Temperature 2:1, 63–64; January/February/March 2015; Published with license by Taylor & Francis Group, LLC

Which is the correct answer to the Mpemba puzzle?

Andrej A Romanovsky*
FeverLab, Trauma Research, St. Joseph's Hospital and Medical Center, Phoenix, AZ USA

Dear Editorial Board members,

In my editorial in the last issue of *Temperature*,[1] I included a riddle that was suggested to me by Gerald Pollack (University of Washington, Seattle, Washington, USA). Here is the original text of the riddle: "In 1963, Erasto Mpemba, a precocious middle school student in Tanganyika (now Tanzania) was taking a cooking course. The subject was: making ice cream. The participants would dump a premixed "ice cream" powder into water, stir the mixture, and stick it into a freezer. Soon they could enjoy their dessert. Mpemba noticed something odd. When he mixed the powder with warm water instead of cold water, the ice cream froze sooner. Since then, many have confirmed the Mpemba paradox: warm water freezes more quickly than cold water. Why?" In the editorial,[1] I gave the readers a hint, stating that the puzzle was based on Pollack's latest book, which I disclose now: see reference 2. However, neither of the 2 answers we received[3,4] used this hint.

One answer came from Chang Quing Sun (Nanyang Technological University, Singapore).[3] His explanation of the Mpemba paradox is focused on the microstructure of water and, specifically, on the hydrogen bond. A relatively short description of what Sun calls the abnormal relaxation of the hydrogen bond, and how this relaxation accelerates water freezing, can be found in this issue of *Temperature*.[3] Sun views the Mpemba paradox as a fundamental effect, which is insensitive to convection, evaporation, water impurity, and many other processes and factors.

The present text is my Reply to the second answer, which is a Letter to the Editor written by Marek Balážovič (Constantine the Philosopher University, Nitra, Slovakia) and Boris Tomášik (Matej Bel University, Banská Bystrica, Slovakia).[5] Interestingly, the Mpemba paradox was the topic of Balážovič's thesis, on which Tomášik acted as the supervisor. In contrast to Sun, Balážovič and Tomášik consider the Mpemba phenomenon multi-causal. They also emphasize that, in real life, the outcome of experiments aimed at reproducing the Mpemba effect is highly sensitive to experimental conditions, e.g., water purity. Depending on the conditions, heating water may lower, raise, or not change the original freezing temperature. Is this an example of what Thomas Huxley called the great tragedy of Science—the slaying of a beautiful hypothesis by an ugly fact? The authors list 8 factors, which, under different experimental conditions, may contribute to various extents to the faster freezing of warm water—when it occurs. These factors range from ice coating in the freezer (remember, student Erasto was making ice cream in a freezer) to the microstructure of water (Sun's[4] fundamental mechanism).

In their Letter,[1] Balážovič and Tomášik mentioned that 2 years ago, the Royal Society of Chemistry offered a £1,000 prize for the best explanation of the Mpemba phenomenon. However, the

Reply to: Balážovič M, Tomášik B. Paradox of temperature decreasing without unique explanation. Temperature 2015; 61-2; http://dx.doi.org/10.4161/23328940.2014.975576

Keywords: Erasto Mpemba, Mpemba paradox, Mpemba phenomenon, Mpemba effect, temperature, water freezing, ice

*Correspondence to: Andrej A Romanovsky; Email: aromano@chw.edu
URLs: www.TheBarrow.org/FeverLab; www.FeverLab.net

Submitted: 12/19/2014

Revised: 01/16/2015

Accepted: 01/16/2015

http://dx.doi.org/10.1080/23328940.2015.1009800

Figure 1. Erasto Mpemba talking at a meeting in Dar es Salaam (Tanzania) in November of 2011. Photo by Hellen Gaudence (fragment), with permission.

authors did not tell us who won the prize, or what the winning explanation was. I have found that the winning essay was written by Nikola Bregović (University of Zagreb, Croatia).[5] Similar to Balážovič and Tomášik, he considered the multi-causal nature of the phenomenon, although his list of factors involved was somewhat narrower, and the emphasis was placed on the convection induced by a temperature gradient. His entry was juried to be the best and most original among all entries received by the society from . . . 22,000 competitors! Mr. Erasto B. Mpemba, retired wildlife officer (**Fig. 1**), must be astonished to see how much interest there is today in the unusual observation that he made as a schoolboy in 1963 and published together with his teacher a few years later.[6] What an amazing story!

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

References

1. Romanovsky AA. Temperature 2014; 1:71–5; http://dx.doi.org/10.4161/temp.29600
2. Pollack GH. The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor. Seattle: Ebner & Sons, 2013.
3. Sun CQ. Temperature 2015; 38-9; http://dx.doi.org/10.4161/23328940.2014.974441.
4. Balážovič M, et al. Temperature 2015; 2:61-2; http://dx.doi.org/10.4161/23328940.2014.975576.
5. Bregović N. Mpemba effect from a viewpoint of an experimental physical chemist. http://www.rsc.org/images/nikola-bregovic-entry_tcm18-225169.pdf, 2012
6. Mpemba EB, et al. Phys Educ 1969; 4:172–5; http://dx.doi.org/10.1088/0031-9120/4/3/312