



**Citation:** B.W. Ninham (2020) Postscript. *Substantia* 4(2) Suppl.: 119-121. doi: 10.36253/Substantia-1146

**Copyright:** © 2020 B.W. Ninham. This is an open access, peer-reviewed article published by Firenze University Press (<http://www.fupress.com/substantia>) and distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Data Availability Statement:** All relevant data are within the paper and its Supporting Information files.

**Competing Interests:** The Author(s) declare(s) no conflict of interest.

## Postscript

BARRY W. NINHAM

*Department of Applied Mathematics, Research School of Physical Sciences, The Australian National University, Canberra, Australia*  
E-mail: [barry.ninham@anu.edu.au](mailto:barry.ninham@anu.edu.au)

1348 was the year of the great plague in Europe. One third of the population died. A project into causes commissioned by the King of France from the best Doctors of Medicine of the premier Sorbonne University found out why. The plague, they discovered, was due to a rare conjunction of the planets Mars, Jupiter and Saturn.

That all made sense. These planets were associated with 3 of the 4 humours of the body, the balance of which determined health. Astrology was God-given in those Geocentric times. To dispute such a proof was tantamount to impiety.

Similar dogma attends the certainty of the science of each and every era. With time the theories of one generation evolve and are dismissed by the next as naïve, comparable with the book of Genesis. But not so credible!

Witness quantum entanglement.

This we know. Nonetheless current scientific theories are invariably defended as vigorously as the Bible is taken literally to be God's revealed truth by some fundamentalist believers. And so it is today.<sup>1</sup> Priests will be priests and professors will be professors.

We have reported on a suite of simple new water technologies, in desalination, in sterilisation, in heavy metal pollution and harvesting, in cavitation, in a new class of environmentally friendly surfactants, on control of slimes and sludges from mining and floods. All are cheap, scalable. All are desperately needed. Why were these not developed before?

The answer is that all depend on science<sup>2</sup> that does NOT fit into the standard dogmas of physical, colloid and surface chemistry. These theories we expect to be the enabling disciplines that underpin life sciences and chemical engineering sciences. In this, the physical sciences have signally failed. They have not done the job. The Greeks told us why. Of the four elements, fire, water, earth and air, we forgot about the air.

### OUR THEORIES IGNORED DISSOLVED GAS IN WATER

The exemplar is the electrolyte ion pair specific bubble-bubble fusion interaction inhibition phenomenon.<sup>3</sup> It occurs around 0.17 M, precisely the

ionic strength of the blood. It has been known for a century, widely known for 40 years. Perhaps the simplest imaginable experiment, it cannot be explained by classical physical chemistry. The standard theories also omit specific ion (Hofmeister effects). All of our novel technologies depend on these things.

Concepts like pH and buffers, and pKa and osmotic pressure, activities, zeta potentials and membrane potentials, ion pumps, electrostatic forces, molecular recognition, antibody-antigen and enzyme specificity are part of the language and intuition of biology and electrochemistry.

The interpretation of such measurements that depend on a now outmoded astrology, flawed theories that omit the role of dissolved gas. "Hydrophobic" interactions go away when dissolved gas is removed.<sup>4</sup> Similarly the theories omit or treat incorrectly specific ion effects. Simulation suffers from the same defects.

So what we think ought to be the relevant science in exploring new arenas is impotent. It is as handicapped as was that geocentric astrology of the good Doctors of Paris.

Our new technologies rely on unexplained effects associated with bubbles and dissolved gas. And as we proceeded it became clearer that we could begin to see the outline of something very new. The very effective sterilisation of water, killing of viruses and other pathogens by warm CO<sub>2</sub> in a column above 0.17 M, physiological concentration suggested more.<sup>5,6</sup> Nanobubbles of CO<sub>2</sub>, oxygen and nitrogen under these conditions will also be stable and produce free radicals that drive not just enzymatic reactions,<sup>7,8</sup> but chemical reactivity generally.<sup>9,10,11</sup> And so it turns out. For example, the structure and function of the endothelial surface layer in physiology was revealed as a dynamic foam of CO<sub>2</sub> nanobubbles.<sup>12</sup> It complements the lung surfactant structure and its delivery of oxygen and nitrogen via nanobubbles.<sup>13</sup> The ESL protects tissue from invasions by pathogens and acts to destroy COVID viruses.<sup>14</sup>

The self-assembly of gas nanobubbles as a function of salt in bulk solution<sup>4</sup> and at surfaces mimics the same subtleties in self-assembly as surfactants<sup>15,16</sup> and provides the energy that drives chemical reactions.<sup>7-11</sup> The ubiquity of stable spontaneous nanobubbles that are sources of free radicals<sup>17</sup> adds a whole new flexibility to the rigidity and limitations of present antibody-antigen and enzyme substrate interaction ideas in immunology and biochemistry.

THESE THINGS IF ONLY DIMLY PERCEIVED,  
ARE NOW A LITTLE CLEARER

There remains the hurdle of Dean Swift's Confederacy of Dunces and their dialogue of the deaf. But if we

ignore them, we can begin to see a scientific parallel for the Reverend Martin Luther King's Promised Land.

We remark finally that an excellent study of the effects of shaking and bubbles on inactivation of viruses and bacteria as long ago as 1948.<sup>18</sup>

## REFERENCES

1. B. W. Ninham, The Biological/Physical Sciences Divide and the Age of Unreason, *Substantia*, **2017**, 1 (1) 7- 24.
2. B. W. Ninham, R. M. Pashley, P. Lo Nostro, Surface forces: Changing concepts and complexity with dissolved gas, bubbles, salt and heat, *Curr. Opin. Colloid Interface Sci.*, **2016**, 27, 25-32.
3. V. S. J. Craig, B. W. Ninham, R. M. Pashley, The Effect of Electrolytes on Bubble Coalescence in Water, *J. Phys. Chem.* **1993**, 97 (39), 10192-10197.
4. B. W. Ninham and P. Lo Nostro, Unexpected Properties of Degassed Solutions, *J. Phys. Chem.*, **2020**, 124(36), 7872-7878.
5. A. G. Sanchis, R. M. Pashley, B. W. Ninham, Water sterilisation using different hot gases in a bubble column reactor, *J. Environ. Chem. Eng.*, **2018**, 6, 2651-2659.
6. A. G. Sanchis, R. M. Pashley, B. W. Ninham, Virus and bacteria inactivation by CO<sub>2</sub> bubbles in solution, *NPJ Clean Water*, **2019**, v 2 Number 1.
7. H.-K. Kim, E. Tuite, B. Nordén, B. W. Ninham, Co-ion dependence of DNA nuclease activity suggests hydrophobic cavitation as a potential source of activation energy, *Eur. Phys. J.*, **2001**, 4, 411-417.
8. B. Feng, R. P. Sosa, A. K. F. Mårtensson, K. Jiang, A. Tong, K.D. Dorfman, M. Takahashi, P. Lincoln, C. J. Bustamante, F. Westerlund, B. Nordén, Hydrophobic catalysis and a potential biological role of DNA unstacking induced by environment effects, *P. National Acad. Sci. United States of America*, **2019**, 116, 17169-34343.
9. M. E. Karaman, B. W. Ninham, R. M. Pashley, Effects of dissolved gas on emulsions, emulsion polymerization, and surfactant aggregation, *J. Phys. Chem.*, **1996**, 100 (38), 15503-15507.
10. M. Alfridsson, B. W. Ninham, S. Wall, Role of co-ion specificity and dissolved atmospheric gas in colloid interaction, *Langmuir*, **2000**, 16 (26), 10087-10091.
11. B. W. Ninham, K. Kurihara, O. I. Vinogradova, Hydrophobicity, Specific Ion Adsorption and Reactivity, *Colloids Surf., A: Physiochem. Eng. Aspects*, **1997**, 123-124, 7-12.
12. B. P. Reines, B. W. Ninham, Structure and function of the endothelial surface layer: unraveling the nano-

- architecture of biological surfaces, *Quarterly Rev. Biophys.*, **2019**, 52, 1–11.
13. M. Larsson, K. Larsson, S. Andersson, J. Kakhar, T. Nylander, B. W. Ninham, P. Wollmer, The alveolar surface structure: Transformation from a liposome-like dispersion into a tetragonal CLP bilayer phase, *J. Dispersion Sci. Technol.*, **1999**, 20 (1&2), 1-12.
  14. B. P. Reines, B. W. Ninham, Pulmonary intravascular coagulopathy in COVID-19 pneumonia, *Lancet Rheumatol.*, **2020**, 2(8), 458-459.
  15. B. W. Ninham, K. Larsson, P. Lo Nostro, Two Sides of the Coin. Part 1. Lipid and surfactant self-assembly revisited, *Colloids Surf. B: Biointerfaces*, **2017**, 152, 326–338.
  16. B. W. Ninham, K. Larsson, P. Lo Nostro, Two Sides of the Coin. Part 2. Colloid and Surface Science meets real Biointerfaces., *Colloids Surf. B: Biointerfaces*, **2107**, 159, 394-404.
  17. N. F. Bunkin, B. W. Ninham, P. S. Ignatiev, V. A. Kozlov, A. V. Shkirin and A. V. Starosvetskiy, Long-Lived Nanobubbles of dissolved Gas in Aqueous Solutions of Salts and Erythrocyte Suspensions, *J. Biophotonics*, **2011**, 4 (3), 150–164.
  18. M. H. Adams, Surface inactivation of bacterial viruses and of proteins, *J. Gen. Physiol.*, **1948**, 31(5), 417-431.