates, because it can react to subtle irritations by strong and prolonged rises in photon emission intensity.

It is premature to suggest a more detailed model of the processes responsible for this permanently excited state of activated bicarbonate solutions, and for its continuous pumping. However, some preconditions that should be taken into account in developing such a model should be mentioned.

Aqueous systems can be regarded in first approximation as consisting of two-phases. One of the phases is represented as an organized quasi-liquid crystalline aqueous phase having the



properties of a reducer. The other phase is a more "gas-like" water, containing the terminal oxidizer, oxygen.

Carbonates present in such water may perform several functions simultaneously. CO_2 may support water structuring,²¹ and structured water splits more easily under the action of multiple physical factors. Water splitting results in the appearance of free radicals (H atoms and hydroxyl radicals), and HCO_3^- is easily oxidized by a hydroxyl radical ($\text{HO}\cdot$), turning into a carbonate radical $\text{CO}_3^{\cdot-}$.

The latter may participate in multiple reactions. In particular, the carbonate radical may support organized water oxidation, by oxidizing hydrogen peroxide that is always present in water, even in trace quantities,²² and recombining it after the emergence of organic compounds, such as oxocarbons.²³

As a result, a network of coupled and mutually supporting redox reactions emerges; the energy yield for most of them is in the range of the energy of electronic excitation. Thus, carbonates may act as intermediates between reagents and products of the ideal reaction of water burning outlined above. On the one hand, they diminish the energy of activation for this reaction; and on the other, they introduce new cycling pro-

21. L. Pauling, 1961. "A molecular theory of general anesthesia," *Science*, Vol. 134, pp. 15-21.

22. G.G. Komissarov, 2003. *Photosynthesis: Physical-chemical approach* (Moscow: URSS, pp. 154-170).

23. P. Mazellier, E. Leroy, J. De Laat, B. Legube, 2002. "Transformation of carbendazim induced by the $\text{H}_2\text{O}_2/\text{UV}$ system in the presence of hydrogenocarbonate ions: Involvement of the carbonate radical," *New J. Chem.*, Vol. 26, pp. 1784-1790.

cesses into the system. They enrich the network of redox reactions in the system and make it more stable. Thus, (bi)carbonates may be regarded as peculiar catalysts of (reversible) water "burning."

Regarding the role of H_2O_2 , it is important to stress that the reactions of combustion generally proceed as branching (avalanche-like) chain reactions, and obey particular laws pertaining to such processes.²⁴ Combustion may start only when the oxygen concentration exceeds a threshold, and a certain triggering stimulus (a "spark") with high enough potential is needed for its initiation. H_2O_2 probably carries out this dual role introduced into a bicarbonate solution. Part of it is decomposed with an energy release which acts as the "spark," or trigger. At the same time, the initial level of oxygen in the solution increases over the threshold needed for the kindling of the chain reaction.

When burning is initiated, the energy released promotes excitation of both the fuel and oxygen, resulting in reinforcement or invigoration of the burning process. (See Figure 9.) When the availability of either oxygen or electrons falls below threshold levels, burning is dampened. During this period, oxygen—a product of the reaction outlined above—again accumulates, and a new wave of water "burning" may arise. Thus the process could become oscillatory.²⁵ In turn, energy will be released in an oscillatory manner and may serve as a pacemaker for coupled reactions. On the other hand, the oscillatory character of the processes occurring in such systems permit their responsiveness to resonant effects.

Source of Energy

Whatever mechanism is producing the stable non-equilibrium state of bicarbonate aqueous systems, its capability to induce permanent photon emission demands a permanent supply of energy. The natural source for this energy, that is always available, is the thermal bath in which the system resides. Pollack and associates have shown that the structural temperature of exclusion-zone (EZ) water is lower than that of the less organized water with which it is in contact.⁷ Hence, a temperature gradient exists between these two water phases, and EZ-water can continuously draw heat energy (infrared-radiation) from the environment and transform it into energy of a much higher potential—the energy of electron excitation which appears as radiation in the visible and ultraviolet-range of the spectrum. From this, it follows that bicarbonate solutions represent *step-up energy transformers*, rather than energy generators.

Exact temporal coincidences of the changes in pattern of photon emission (Figures 4 and 6b) and the amplitude of oscillations of (presumably) the excitations in the near-infrared

range (Figure 7) with cosmic events can hardly be explained as chance or coincidence. In fact, the dependence of processes in aqueous systems upon cosmic events was first conclusively demonstrated by Professor Giorgio Piccardi, who discovered the effect of Solar activity on the behavior of colloidal solutions.²⁶ Regarding this experimentally demonstrated effect, he noted:

...[I]t must be taken into account from an ecological-climatic point of view, because everything that is made up of water or which contains water—solutions, colloidal solutions, suspensions—is subject to the same activity from space (*in particular, the action of the Sun*) as are living organisms, and is modified as a result. Thus, the water of rivers, lakes, seas, marshes, and ponds, their inorganic, organic, and biological colloids, clay sediment, mud, in short what is found in a dispersed state and which has not yet attained a state of thermodynamic equilibrium.²⁵ (p. 127)

The mechanism to explain the long-lasting effects of solar and lunar eclipses on photon emission from aqueous systems, can be considered only hypothetically at this point. Both events represent special cases of gravitational influence upon the Earth. It is clear that the direct effect of variations of gravitation upon water samples is practically negligible. However, the effect on such a massive body as the Earth may result in changes in the parameters of manifold physical fields associated with this body, and these variations may trigger changes in the behavior of non-equilibrium aqueous systems.

It should be noted that cosmic events may influence the behavior of practically all non-equilibrium aqueous systems on the Earth, including the water in living organisms, and produce long-lasting effects in them.

To conclude: Aqueous systems in which a stable non-equilibrium phase of organized water and a much less organized phase of bulk water coexist, and in which oxygen (its active species), and protons (hydroxonium ions) are present, are capable of a sort of *proto-respiration* catalyzed by carbonates. If the system has access to nitrogen and other non-organic compounds, it may grow and develop (evolve), changing at a certain stage of its development into a *proto-organism*.

It should be stressed that such systems evolve because of their intrinsic activity, provided by the inherent properties of water and carbonates, rather than from the action of external forces upon them. However, their behavior is modified by external informational influences to which they are always open. This behavior represents the phenomenon of true self-organization that gives rise to the emergence of more and more complex systems, which are basically similar to each other, but possess individuality, providing for the emergence of diversity, biodiversity, in particular.

24. V.L. Voeikov, V.I. Naletov, 1998. "Weak Photon Emission of Non-Linear Chemical Reactions of Amino Acids and Sugars in Aqueous Solutions. Evidence for Self-Organizing Chain Processes with Delayed Branching." In *Biophotons*, eds. Jiin-Ju Chang, Joachim Fisch, Fritz-Albert Popp. (Dordrecht, The Netherlands, Kluwer Academic Publishers) pp. 93-108.

25. V.L. Voeikov, V.V. Koldunov, D.S. Kononov, 2001. "Long-Duration Oscillations of Chemiluminescence During the AminoCarbonyl Reaction in Aqueous Solutions," *Russ. J. Phys. Chem.*, Vol. 75, pp. 1443-1448.

26. G. Piccardi, 1962. *The Chemical Basis of Medical Climatology* (Springfield, Ill.: Charles C. Thomas Publisher).