Are the peculiar physicochemical water properties related with life?

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Always water is related in our minds with life. Nowadays there is an intensive search of water in the outer space as a preliminary step in order to find life. Water is the predominant substance in Earth, all living beings contain water as solvent for nutrient absorption, as vehicle for residues elimination and as major component. In addition, is crucial for life the pass of the water through biological membranes. Therefore, seems obvious that the cycle of water together with its regulatory effect on the surface Earth temperature may play an important role on living beings.

Water structure and living organisms

Some exclusive physical water properties have been already described (references 1 to 4) as it is the fact that its maximum density value is reached at 4 °C (figure 5). However, there are other, not so well known, peculiar water characteristics:

- At constant pressure in liquid state the minimum specific heat of water occurs at around 36 °C.
- The water under cooling temperature depends on the speed at which this cooling is being performed.
- The influence of vibration and temperature treatment velocity on certain water physical properties as viscosity, resistibility, etc.

A plausible explanation for these water “anomalies” could be the fact of being a bipolar substance with tendency to form long and branched chains with interstitial clusters or vacuoles (references 4 to 11).

The particular branched figures formed in ice crystallization (figure 1) can be explained taking in account its typical saddle shape (figure 2) which allows the formation of holes inside the structure. Water vapor and other gases could accumulated in these holes originating the typical ice bubbles (figure 3) which depend of the cooling rhythm and of the shape in which freezing is being performed.

The efforts and over pressures created during the freezing process are enormous. Also, since Roentgen scientists consider three different kinds of water depending on the temperature range:

i) between 0 to 4°C
ii) between 4 to 36°C
iii) between 36 to 100°C
Although this is a matter of thermodynamic specialists, it is remarkable that water behaves in a very singular way at two temperatures crucial in life: 4°C, at which sea bottoms seems to be thermo equilibrated, and around 36°C at which most eukaryotic animals have their optimal metabolic performances. Water specific heat variation depending on temperature, it has a minimum to 35-36°C (Figure 4). [3]

The fixed points on the Celsius scale are defined by the water phase changes but being affected by pressure and purity degree. We know also that pressure variations depends on altitude and that climatic changes affect living organisms which tend to adapt to them.

The process of water evaporation to the atmosphere is related with the partial vapor differences; thus, it can occur at any temperature releasing always energy. and In living organisms thermo diffusion processes play an important role. Water evaporation is the major way to regulate temperature in warm blood animals. Also, bees and termites regulate their nest temperature near 36 °C taking advance of water evaporation, and the workers congregate very tightly and vibrate in a cold day to maintain their queen warm inside. No surprise that a great deal of animal particular behaviors can be explained on thermodynamic basis.

The liquid transportation processes through biological membranes are complex but it is no doubt about the role played by of the transport on vapor phase. A possible structure change at this point would facilitate the vapor phase and, consequently, its pass through membranes.

It is currently accepted that only few laws govern all transport phenomena and the main, or even the unique, is the minimum energy equilibrium, thus, If a gas can pass better than a liquid through a barrier as a biological membrane, a mechanism would be developed to allow the pass of substances through membranes in gaseous stage.

All these considerations make suggestive the coordinated efforts of scientist specialist on Biology, Chemistry an Physic and our intention is only to invite and promote the research on this line on the hope that field as cryogenic Medicine and obviously Biology could benefit of it in the future.

As a conclusion, the occurrence of life on Earth seems to be related with the so call water structure anomalies which understanding will help substantially to develop or facilitate industrial, food conservation and medical procedures.
Figure 1: Ice crystallization over a plane window

Figure 2: Ice crystallization schemes.
Figure 3: Ice bubbles inside a glass cylinder showing a spatial distribution.

Figure 4: Water specific heat variation depending on temperature in °C.
Figure 5: Water density variation depending on temperature in °C.

Now some phrases to think about them:

'We live by the grace of water' National Geographic Special Edition, Nov. 1993

'Water is the source of all life’ attributed to Thales of Miletus (634-546 BC)

'...we may ask why all trees and bushes - or at least most of them - unfold a flower in a five-sided pattern, with five petals.... Some botanist might well examine the sap of plants to see if any difference there corresponds to the shapes of their flowers.' Johannes Kepler (1611)

'We live in the hope and faith that, by the advance of molecular physics, we shall by-and-by be able to see our way as clearly from the constituents of water to the properties of water, as we are now able to deduce the operations of a watch from the form of its parts and the manner in which they are put together.'

T H Huxley, On the Physical Basis of Life (1869)

'Water is H₂O, hydrogen two parts, oxygen one, but there is also a third thing, that makes it water and nobody knows what it is.'

D H Lawrence (1885-1930)
References


4) http://www.lsbu.ac.uk/water/explan.html

5) http://www.martin.chaplin.btinternet.co.uk/data1.html

6) http://www.martin.chaplin.btinternet.co.uk/anmlies.html#23

7) http://www.martin.chaplin.btinternet.co.uk/intro.html

8) http://www.martin.chaplin.btinternet.co.uk/clusters.html

9) http://www.martin.chaplin.btinternet.co.uk/evidnc.html

10) http://www.robresint.co.uk/default.asp?section=quoteoftheweek

11) http://dichtes-waser.de/eng/The_Anomalies_of_Waser