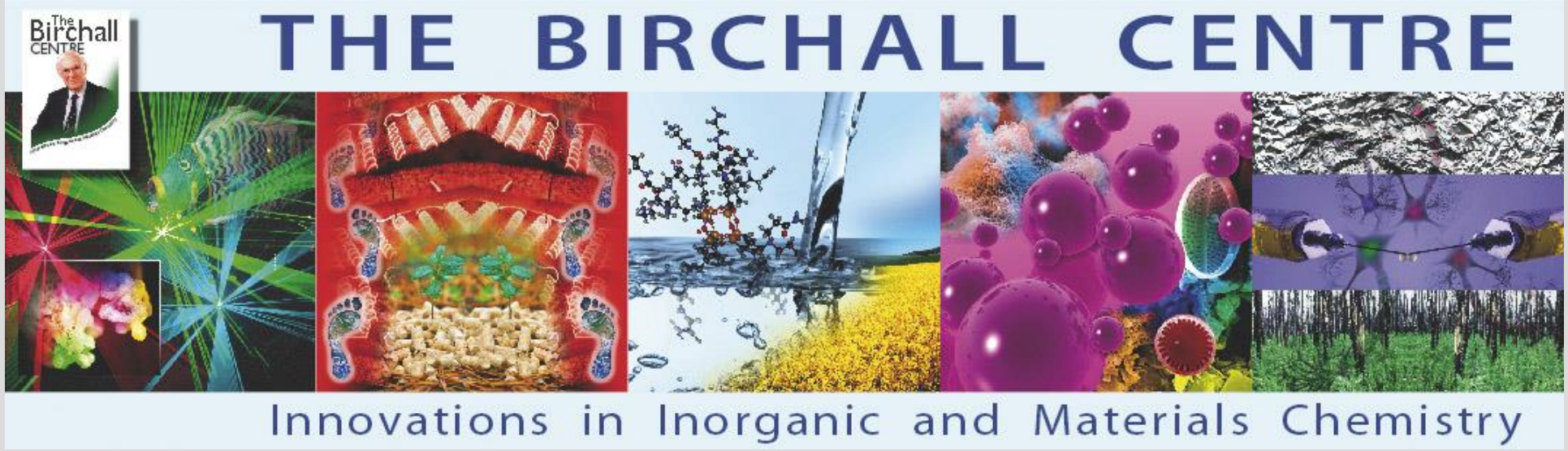


Silicic Acid

Christopher Exley PhD FRSB

The Birchall Centre, Lennard-Jones Laboratories, Keele University, Keele, Staffordshire, ST5 5BG, UK.

c.exley@keele.ac.uk

http://www.keele.ac.uk/aluminium/

Science of the Total Environment 665 (2019) 432–437

Contents lists available at ScienceDirect

Science of the Total Environment

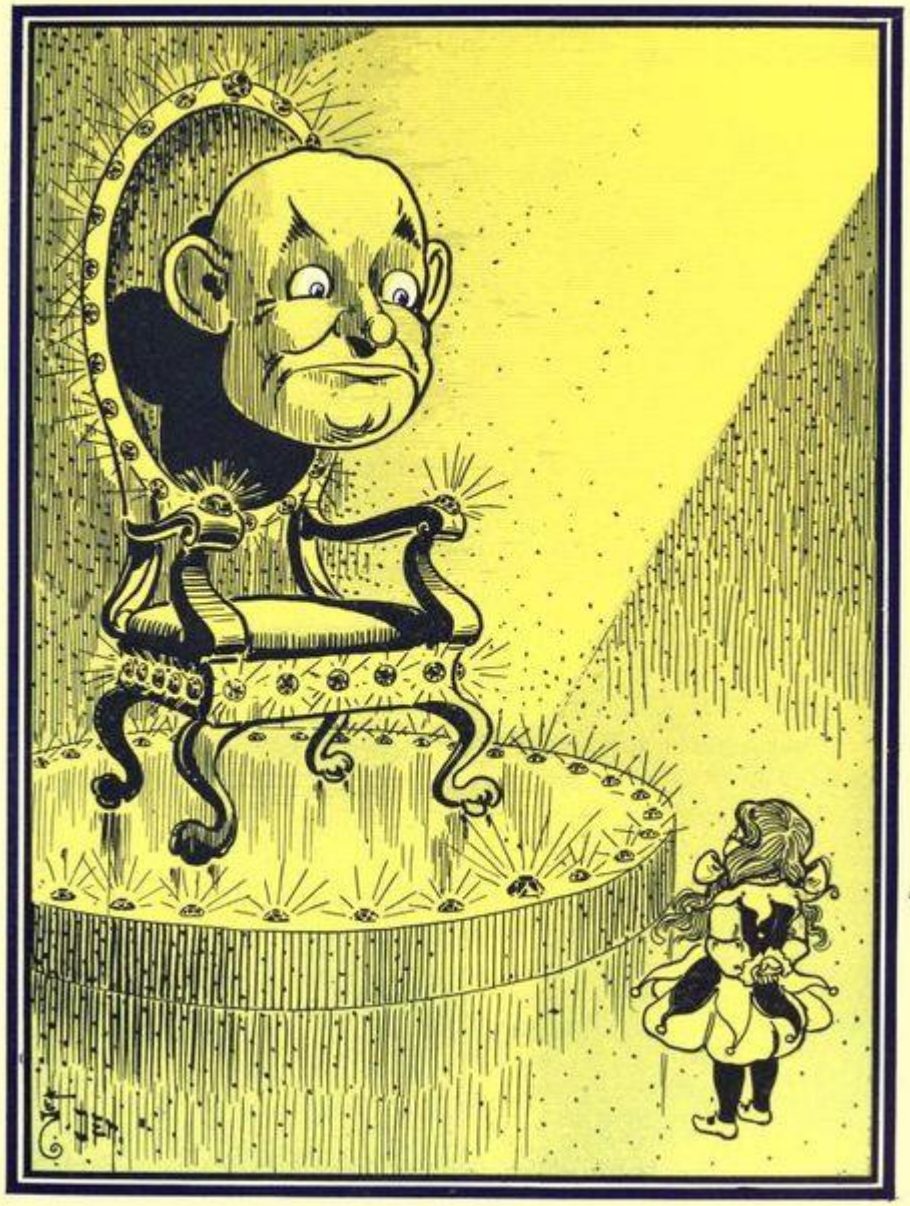
journal homepage: www.elsevier.com/locate/scitotenv

Silicic acid: The omniscient molecule

Christopher Exley [a,*], Gea Guerriero [b], Xabier Lopez [c]

[a] The Birchall Centre, Lennard-Jones Laboratories, Keele University, Staffordshire, United Kingdom
[b] Environmental Research and Innovation Department, Luxembourg Institute of Science and Technology, Esch/Alzette, Luxembourg
[c] Kimika Fakultatea, Euskal Herriko Unibertsitatea (UPV/EHU), and Donostia International Physics Center (DIPC), P.K. 1072, 20080 Donostia, Euskadi, Spain

Omniscient – adjective ‘all knowing’



"The Eyes looked at her thoughtfully."

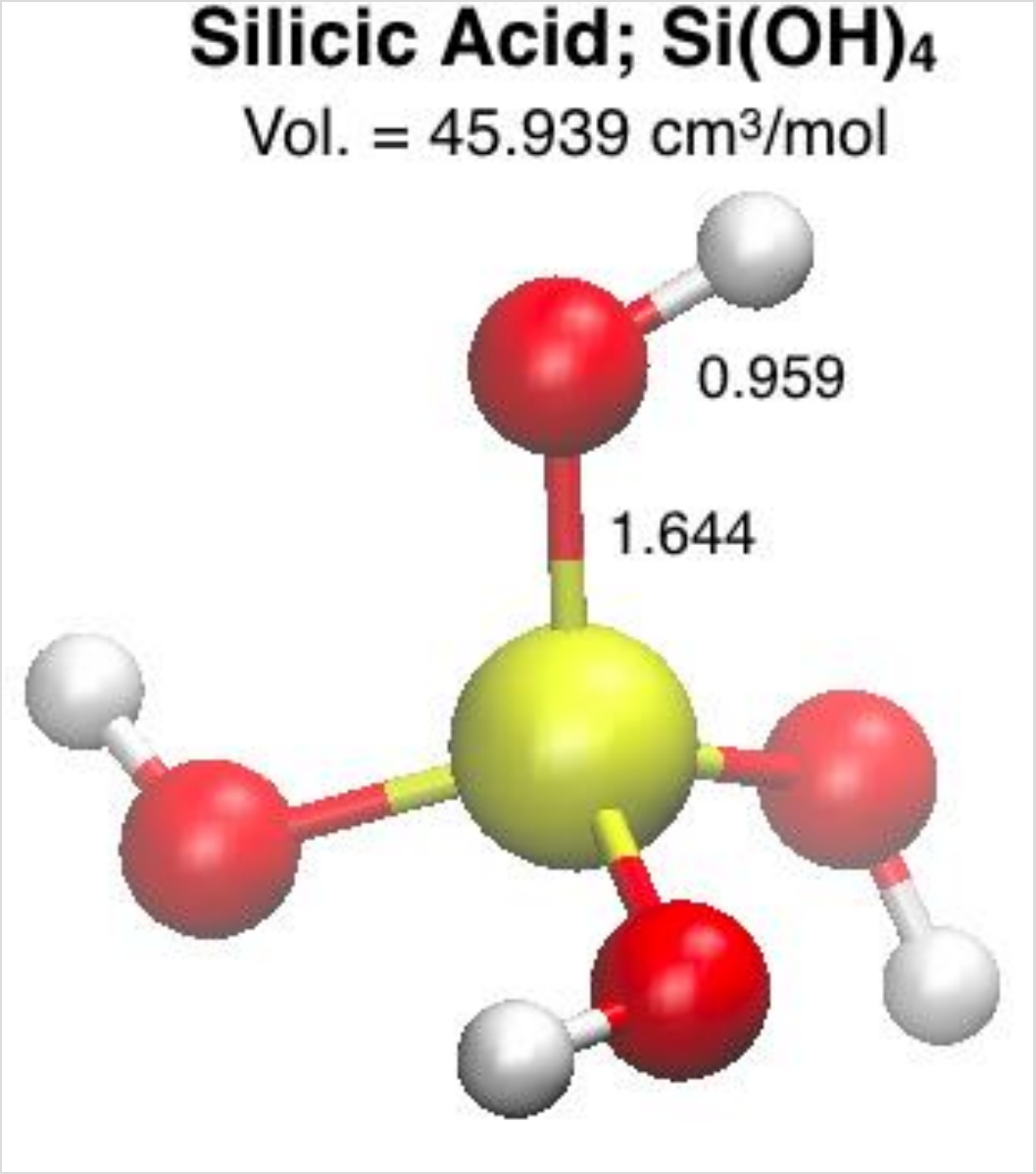

EXTRA! EXTRA!
READ ALL ABOUT IT!
FAKE
NEWS!
MEXICO

Silicic Acid is Fundamental For Planetary Health

Silicic Acid is a Small Neutral Molecule

Silicic Acid; $Si(OH)_4$

Vol. = 45.939 cm^3/mol



Silicic Acid Keeps Aluminium Out of Biota

Reprinted from Nature, Vol. 338, No. 6211, pp. 146-148, 9th March, 1989

Acute toxicity of aluminium to fish eliminated in silicon-rich acid waters

J. D. Birchall*, C. Exley†, J. S. Chappell* & M. J. Phillips†

* ICI plc, PO Box 11, Runcorn, Cheshire WA7 4QE, UK
† Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, UK

AN increased level of aluminium in acidified natural waters is a primary cause of fish death from damage to gill epithelia and loss of osmoregulatory capacity[1–4]. Aluminium toxicity depends on the species of aluminium present (cationic, neutral or anionic) and hence is affected by pH and the presence of complexing ligands, such as fluoride, and organic material, such as humic acid, which may ameliorate aluminium toxicity[5,6]. But silicic acid, $Si(OH)_4$, present in natural waters as a consequence of the weathering of the aluminosilicates of rocks and soil minerals, has a strong and unique affinity for aluminium[7], although its influence on toxicity has not been investigated. Here we show that, with an excess of Si over Al and with the formation of hydroxy-aluminosilicate species, the bioavailability of aluminium at pH 5 is reduced and acute toxicity is eliminated. Silicic acid concentration should therefore be considered as a key parameter in toxicity studies and could be important for the treatment of vulnerable waters.

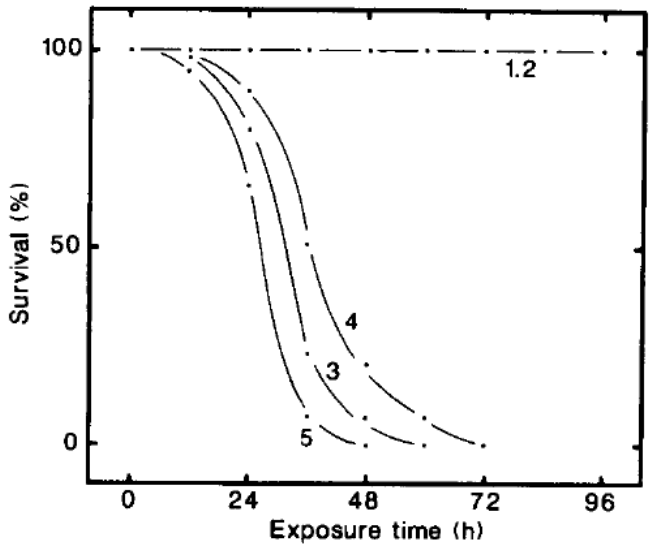
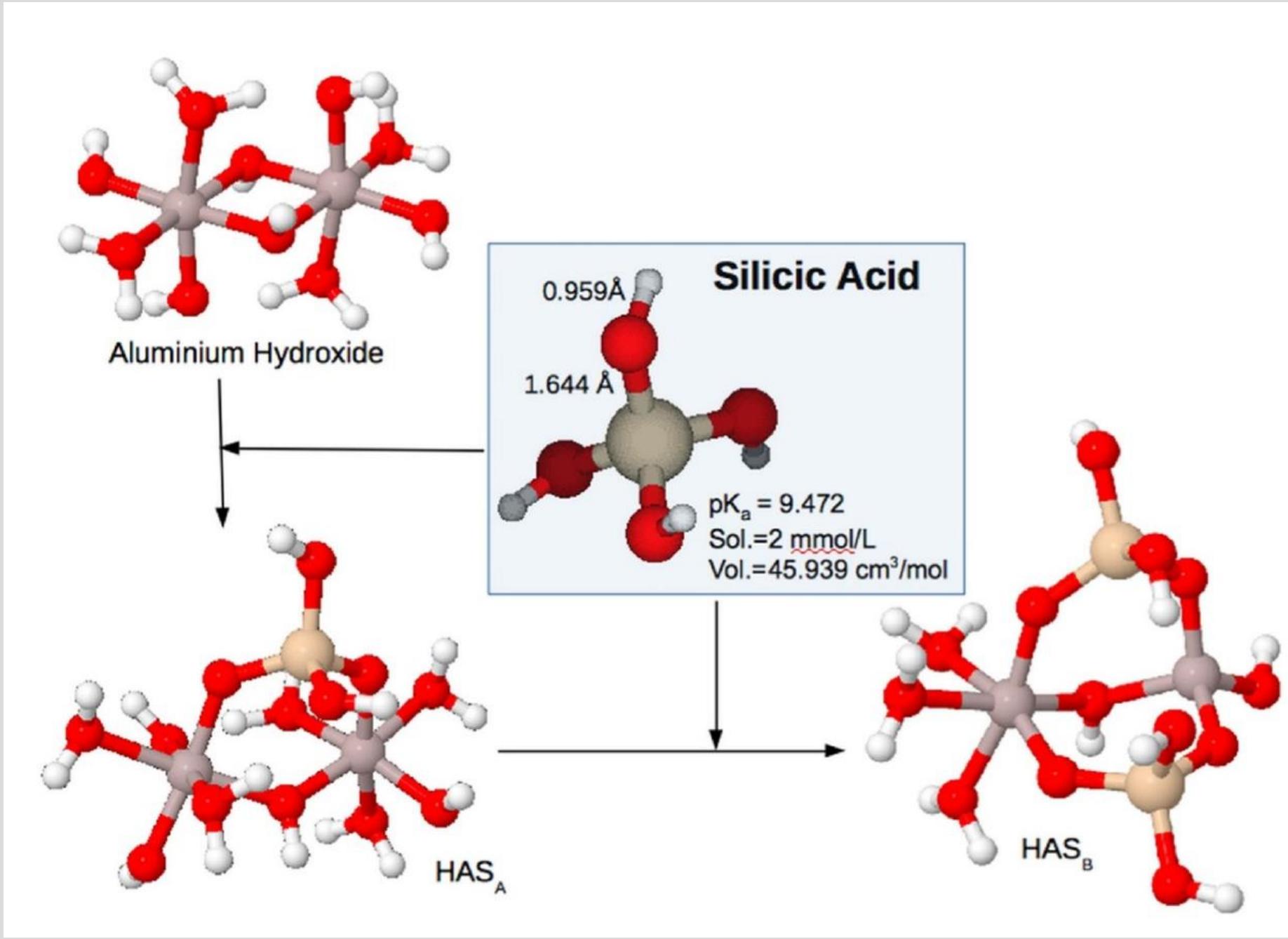
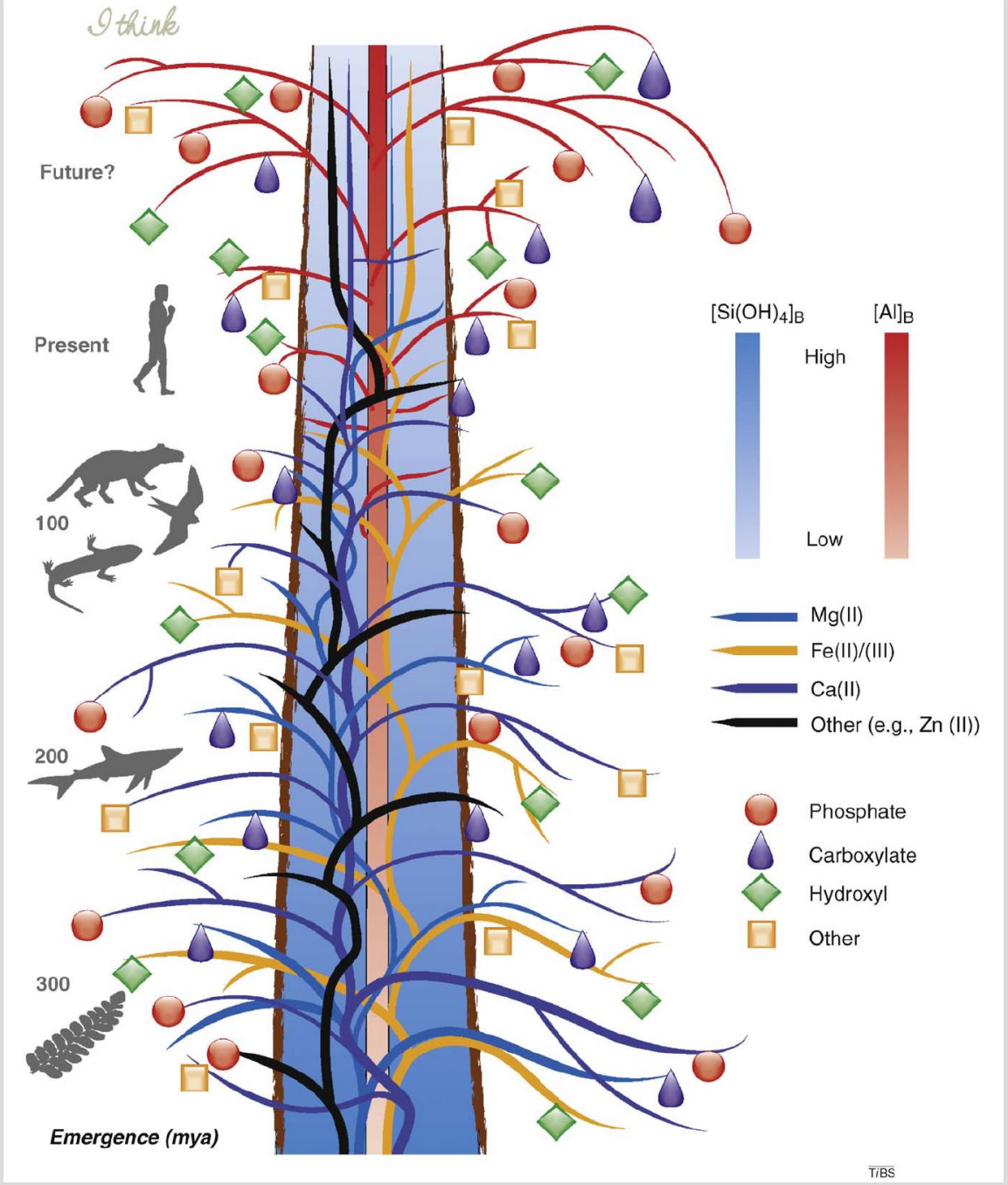


FIG. 1 Per cent survival of Atlantic salmon fry (1 g mass, post-first feeding) as a function of exposure time for the different treatment tanks (120 fish per tank). The curves are labelled for the respective tanks. All fish were kept under the control conditions for seven days before exposure and counts were made at 12-h intervals.

was eliminated and gill structures of the fish were normal when examined in the light microscope, in spite of the fact that this water contained the highest level of exchangeable aluminium. Whole fish were collected at intervals of 12 hours and analysed for accumulated Al and Si. Table 2 shows the mean levels of aluminium and silicon recorded in fish from each of the experimental tanks. The fraction of the total aluminium that is

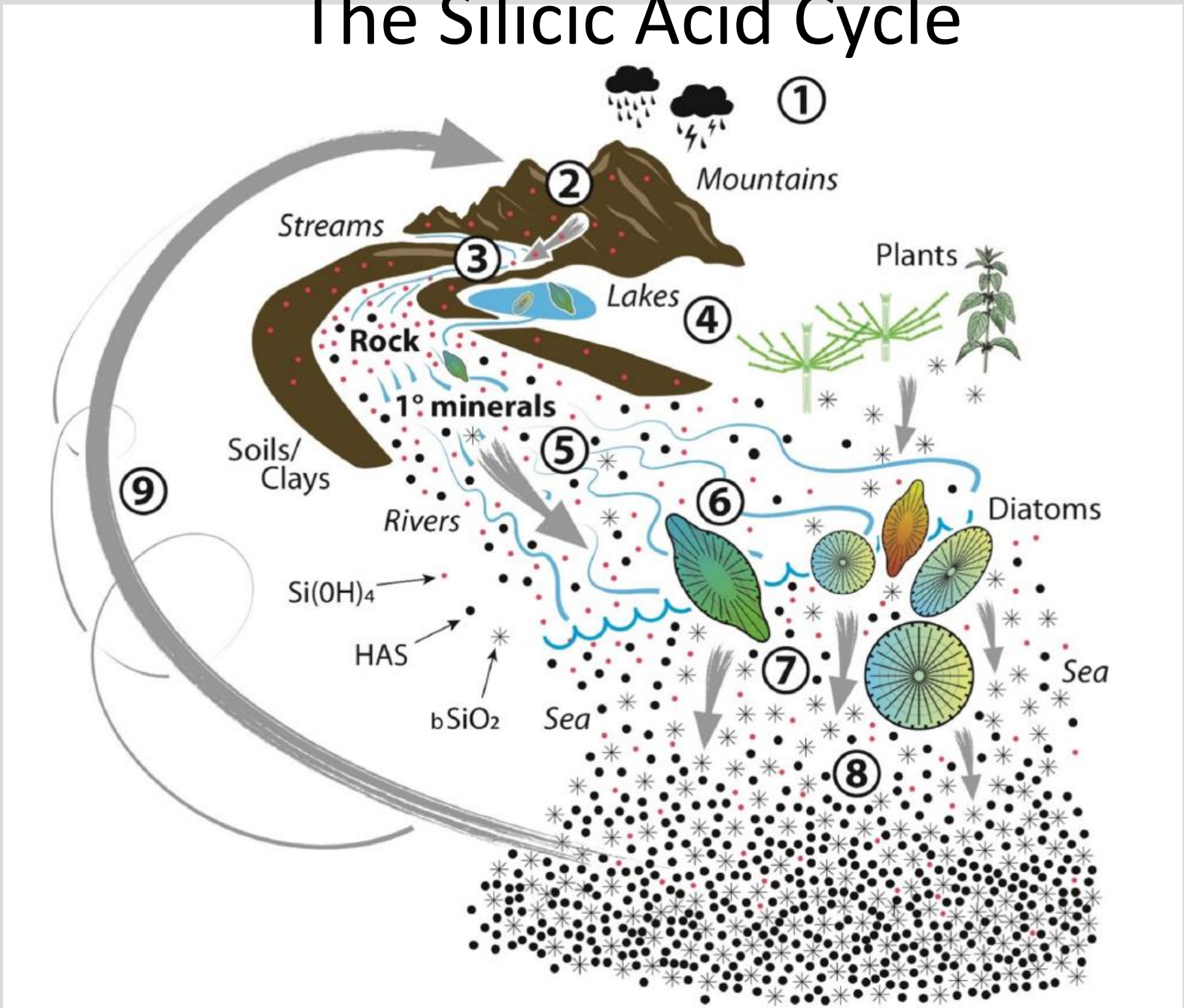

Aluminium Hydroxide
Silicic Acid
0.959Å
1.644 Å
pK$_a$ = 9.472
Sol.=2 mmol/L
Vol.=45.939 cm^3/mol
HAS$_A$
HAS$_B$



Trends in Biochemical Sciences Vol.34 No.12

Silicic Acid is Earth’s Thermostat

The Silicic Acid Cycle



Silicic Acid and Atmospheric Carbon Dioxide are Inextricably Linked Through Mineral Dissolution

[AMERICAN JOURNAL OF SCIENCE, VOL. 283, SEPTEMBER, 1983, P. 641-683]

American Journal of Science

SEPTEMBER 1983

THE CARBONATE-SILICATE GEOCHEMICAL CYCLE AND ITS EFFECT ON ATMOSPHERIC CARBON DIOXIDE OVER THE PAST 100 MILLION YEARS

ROBERT A. BERNER,* ANTONIO C. LASAGA,**
and ROBERT M. GARRELS***

The Role of the Advent of Acid Rain

INFLUENCE OF ACID RAIN ON CO_2 CONSUMPTION BY ROCK WEATHERING: LOCAL AND GLOBAL SCALES

P. AMIOTTE SUCHET, A. PROBST and J.L. PROBST

[1]*CNRS, Centre de Géochimie de la Surface, 1 rue Blessig, 67084 Strasbourg Cedex, France.*

Abstract. Sulphuric and nitric acids, which are supplied by acid precipitation, take over from carbonic acid in weathering reactions, which induced a decrease of the atmospheric/soil CO_2 consumption by weathering (WCO_2). In order to quantify this disturbance, one has compared the bicarbonate fluxes determined at the outlet of 2 small catchments (one is substantially disturbed and the other is is weakly disturbed by acid precipitation). Our study shows that, under the influence of acid precipitation, bicarbonate fluxes (i.e. WCO_2) are decreased by about 73%. It has also been attempted to simulate at the continental scale, the influence of acid precipitation on WCO_2 , using a Global Erosion Model (GEM-CO_2) recently developed. Several simulations have been performed corresponding to different realistic scenarios of global acid precipitation. In the most pessimistic of these scenarios, the GEM-CO_2 simulation shows that the global WCO_2 would be decreased by no more than 10%.

Water, Air and Soil Pollution **85**: 1563–1568, 1995

The weathering of potassium feldspar where carbonic acid is the principal weathering acid in rainfall, a relatively slow reaction rate; $10^{-15.5}$ μmol m^{-2} s^{-1}

$$2KAlSi_3O_8 + 2CO_2 + 11H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2K^+ + 2HCO_3^- + 4Si(OH)_4$$
K-Feldspar Kaolinite Silicic Acid

(6)

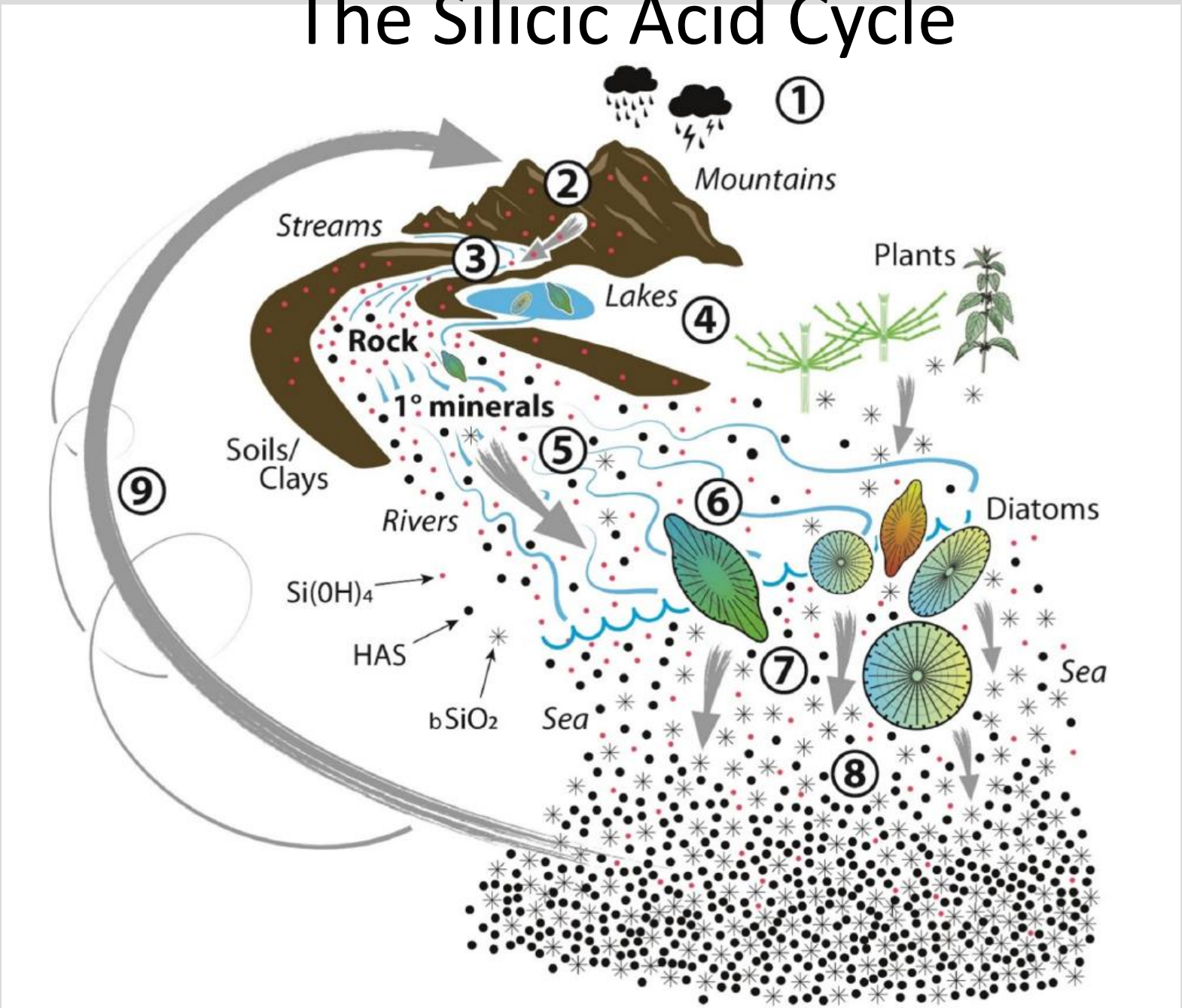
The weathering of potassium feldspar where sulphuric acid is the principal weathering acid in rainfall, a relatively fast reaction rate; $10^{-14.6}$ μmol m^{-2} s^{-1}

$$2KAlSi_3O_8 + H_2SO_4 + 4H_2O \rightarrow Al_2Si_4O_{10}(OH)_2 + 2K^+ + SO_4^{2-} + 2Si(OH)_4$$
K-Feldspar Montmorillonite Silicic Acid

(7)

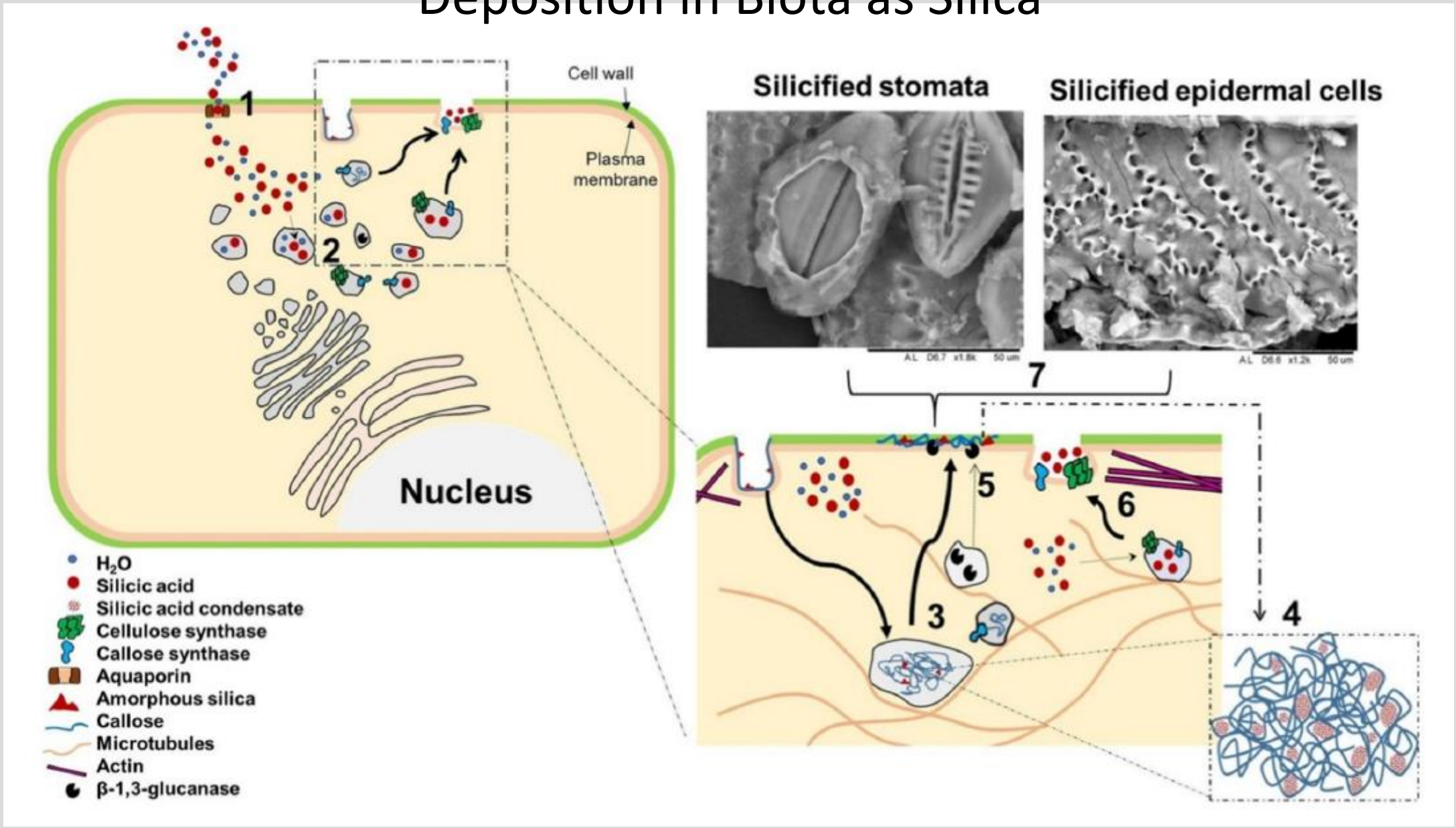
Carbon dioxide fuelled aluminosilicate mineral dissolution acts as a slow-release system for silicic acid, while sulphuric acid fuelled dissolution is more rapid, but less productive per mole of aluminosilicate mineral

The Silicic Acid Cycle



The Advent of Biological Silicification Acted as An Accelerant of Mineral Weathering

Biological Silicification: The Harvesting of Silicic Acid and its Subsequent Deposition in Biota as Silica



Biological Silicification Accelerated Carbon-Dioxide Fuelled Mineral Weathering by Reducing the Concentration of Silicic Acid in Pore and Surface Waters and Brought About **Climate Cooling**

(2000 Million Years Later)

Acid Rain brought About a Change in the Profile of Mineral Weathering and Resulted in Reduced Availability of Silicic Acid, Lower Primary Productivity (Diatoms) and **Climate Warming**

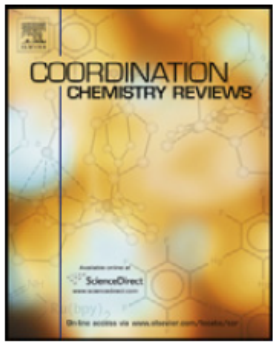
Silicic Acid, The Beneficent Molecule

Coordination Chemistry Reviews 256 (2012) 82–88

Contents lists available at ScienceDirect

Coordination Chemistry Reviews

journal homepage: www.elsevier.com/locate/ccr



Review

Reflections upon and recent insight into the mechanism of formation of hydroxyaluminosilicates and the therapeutic potential of silicic acid

Christopher Exley*

Journal of Alzheimer's Disease 33 (2013) 423–430
DOI 10.3233/JAD-2012-121231
IOS Press

Silicon-Rich Mineral Water as a Non-Invasive Test of the 'Aluminum Hypothesis' in Alzheimer's Disease

Samantha Davenward[a], Peter Bentham[b], Jan Wright[b], Peter Crome[c], Deborah Job[c], Anthony Polwart[d] and Christopher Exley[a,*]
[a]*The Birchall Centre, Lennard-Jones Laboratories, Keele University, Stoke-on-Trent, Staffordshire, UK*
[b]*Birmingham and Solihull Mental Health NHS Foundation Trust, The Barberry Centre, Birmingham, UK*
[c]*North Staffordshire Combined Healthcare NHS Trust, Harplands Hospital, Stoke-on-Trent, UK*
[d]*Life Sciences, Keele University, Stoke-on-Trent, Staffordshire, UK*

Accepted 4 August 2012

Abstract. There has been a plausible link between human exposure to aluminum and Alzheimer's disease for several decades. We contend that the only direct and ethically acceptable experimental test of the 'aluminum hypothesis', which would provide unequivocal data specific to the link, is to test the null hypothesis that a reduction in the body burden of aluminum to its lowest practical limit would have no influence upon the incidence, progression, or severity of Alzheimer's disease. Herein we are testing the hypothesis that silicon-rich mineral waters can be used as non-invasive methods to reduce the body burden of aluminum in individuals with Alzheimer's disease and a control group consisting of their carers and partners. We have shown that drinking up to 1 L of a silicon-rich mineral water each day for 12 weeks facilitated the removal of aluminum via the urine in both patient and control groups without any concomitant affect upon the urinary excretion of the essential metals, iron and copper. We have provided preliminary evidence that over 12 weeks of silicon-rich mineral water therapy the body burden of aluminum fell in individuals with Alzheimer's disease and, concomitantly, cognitive performance showed clinically relevant improvements in at least 3 out of 15 individuals. This is a first step in a much needed rigorous test of the 'aluminum hypothesis of Alzheimer's disease' and a longer term study involving many more individuals is now warranted.

We have provided preliminary evidence that over 12 weeks of silicon-rich mineral water therapy the body burden of aluminum fell in individuals with Alzheimer’s disease and, concomitantly, cognitive performance showed clinically relevant improvements in at least 3 out of 15 individuals. This is a first step in a much needed rigorous test of the ‘aluminum hypothesis of Alzheimer’s disease’ and a longer term study involving many more individuals is now warranted.

EBioMedicine 26 (2017) 60–67

Contents lists available at ScienceDirect

EBioMedicine

journal homepage: www.ebiomedicine.com

Research Paper

Urinary Excretion of Aluminium and Silicon in Secondary Progressive Multiple Sclerosis

Krista Jones [a], Caroline Linhart [b], Clive Hawkins [c], Christopher Exley [a,*]

[a] The Birchall Centre, Lennard-Jones Laboratories, Keele University, United Kingdom
[b] Department of Medical Statistics, Informatics and Health Economics, Medical University of Innsbruck, Austria
[c] Institute of Science and Technology in Medicine, Keele University, United Kingdom

ARTICLE INFO

Article history:
Received 21 September 2017
Received in revised form 16 October 2017
Accepted 30 October 2017
Available online 1 November 2017

Keywords:
Secondary progressive multiple sclerosis
Aluminium and human health
Silicon-rich mineral water
Urinary aluminium excretion
Urinary silicon excretion, non-invasive therapy

ABSTRACT

Background: Progressive multiple sclerosis is a chronic autoimmune condition of unknown aetiology and few therapeutic options. Human exposure to aluminium has been linked with multiple sclerosis and affected individuals are known to excrete unusually high amounts of aluminium in their urine. Silicon-rich mineral waters facilitate the removal of aluminium from the body in urine and herein we have tested their efficacy in affecting urinary excretion of aluminium in individuals diagnosed with secondary progressive multiple sclerosis (SPMS).
Methods: Urinary excretion of aluminium and silicon, measured using transversely-heated graphite furnace atomic absorption spectrometry, was determined in 15 individuals diagnosed with SPMS over 24 weeks, a 12 week baseline period (control) followed by a 12 week treatment period, during which individuals consumed up to 1.5 L of a silicon-rich mineral water every day.
Findings: Individuals with SPMS excreted high amounts of aluminium during the baseline period (135.2 nmol/mmol Crt (70.3–222.2, n = 180) and females excreted significantly more aluminium than males. Regular drinking of a silicon-rich mineral water increased the urinary excretion of aluminium significantly (349.0 nmol/mmol Crt (231.7–524.7, n = 180; three-way ANOVA, $F_{1,13} = 59.17$, p-value = 0.000003) relative to the baseline period. The majority of individuals, 14 out of 15, excreted more aluminium (μmol/24 h) following drinking of a silicon-rich mineral water (independent-test, $p < 0.05$). Silicon-rich mineral waters may be an effective and non-invasive therapy for the removal of aluminium from the body of individuals with SPMS.

Regular drinking of a silicon-rich mineral water increased the urinary excretion of aluminium significantly (349.0 nmol/mmol Crt (231.7–524.7, n = 180; three-way ANOVA, $F_{1,13} = 59.17$, p-value = 0.000003) relative to the baseline period. The majority of individuals, 14 out of 15, excreted more aluminium (μmol/24 h) following drinking of a silicon-rich mineral water (independent-test, $p < 0.05$). Silicon-rich mineral waters may be an effective and non-invasive therapy for the removal of aluminium from the body of individuals with SPMS.

Myriad Anecdotes a Clinical Trial Doth Not Make

“A little over 2 months ago we started Fiji water. I thought it was silly so I drank 1.5 liters very quickly and my 5 year old (who has asd and spd) had 16 oz. My son got a headache a few hours later and had some wild behaviors in the following days. I continued to drink 1.5 and I lowered my son quite a bit. I then started to get super dizzy so I lowered my consumption as well. That first week was pretty dramatic! My brain fog lifted and the feeling of a heavy chest vanished. My son was much calmer, more focused, less sensory sensitive, and generally more happy. Fast forward 2 months. My sons eye contact has increased dramatically, he sings every once and awhile, he is playing more with kids, and he now begs for Fiji water. My own symptoms have improved quite a bit, I have POTS, MCAS, and EDS”.