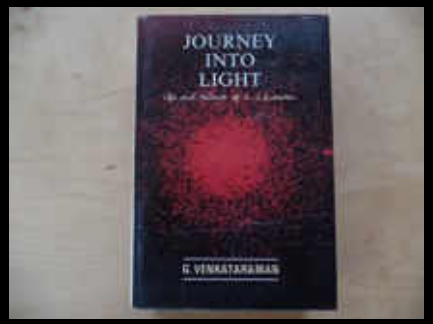
Global science for global well-being

Thalappil Pradeep
Institute Professor
Deepak Parekh Institute Chair Professor
IIT Madras



Thank you, Shihab

IIT Tirupati, February 25, 2023

Earthrise, taken on December 24, 1968, by Apollo 8 astronaut William Andres.

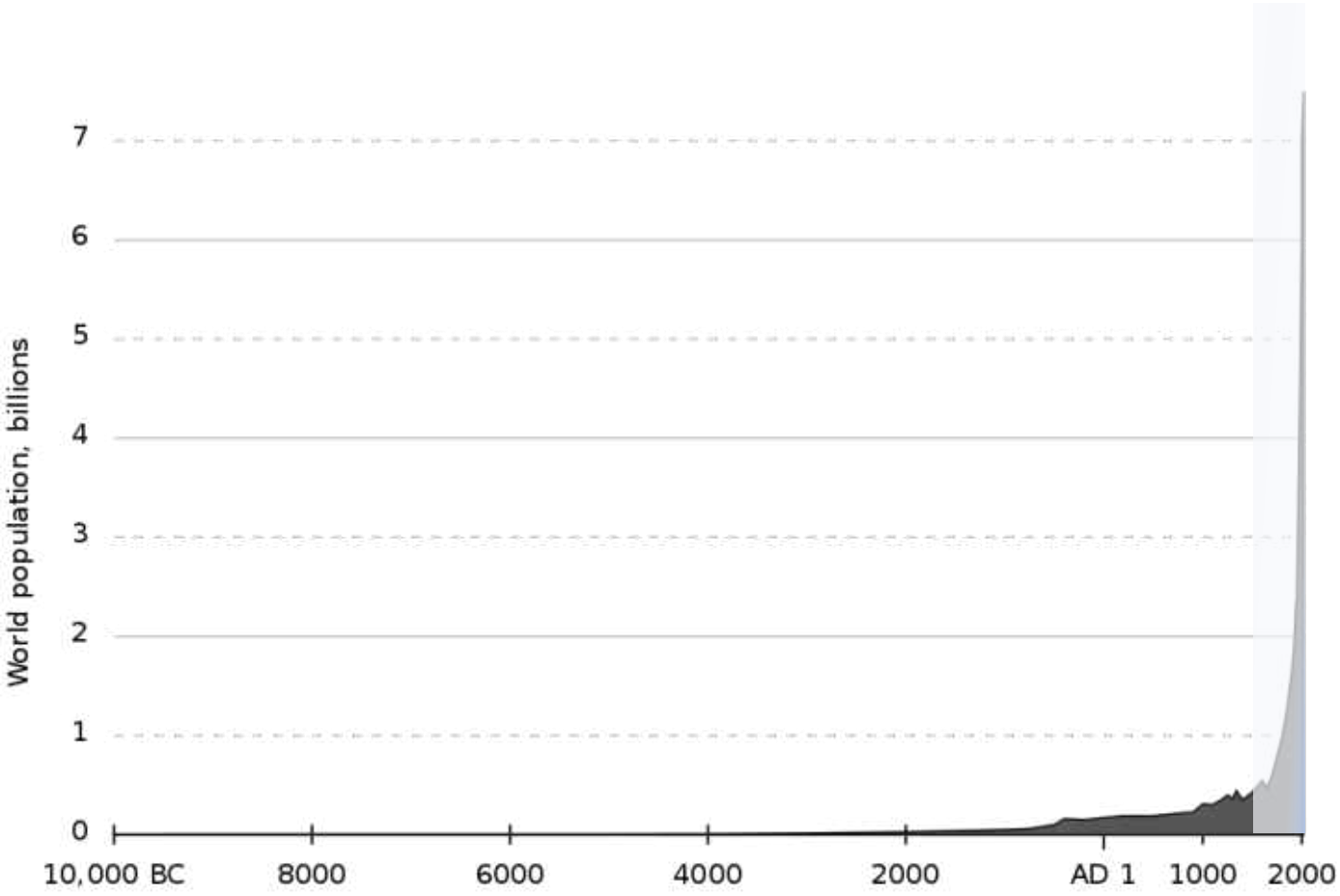
Nature photographer Galen Rowell declared it "the most influential environmental photograph ever taken".

Global science – why now?

"Pale blue dot" Voyager 1 Feb. 14, 1990

From Wikipedia

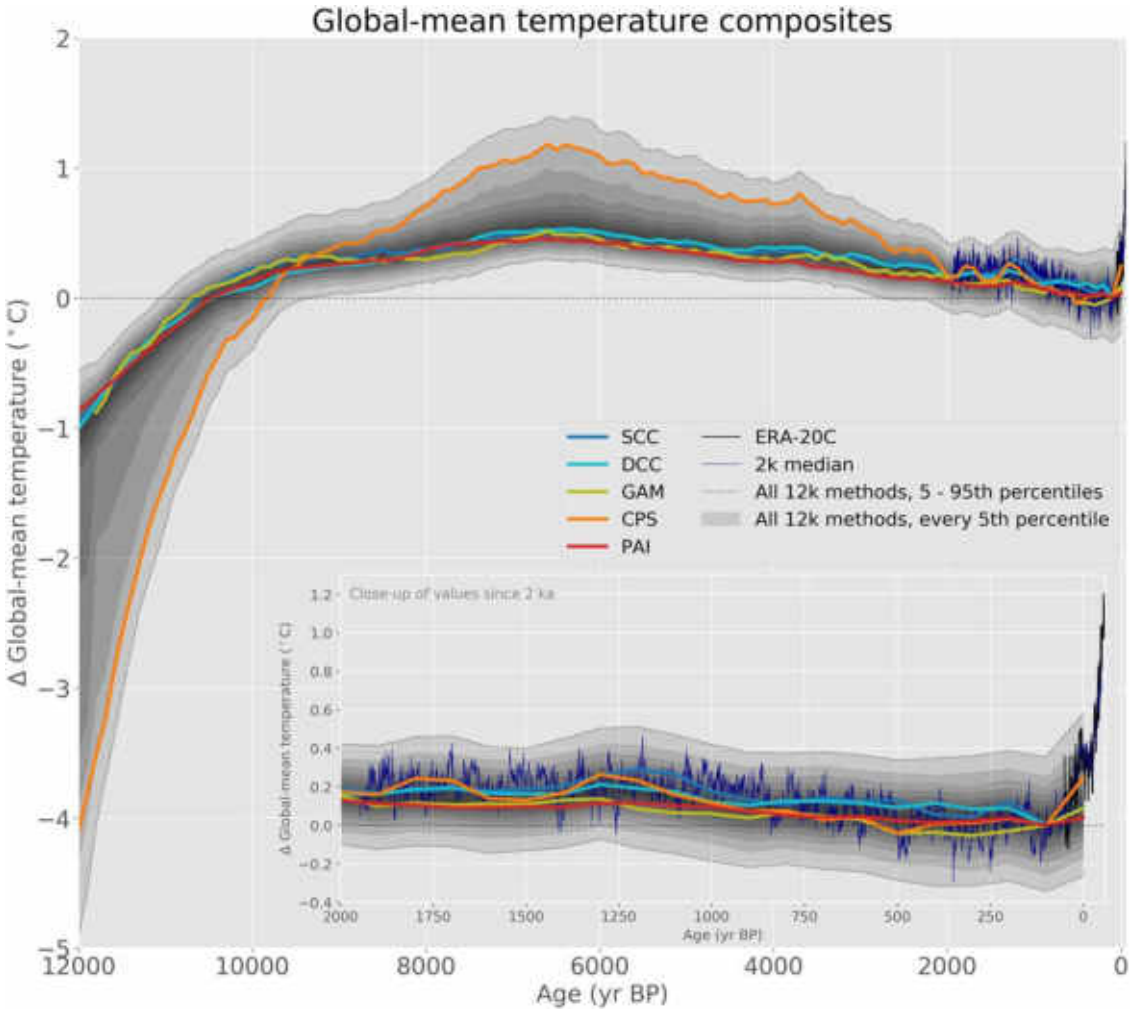
World population



Wikipedia

Galileo Galilei 1589-92

The Holocene Epoch – The triumph of man

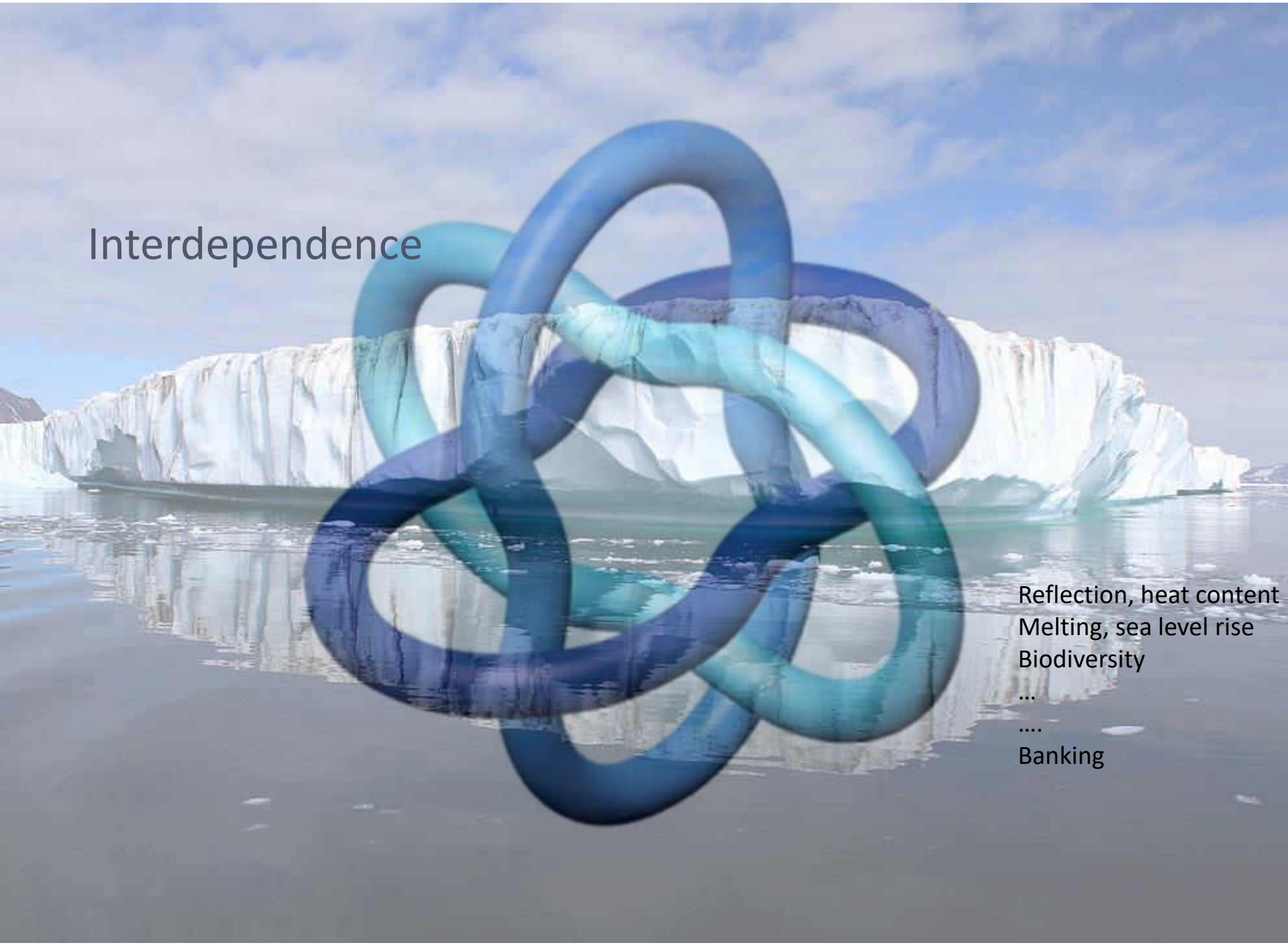


Global mean surface temperature from the Temperature 12k database using different reconstruction methods. The black line is instrumental data for 1900–2010 from the ERA-20C reanalysis product. The inset displays an enlarged view of the past 2000 years.

Darrell Kaufman et al. *Scientific Data* **volume 7**, Article number: 201 (2020)

The control over carbon emissions by developed countries is probably not the reason for the globe's survival, but the lack of development in less-developed countries is….
Intergovernmental Panel on Climate Change (IPCC). 2014

Interdependence



Reflection, heat content
Melting, sea level rise
Biodiversity
…
….
Banking

THE LIMITS TO growth

Donella H. Meadows
Dennis L. Meadows
Jørgen Randers
William W. Behrens III

A Report for THE CLUB OF ROME'S Project on Predicament of Mankind

A POTOMAC ASSOCIATES BOOK $2

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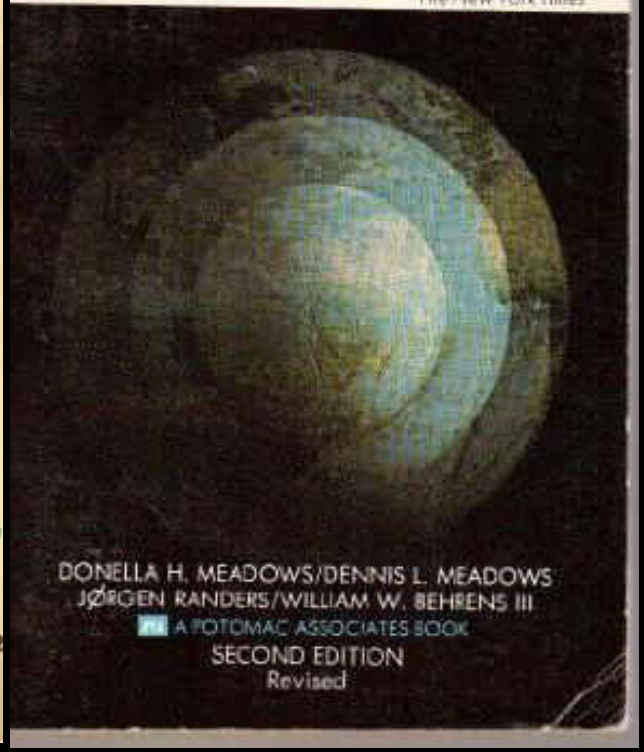
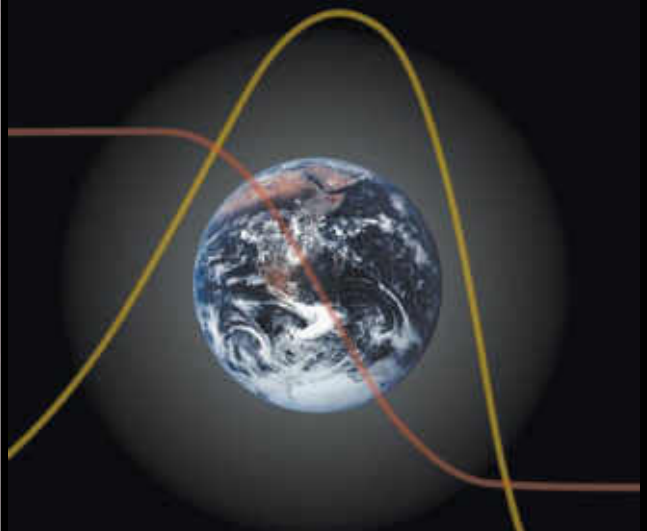
THE LIMITS TO GROWTH

The headline-making report on the imminent global disaster facing humanity—and what we can do about it before time runs out. "One of the most important documents of our age!" —Anthony Lewis, The New York Times



DONELLA H. MEADOWS/DENNIS L. MEADOWS
JØRGEN RANDERS/WILLIAM W. BEHRENS III
A POTOMAC ASSOCIATES BOOK
SECOND EDITION
Revised

LIMITS TO GROWTH



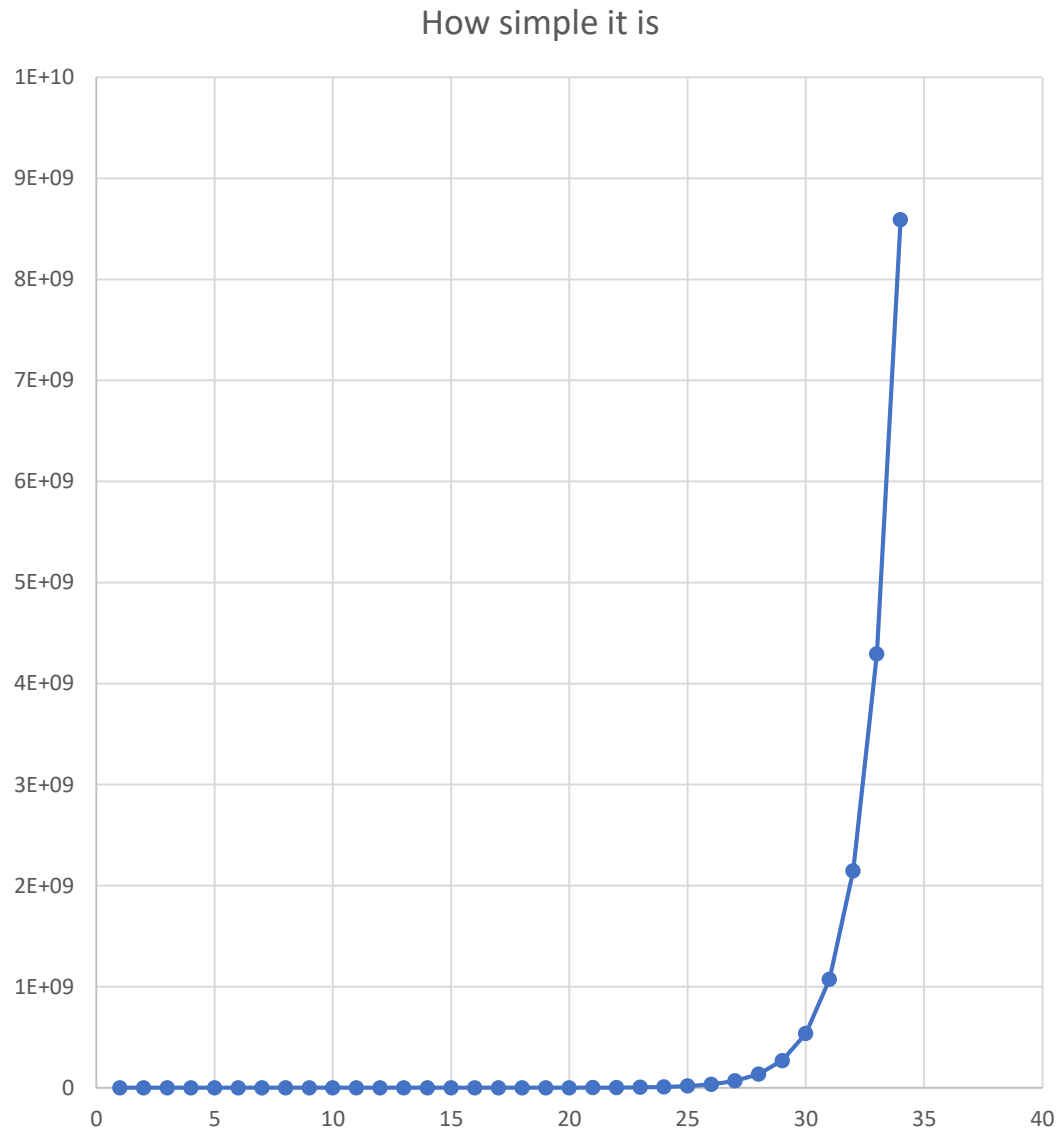
The 30-Year Update

Donella Meadows | Jorgen Randers | Dennis Meadows

Science made it possible

- 34 generations to make
- our population

- 34 x 25 = 850 years



Reactions that changed the world

1. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

2. $H_2 + 3\ H_2 \rightarrow 2NH_3$ 220 million tons a year

3. $NH_3 + CO_2 \rightarrow NH_2\text{-}CO\text{-}NH_2 + H_2O$ >180 million tons 2022

4. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

5. $nC_2H_4 \rightarrow -(CH_2)n-$ polyethylene >130 million tons 2022

6. Polymerase chain reaction

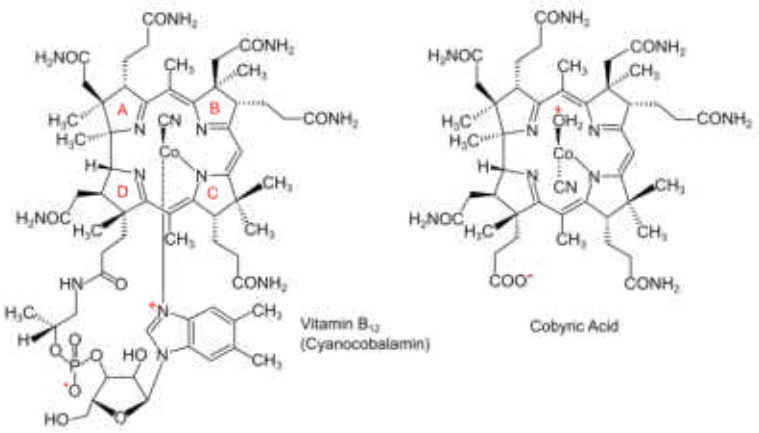
7. Electrochemistry

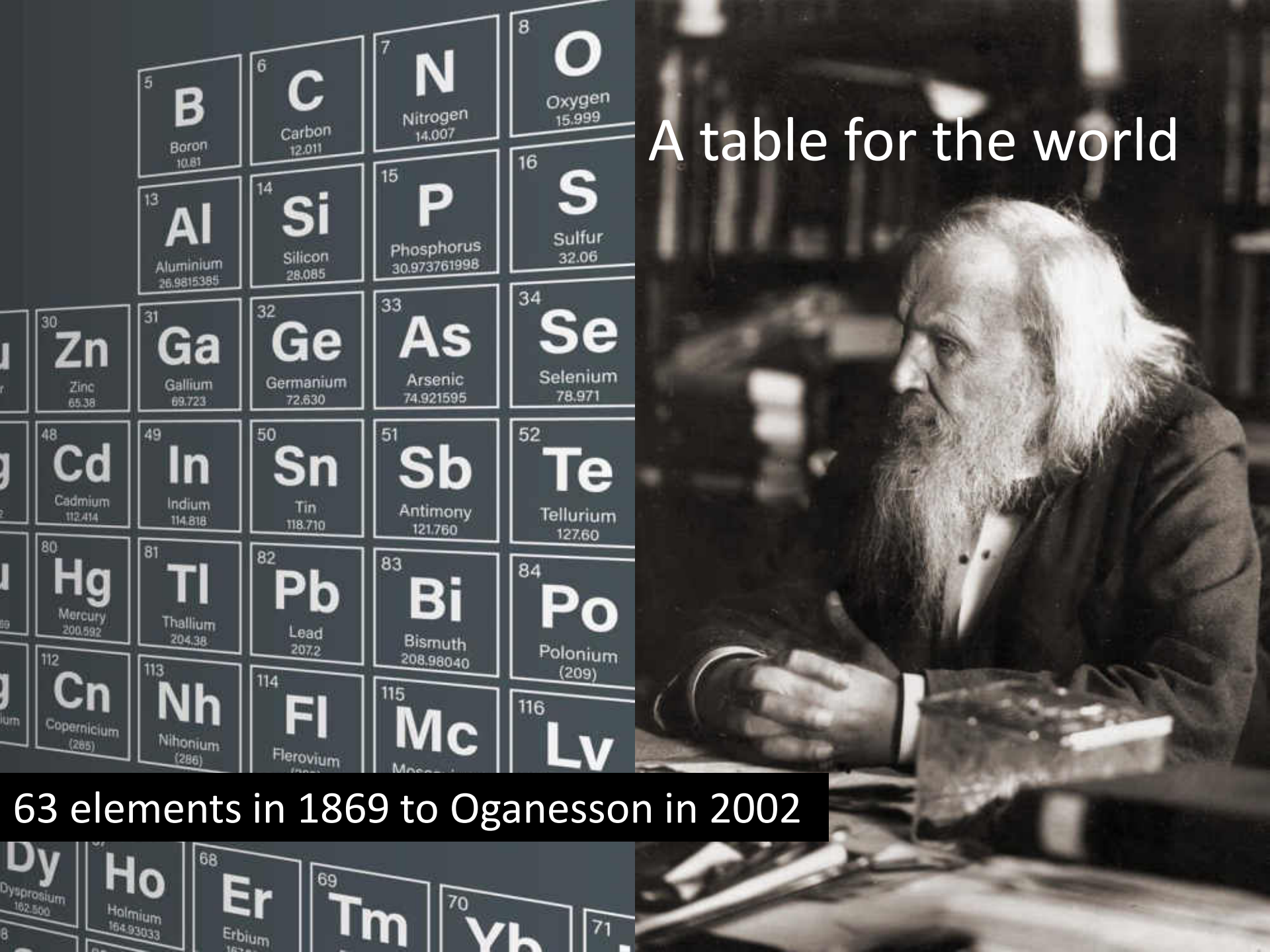
Molecules that changed the world

Aspirin, urea, morphine, strychnine, penicillin, vitamin B12, Taxol, and quinine

Molecules that destroyed the world

CFCs, DDT, Agent orange - 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), endosulfan, thalidomide,…




A table for the world
63 elements in 1869 to Oganesson in 2002
5 B Boron 10.81
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
13 Al Aluminium 26.9815385
14 Si Silicon 28.085
15 P Phosphorus 30.973761998
16 S Sulfur 32.06
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.630
33 As Arsenic 74.921595
34 Se Selenium 78.971
48 Cd Cadmium 112.414
49 In Indium 114.818
50 Sn Tin 118.710
51 Sb Antimony 121.760
52 Te Tellurium 127.60
80 Hg Mercury 200.592
81 Tl Thallium 204.38
82 Pb Lead 207.2
83 Bi Bismuth 208.98040
84 Po Polonium (209)
112 Cn Copernicium (285)
113 Nh Nihonium (286)
114 Fl Flerovium
115 Mc
116 Lv
Dy Dysprosium 162.500
Ho Holmium 164.93033
68 Er Erbium
69 Tm
70 Yb
71

Molecules – Diseases and their cure

Reprinted from SCIENCE, November 25, 1949, Vol. 110, No. 2865, pages 543-548.

Sickle Cell Anemia, a Molecular Disease[1]

Linus Pauling, Harvey A. Itano,[2] S. J. Singer,[3] and Ibert C. Wells[3]

Gates and Crellin Laboratories of Chemistry,
California Institute of Technology, Pasadena, California[4]

THE ERYTHROCYTES of certain individuals possess the capacity to undergo reversible changes in shape in response to changes in the partial pressure of oxygen. When the oxygen pressure is lowered, these cells change their forms from the normal biconcave disk to crescent, holly wreath, and other forms. This process is known as sickling. About 8 percent of American Negroes possess this characteristic; usually they exhibit no pathological consequences ascribable to it. These people are said to have sicklemia, or sickle cell trait. However, about 1 in 40 (*4*) of these individuals whose cells are capable of sickling suffer from a severe chronic anemia resulting from excessive destruction of their erythrocytes; the term sickle cell anemia is applied to their condition.

The main observable difference between the erythrocytes of sickle cell trait and sickle cell anemia has been that a considerably greater reduction in the partial pressure of oxygen is required for a major fraction of the trait cells to sickle than for the anemia cells (*11*). Tests *in vivo* have demonstrated that between 30 and 60 percent of the erythrocytes in the venous circulation of sickle cell anemic individuals, but less than 1 percent of those in the venous circulation of sicklemic individuals, are normally sickled. Experiments *in vitro* indicate that under sufficiently low oxygen pressure, however, all the cells of both types assume the sickled form.

The evidence available at the time that our investigation was begun indicated that the process of sickling might be intimately associated with the state and the nature of the hemoglobin within the erythrocyte. Sickle cell erythrocytes in which the hemoglobin is combined with oxygen or carbon monoxide have the biconcave disk contour and are indistinguishable in that form from normal erythrocytes. In this condition they are termed prominocytes. The hemoglobin appears to be uniformly distributed and randomly oriented within normal cells and prominocytes, and no birefringence is observed. Both types of cells are very flexible. If the oxygen or carbon monoxide is removed, however, transforming the hemoglobin to the uncombined state, the prominocytes undergo sickling. The hemoglobin within the sickled cells appears to aggregate into one or more frai, and the cell membranes collapse. The cells become birefringent (*11*) and quite rigid. The addition of oxygen or carbon monoxide to these cells reverses these phenomena. Thus the physical effects just described depend on the state of combination of the hemoglobin, and only secondarily, if at all, on the cell membrane. This conclusion is supported by the observation that sickled cells when lysed with water produce discoidal, rather than sickle-shaped, ghosts (*10*).

It was decided, therefore, to examine the physical and chemical properties of the hemoglobins of individuals with sicklemia and sickle cell anemia, and to compare them with the hemoglobin of normal individuals to determine whether any significant differences might be observed.

Experimental Methods

The experimental work reported in this paper deals largely with an electrophoretic study of these hemoglobins. In the first phase of the investigation, which concerned the comparison of normal and sickle cell anemia hemoglobins, three types of experiments were performed: 1) with carbonmonoxyhemoglobins; 2) with uncombined ferrohemoglobins in the presence of dithionite ion, to prevent oxidation to methemoglobin; and 3) with carbonmonoxyhemoglobins in the presence of dithionite ion. The experiments of type 3 were performed and compared with those of type 1 in order to ascertain whether the dithionite ion itself causes any specific electrophoretic effect.

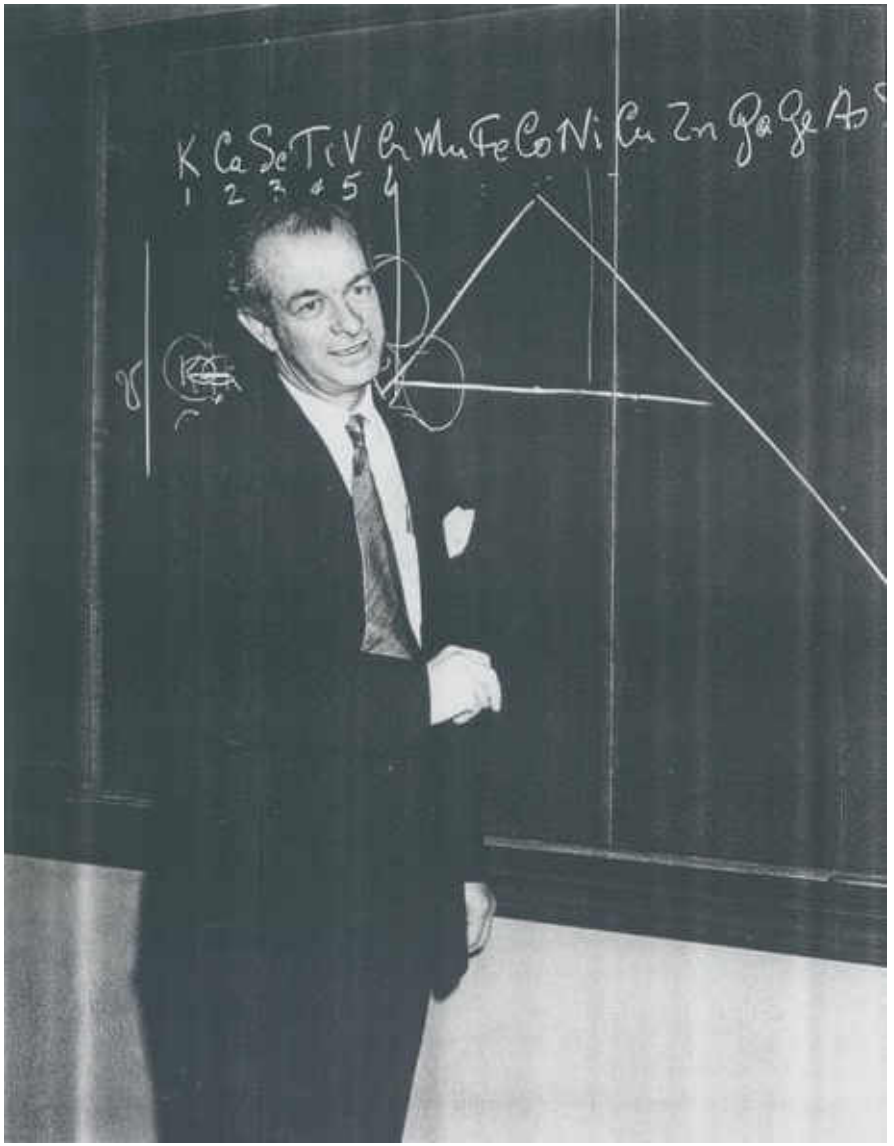
Samples of blood were obtained from sickle cell anemic individuals who had not been transfused within three months prior to the time of sampling. Stroma-free concentrated solutions of human adult hemoglobin were prepared by the method used by Drabkin (*5*). These solutions were diluted just before use with the

[1] This research was carried out with the aid of a grant from the United States Public Health Service. The authors are grateful to Professor Ray D. Owen, of the Biology Division of this Institute, for his helpful suggestions. We are indebted to Dr. Edward R. Evans, of Pasadena, Dr. Travis Winsor, of Los Angeles, and Dr. G. H. Beeth, of the Tulane University School of Medicine, New Orleans, for their aid in obtaining the blood used in these experiments.

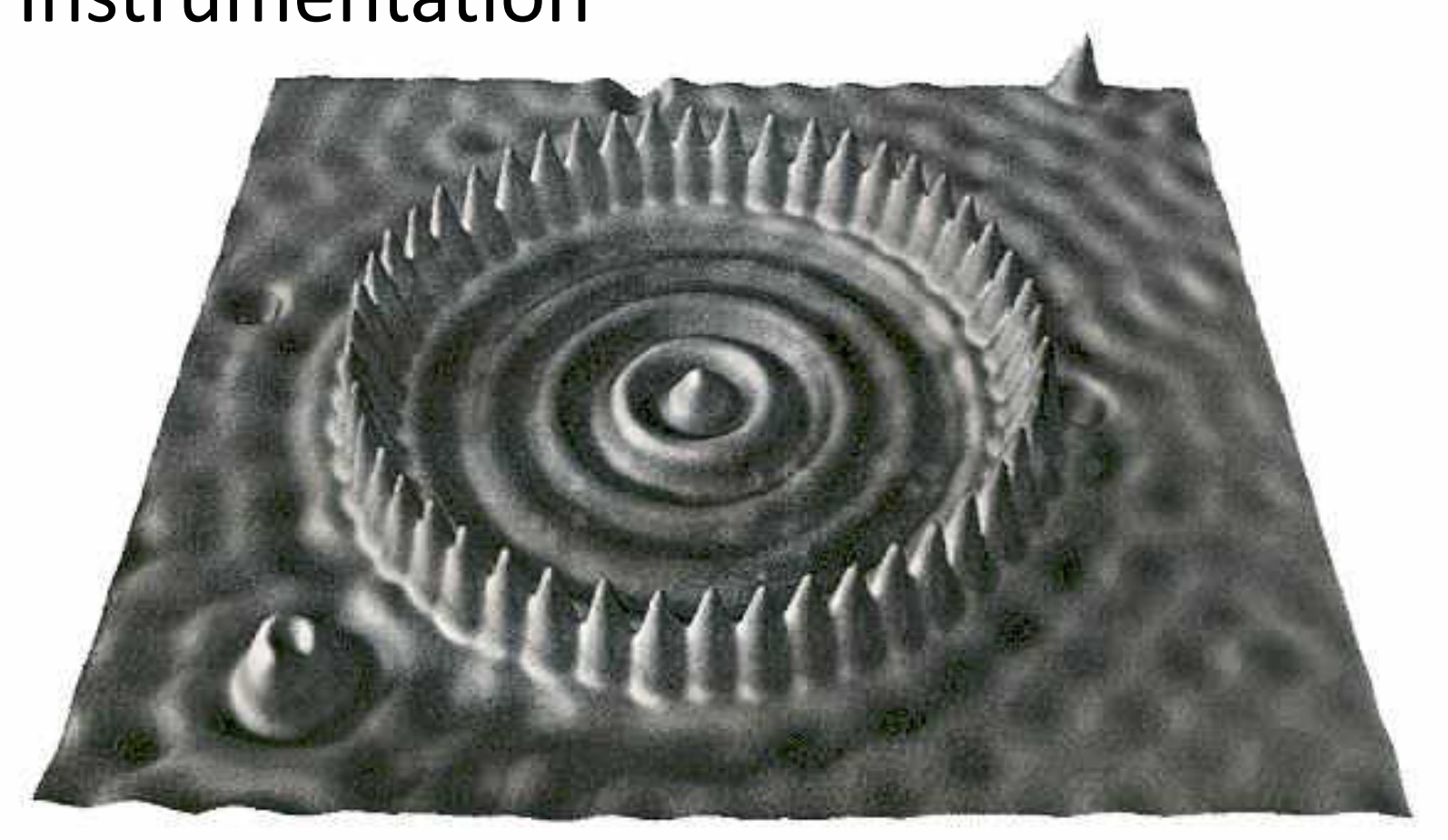
[2] U. S. Public Health Service postdoctoral fellow of the National Institutes of Health.

[3] Postdoctoral fellow of the Division of Medical Sciences of the National Research Council.

[4] Contribution No. 1233.



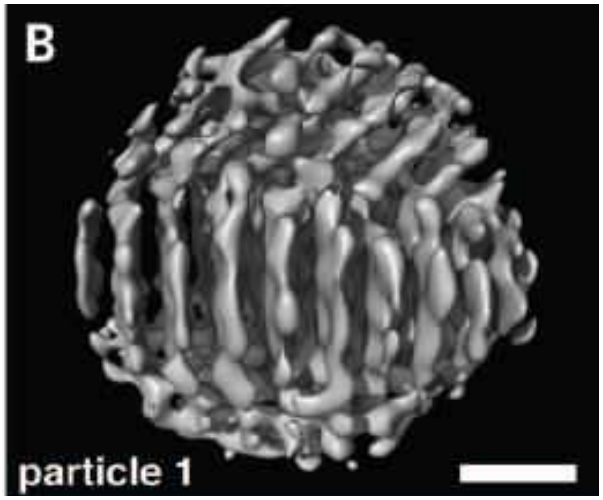
Instrumentation



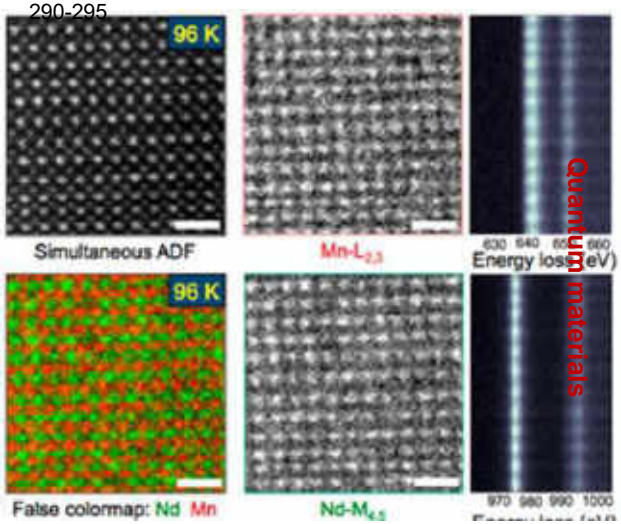
STM image of a “quantum corral” (courtesy IBM Research Division).

D. W. Eigler, et. Al. Science, 262(5131), 218-220.

Seeing atoms, molecules and assemblies



3D Structure of Individual Nanocrystals in Solution by Electron Microscopy. Park, J. et al., *Science* **2015,** *349,* 290-295

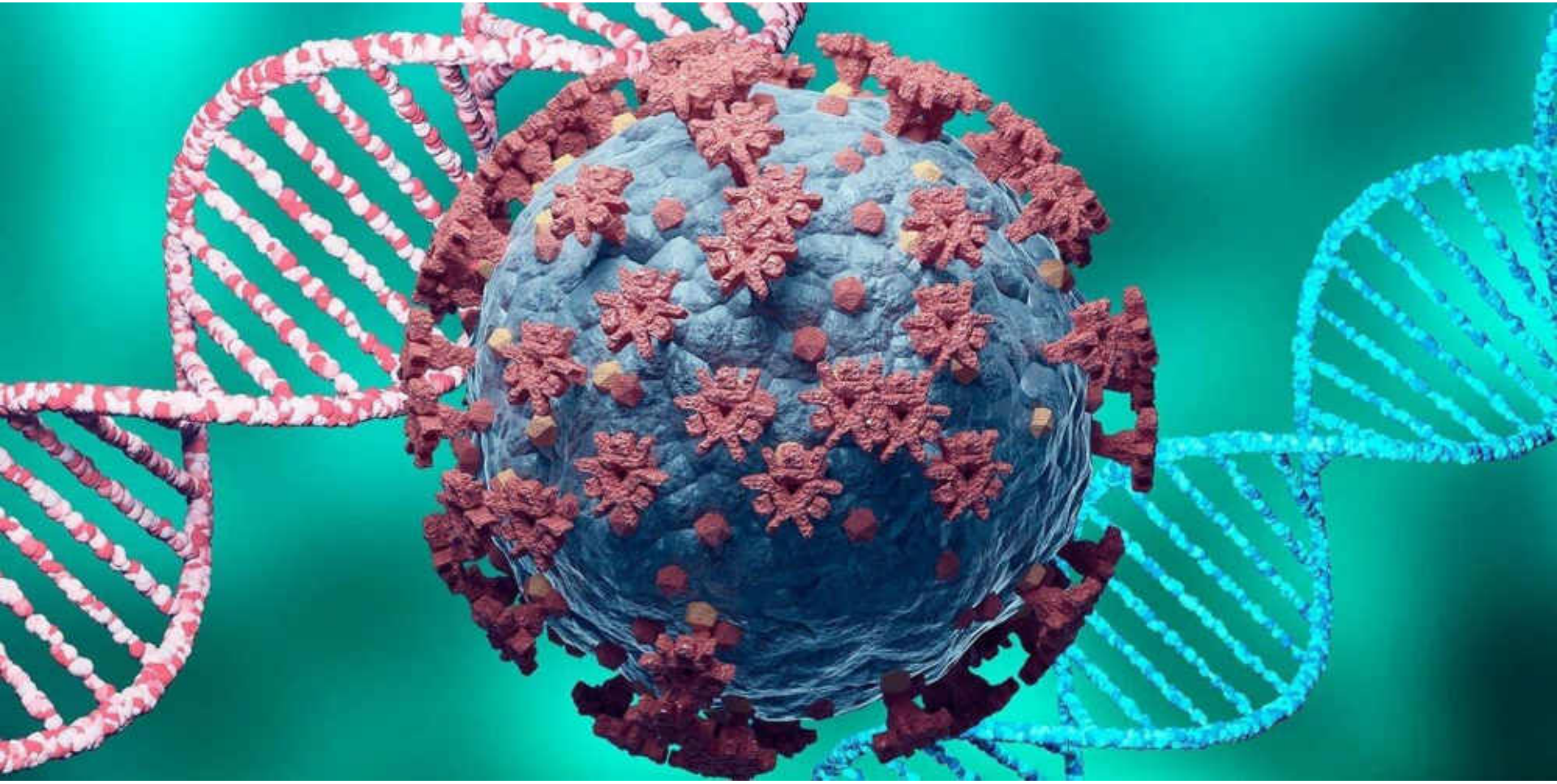


Baek, D. J. et al., *Microsc.Microanal.* **2018**, *24*, 454−455
Nature and evolution of incommensurate charge order in manganites visualized with cryogenic scanning transmission electron microscopy. Baggari, I. E. et al., *Proc. Natl. Acad. Sci.* **2018**, *115*, 1445−1450.

https://www.....

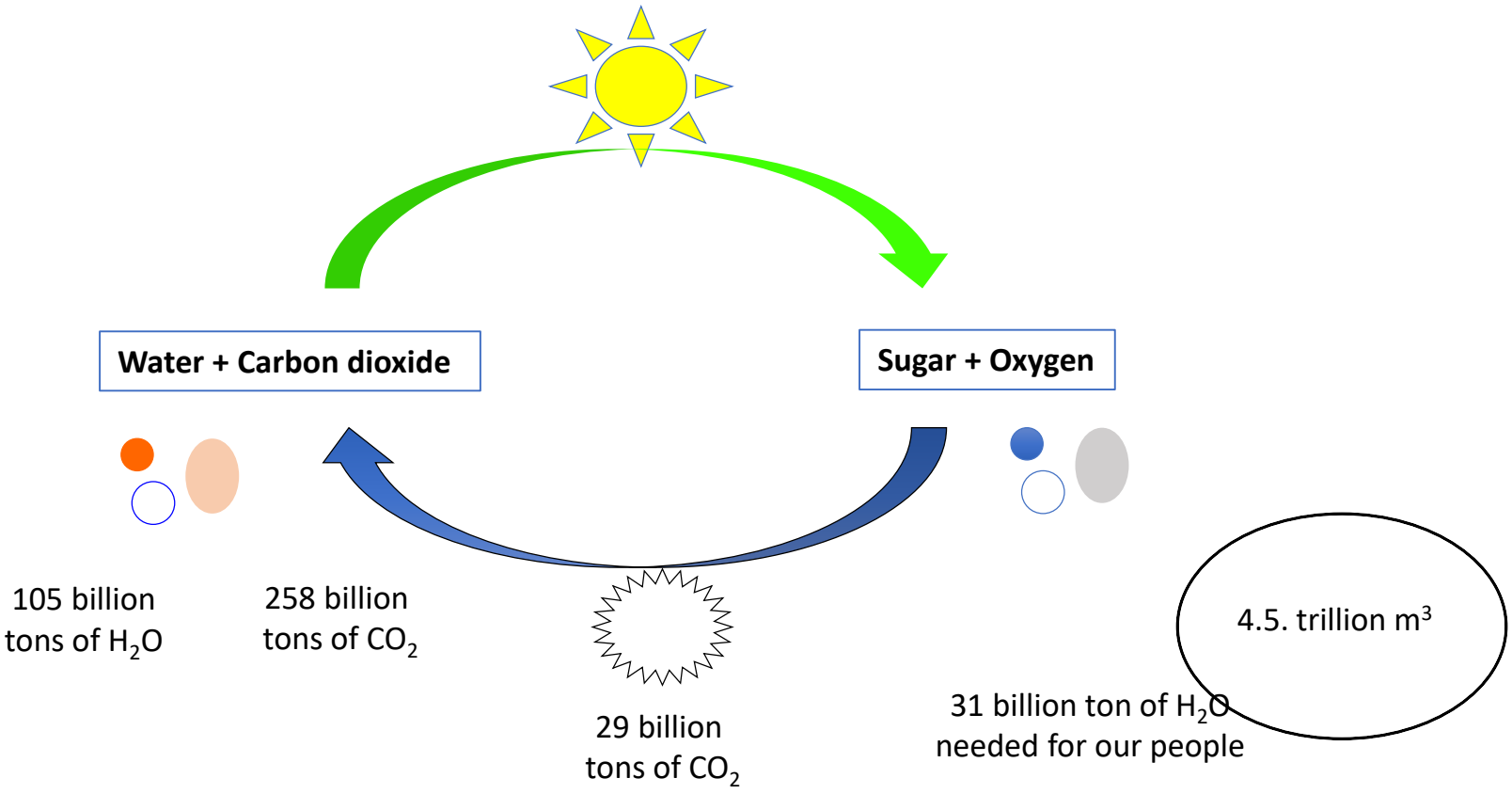
From https://www.simplilearn.com/what-is-internet-article

Nature, engineering, life….



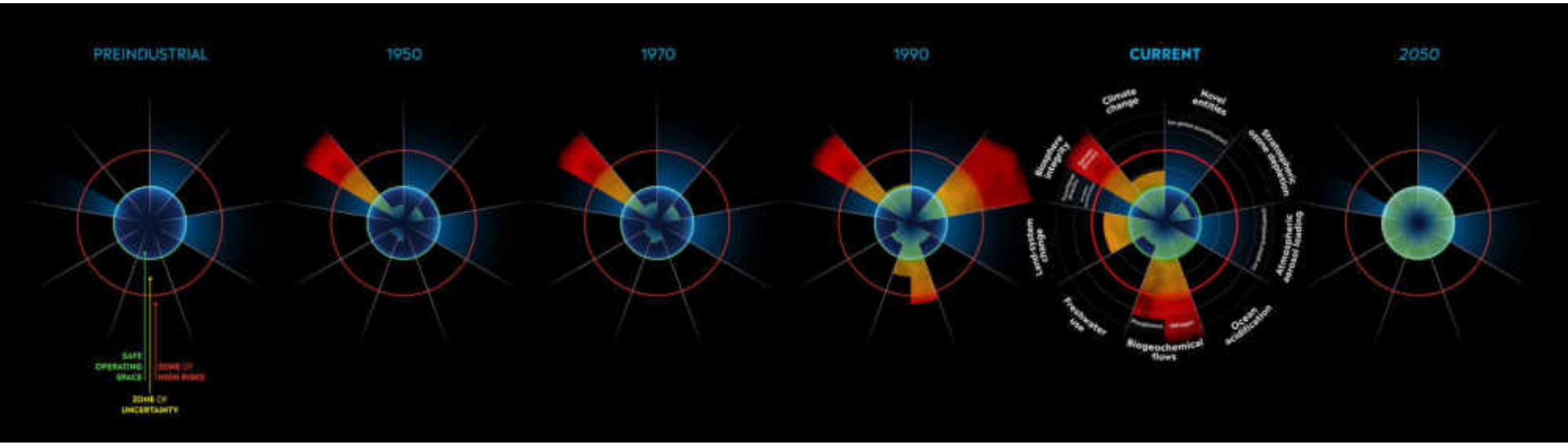
From WHO

We opened the cycle



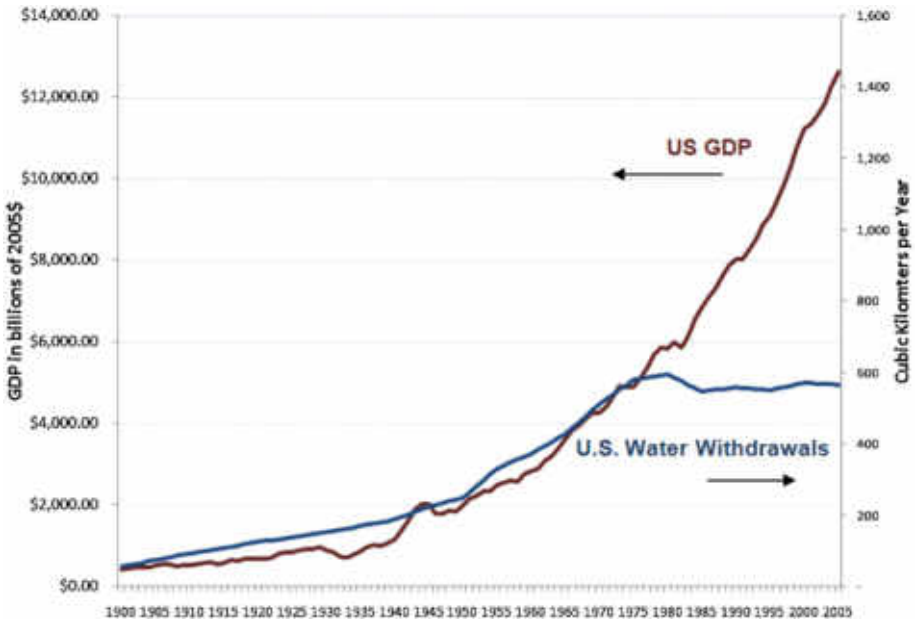
Our restriction – confined space

Planetary boundaries



https://globaia.org/planetary-boundaries

Water and GDP



US gross domestic product (GDP) in 2005 dollars from 1900 to 2005 (left axis) plotted with total water withdrawals for all purposes in cubic kilometers per year (right axis). Data on GDP come from the US Bureau of Economic Analysis; data on water use comes from the US Geological Survey.

Peter H. Gleick and Meena Palaniappan, Peak water limits to freshwater withdrawal and use, PNAS, 2010, 107, 11155–11162


Biological complexity is built with just a few elements
https://blog.gale.com/celebrating-the-periodic-table/

We developed environmentally friendly water positive nanoscale materials for affordable, sustainable and rapid removal of arse
from drinking water.

There are over 1700 community installations across the country, serving 1.3 million people with arsenic and iron-free water ever

Biopolymer-reinforced synthetic granular nanocomposites for affordable point-of-use water purification

Mohan Udhaya Sankar[1], Sahaja Aigal[1], Shihabudheen M. Maliyekkal[1], Amrita Chaudhary, Anshup, Avula Anil Kumar, Kamalesh Chaudhari, and Thalappil Pradeep[2]

Unit of Nanoscience and Thematic Unit of Ex

Madras, Chennai 600 036, India

Edited by Eric Hoek, University of California,

(received for review November 21, 2012)

Creation of affordable materials for cons
water is one of the most promising ways
drinking water for all. Combining the
composites to scavenge toxic species
other contaminants along with the ab
affordable, all-inclusive drinking water
without electricity. The critical proble
synthesis of stable materials that can
uously in the presence of complex s
drinking water that deposit and caus
surfaces. Here we show that such con
be synthesized in a simple and effective
out the use of electrical power. The na
sand-like properties, such as higher shea
forms. These materials have been used
water purifier to deliver clean drinking
ily. The ability to prepare nanostructu
ambient temperature has wide releva
water purification.

hybrid | green | appropriate technology | frugal science | developing world

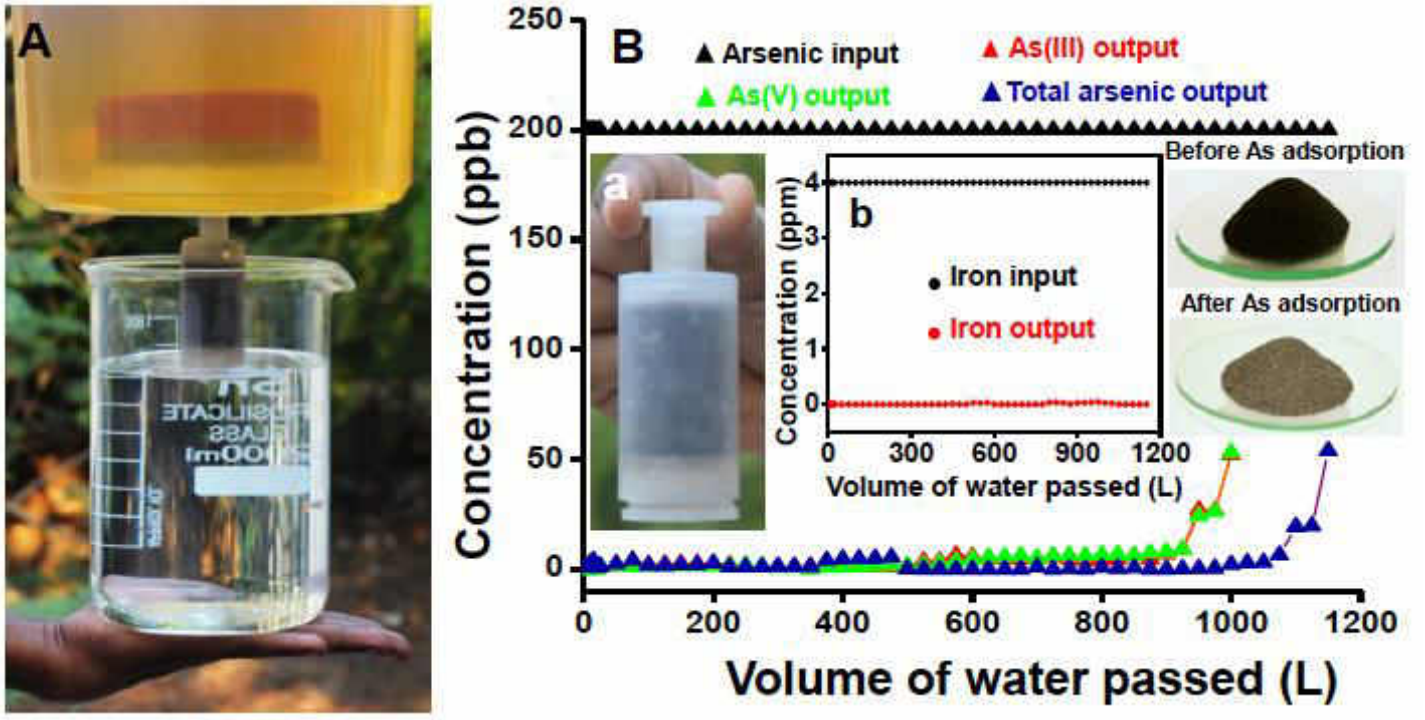
vailable; and (*c*) continued retention
matrix is difficult.
ate a unique family of nanocrystalline
n granular composite materials pre-
ature through an aqueous route. The
mposition is attributed to abundant -O-
on chitosan, which help in the crys-
oxide and also ensure strong covalent
surface to the matrix. X-ray photo-
) confirms that the composition is rich
ps. Using hyperspectral imaging, the
aching in the water was confirmed.
to reactivate the silver nanoparticle
ial antimicrobial activity in drinking
osites have been developed that can
ts in water. We demonstrate an af-
device based on such composites de-
nd undergoing field trials in India, as
spread eradication of the waterborne

disease burden.

Results and Discussion

M. Udhaya Sankar, et. al. *Proc. Natl. Acad. Sci.,* 110 (2013) 8459-8464.

Range of materials, their affordability and safety



Safety of spent media, TCLP

A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 1604260.

Clean water for everyone

ACS Sustainable Chemistry & Engineering Editorial, December 2016

Implementation - From 25 KLD to 1 MLD

Large water supply schemes

Capacity: above 1 MLD

5 schemes in use across India

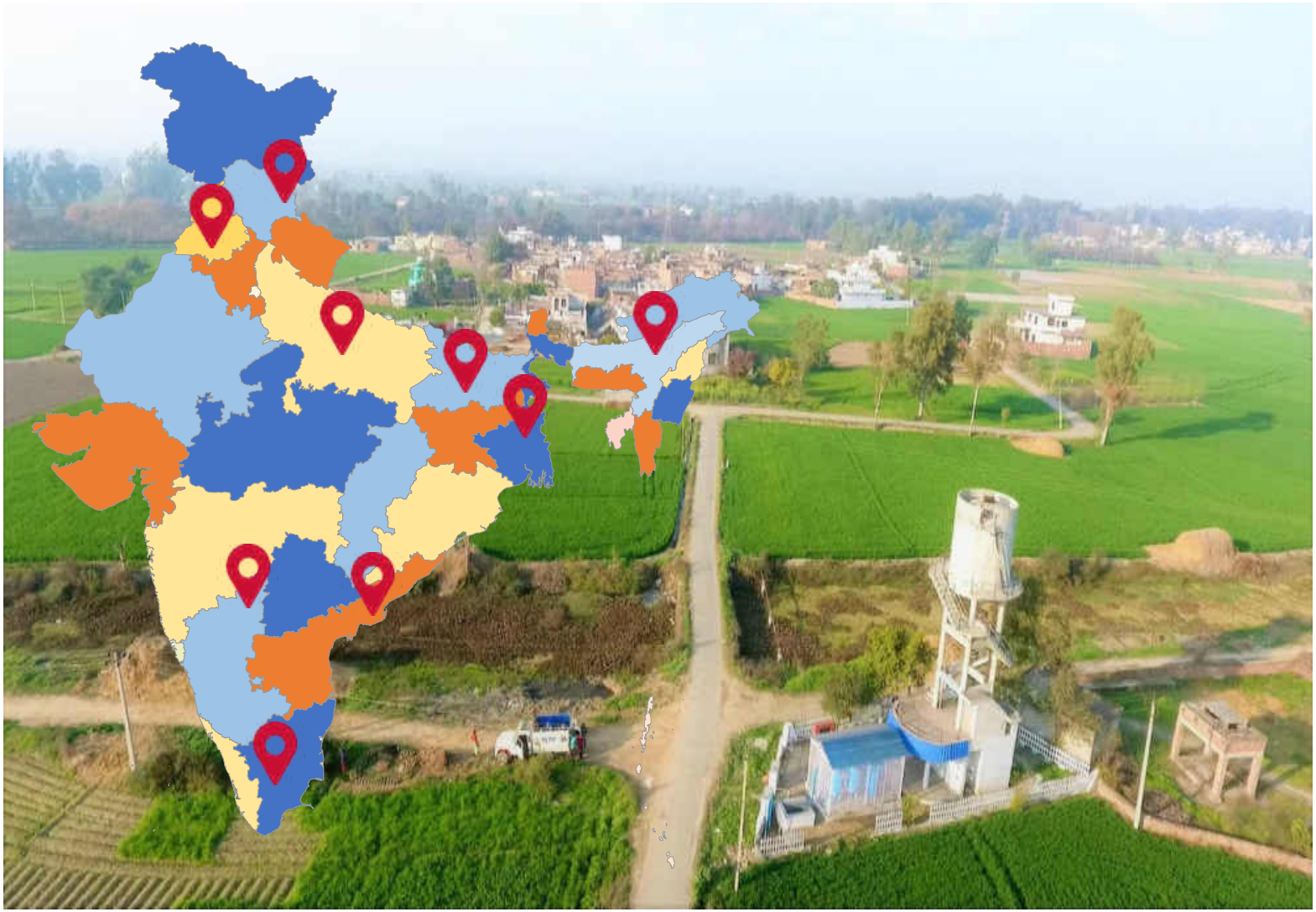
Retrofitted Water Purification Plant

Capacity: 0.1-1 MLD

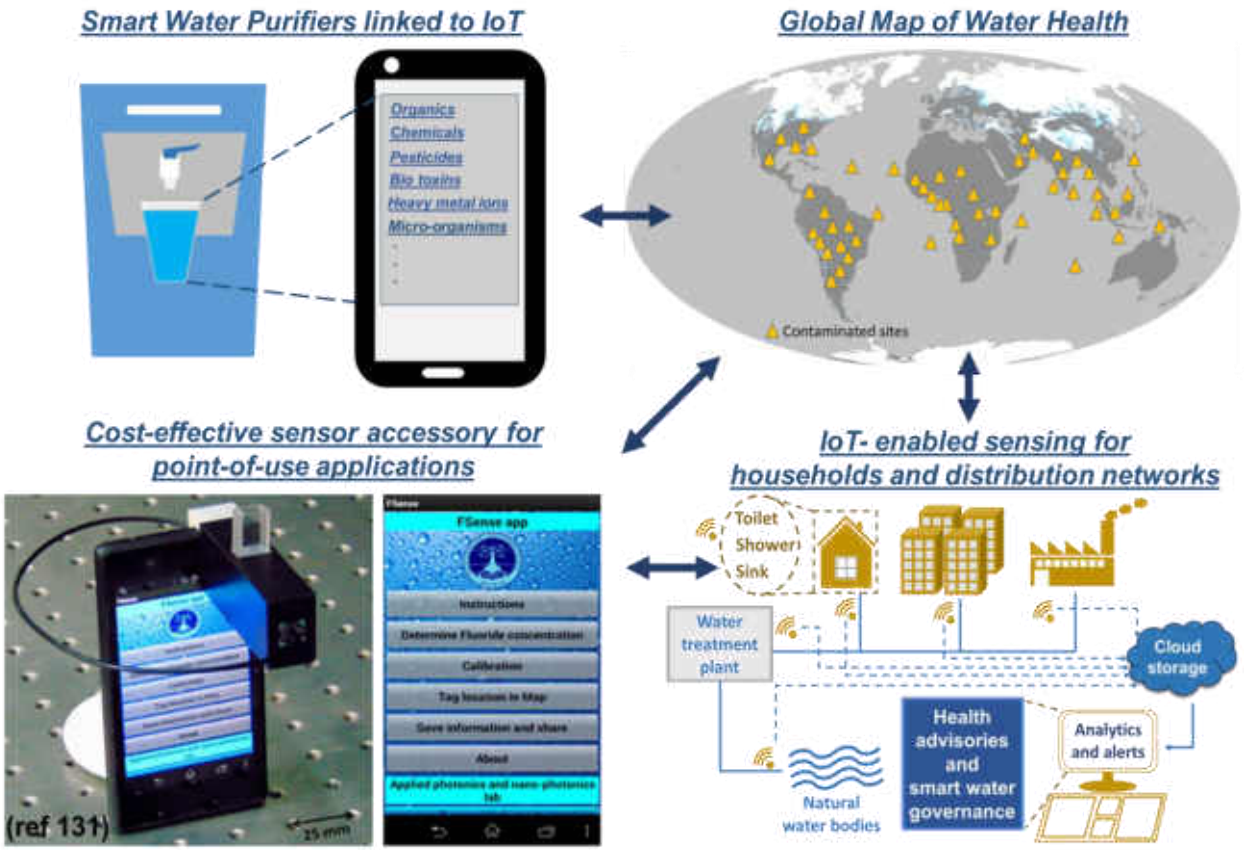
Over 180 units in use across India

Across the country

Expanding the reach



Smart water purifiers and big data

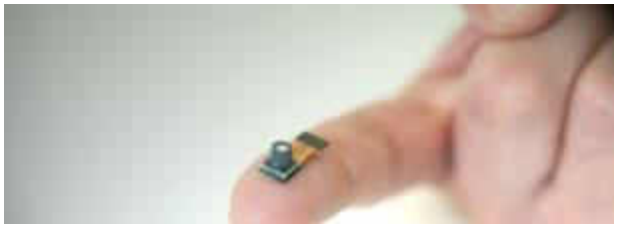


Ankit Nagar and Thalappil Pradeep. *ACS Nano* (perspective), 2020.

Where can we invest our time and effort?

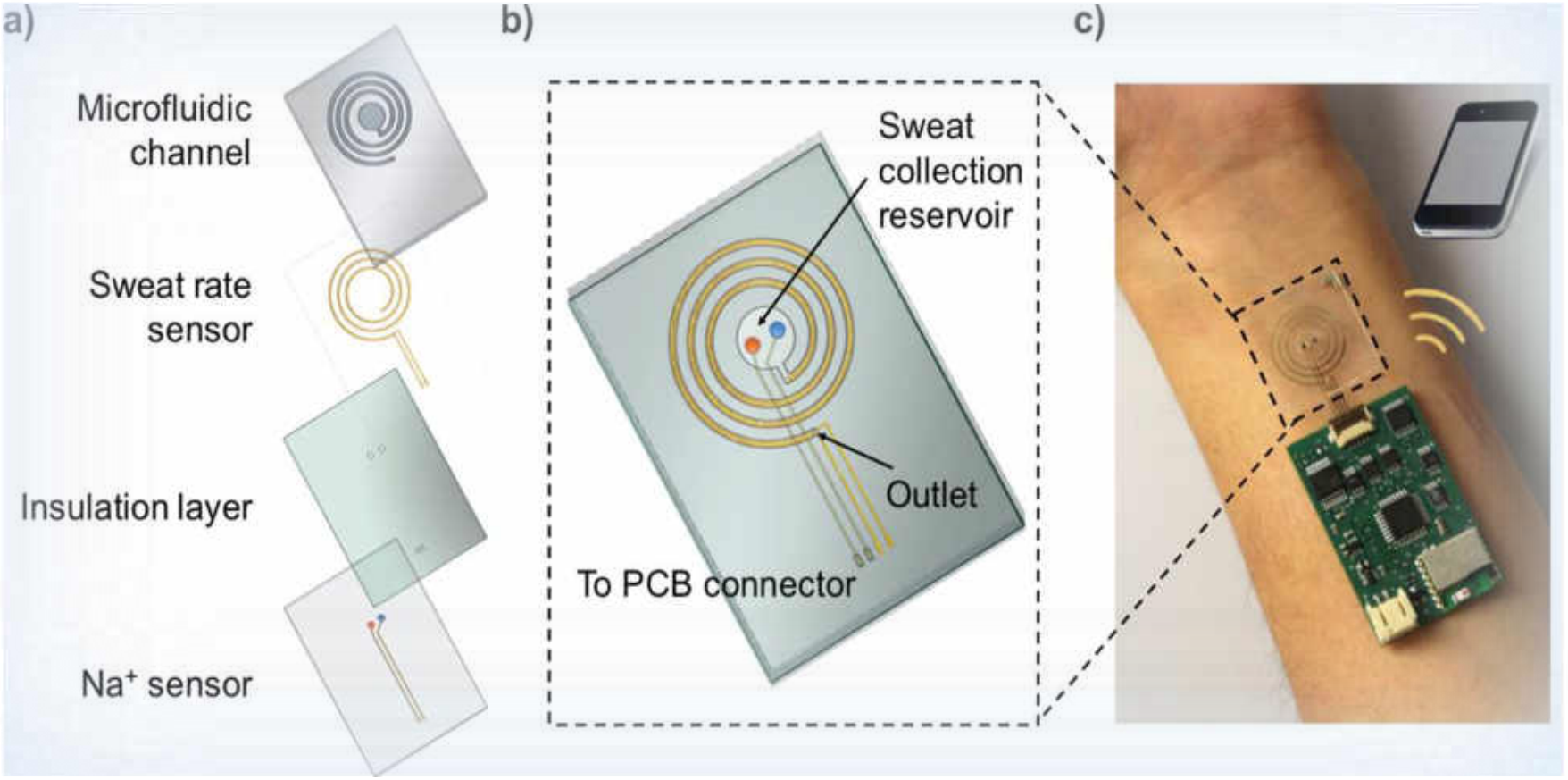
Image from: https://delta2020.com/blog/203-our-shrinking-world

Sensors and new opportunities



Water quality measurement – In the pipeline

Health



H.Y.Y. Nyein, et. Al., ACS Sens. 2018, 3, 944−952

Food

Author’s laboratory

Indian Institute of Technology Madras





Bhaskar Ramamurthi/V. Kamakoti

Thank you all

pradeep@iitm.ac.in
https://pradeepresearch.org/