

FROM CHEMISTRY'S BIG BANG TO ONE- WORLD CHEMISTRY

A STORY FOR CHEMICAL EDUCATION

CHAPTERS OF THE STORY

- 1. The Chemistry Big Bang (1770-1870)
- 2. The Benefits of Chemistry (1870-1970)
- 3. One-World Chemistry and Sustainable Development (1970-2070)
- 4. Implications for Chemistry Education in the IYPT

1. THE CHEMISTRY BIG BANG

1.1 LAVOISIER (1743-1794)

- Elements defined as substances that cannot be broken down to simpler substances by chemical practice.
- Law of conservation of mass and measuring mass to follow chemical changes.
- Binary nomenclature of compounds (eg sodium chloride (instead of salt!)).
- “Traité élémentaire de chimie” with first list of chemical elements (1789)
- The “father of chemistry”, guillotined in the reign of terror during the French revolution.

THE CHEMISTRY BIG BANG continued

1.2 DALTON (1766-1844)

- All the atoms of one element are the same
- Atoms of different elements differ in weight
- Atoms of different elements combine in simple ratios – 1:1 unless otherwise indicated
- Quantitative analysis of compounds used to establish atomic weights (relative to H=1)
- “A New System of Chemical Philosophy” (1808)
- A school teacher in Manchester (UK)

THE CHEMISTRY BIG BANG concluded

- Avogadro (1811): All gases contain the same numbers of molecules (at the same V, T and P); distinguished between atoms and molecules; like atoms can combine to form molecules.
- Faraday (1834): Laws of electrolysis; linking valency with electricity;
- Cannizzaro (1860): At the 1st International Congress of Chemists in Karlsruhe resolved many atomic weight contradictions using Avogadro's ideas.
- Mendeleev (1869): The periodic law relating element properties (especially valency) with atomic weights.

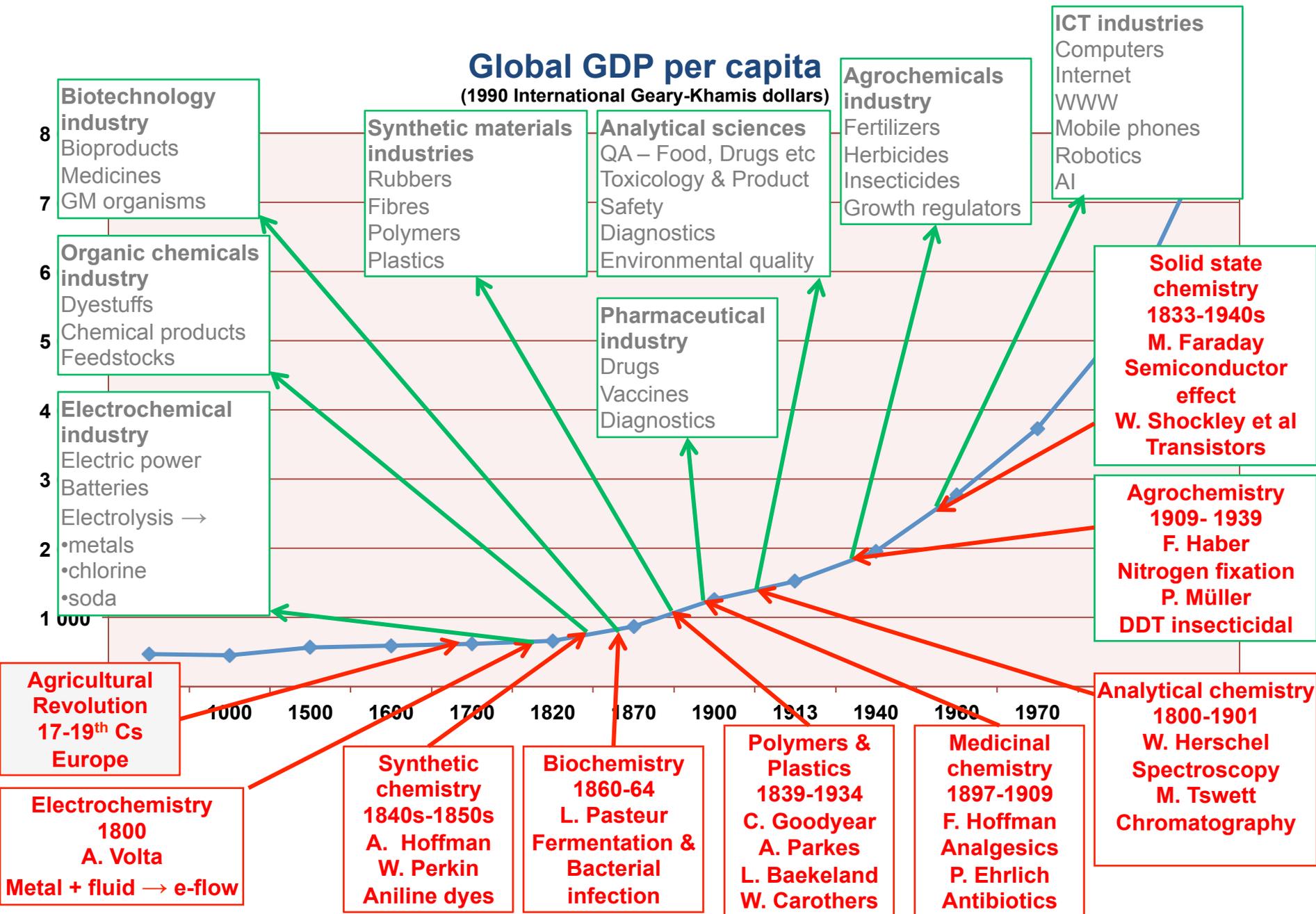
2. THE BENEFITS OF CHEMISTRY

“The development of the Periodic Table of the Elements is one of the most significant achievements in science and a unifying scientific concept, with broad implications in Astronomy, Chemistry, Physics, Biology and other natural sciences...It is a unique tool enabling scientists to predict the appearance and properties of matter on Earth and in the Universe. Many chemical elements are crucial to enhance the value and performance of products necessary for humankind, our planet, and industrial endeavours.”

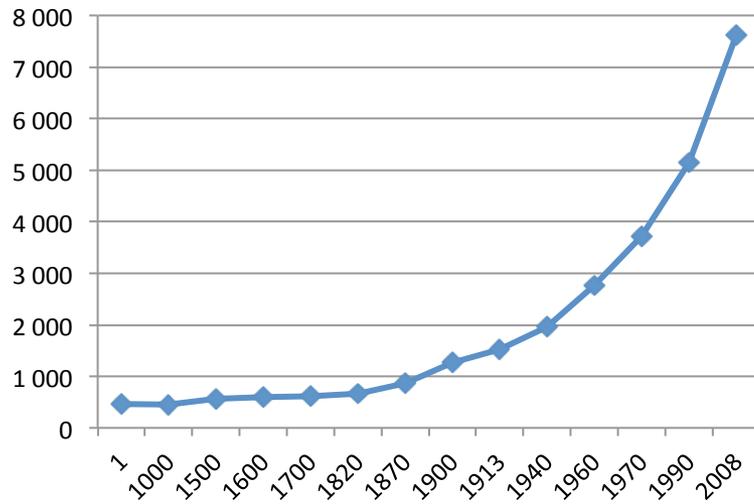
(IUPAC Press release December 2017 following the UN General Assembly's proclamation of 2019 as the IYPT)

Global GDP per capita

(1990 International Geary-Khamis dollars)

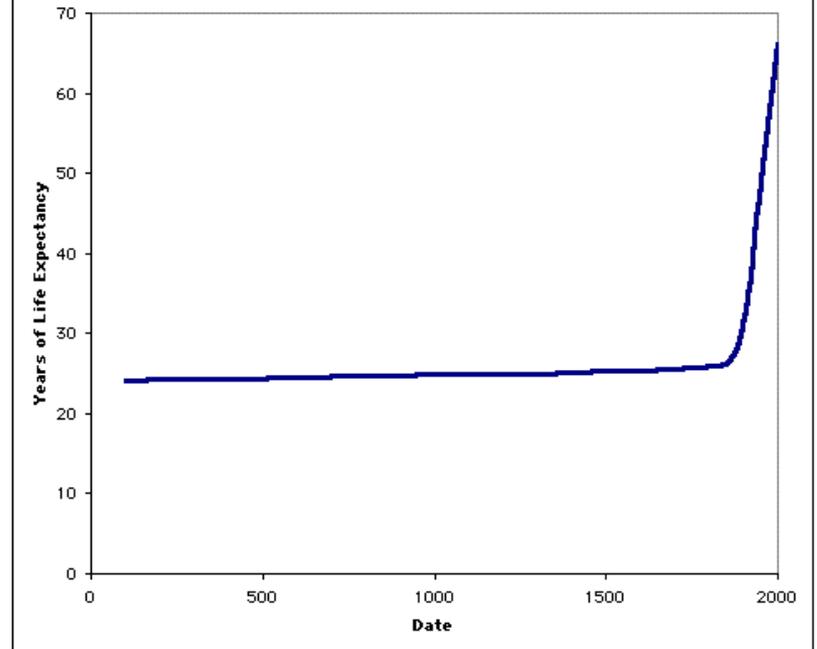


Global GDP per capita



GDP data from:
A. Maddison, *Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD*. www.ggdc.net/MADDISON/oriindex.htm

World Life Expectancy



Life expectancy graph from:
http://www.j-bradford-delong.net/movable_type/images2/Life_Expect_Long.gif

THE BENEFITS OF CHEMISTRY continued

UNEP Global Environmental Report (2019):

- 9 million people per annum are killed by pollution – 80% of these deaths are related to air pollution
- “Modern society is living in the most chemical-intensive era in human history: the pace of production of new chemicals largely surpasses the capacity to fully assess their potential adverse impacts on human health and ecosystems.”

THE BENEFITS OF CHEMISTRY concluded

- UNFCCC (2019):

“Climate change presents the single biggest threat to sustainable development everywhere and its widespread, unprecedented impacts disproportionately burden the poorest and most vulnerable.

Urgent action to halt climate change and deal with its impacts is integral to the successful implementation of the SDGs.”

[SDG 12: Ensure sustainable consumption and production patterns]

3. ONE-WORLD CHEMISTRY & SUSTAINABLE DEVELOPMENT

One-world chemistry and systems thinking: Matlin, Mehta, Hopf & Krief (IOCD, 2016)

- Chemistry cannot be separated from the context in which it is conducted and its practice must be considered in relation to its impacts on many interconnected systems.
- Chemistry - the “central science” - must become a “central sustainability science”
- Both teaching and practice must be informed by systems thinking and consequently embrace approaches that cross disciplinary boundaries.

4. IMPLICATIONS FOR CHEMISTRY EDUCATION IN THE IYPT

A SOUTH AFRICAN SECONDARY SCHOOL PERSPECTIVE ON SYSTEMS THINKING

- FET Physical Sciences comprises physics & chemistry (50:50)
- The curriculum doc defines knowledge areas (KAs) which are studied from Grade 10 to Grade 12
- There is zero curricular linkage between KAs & zero reference to Life Sciences
- The KA Chemical Systems was 18,75% of the NCS curriculum introduced in 2003; this was reduced to 4,5% in the CAPS revision in 2011.

IMPLICATIONS FOR CHEMISTRY EDUCATION IN THE IYPT continued

TOWARDS SYSTEMS THINKING IN THE CURRICULUM

One-world chemistry does not argue for:

the abandonment of teaching individual sciences in favour of an undifferentiated 'general science'

It does argue for:

stressing the unity of scientific principles and thought processes from the earliest stages of science education....

embedding in chemistry education from a very early stage, a growing awareness of the ways that chemistry interconnects with other disciplines...

[Quoted from IOCD website, accessed May 2019]

IMPLICATIONS FOR CHEMISTRY EDUCATION IN THE IYPT continued

BIG IDEAS *of* SCIENCE AND *about* SCIENCE

“Conceiving the goals of science education, not in terms of a body of facts and theories, but as a progression towards understanding key ideas of relevance to students’ lives during and beyond their school years.”

eg “All matter in the Universe is made of very small particles”

“Science is about finding the cause or causes of phenomena in the natural world”

(2010-2015: Association for Science Education (UK); Inter-Academies Project (Italy); National Academy of Sciences (USA))

IMPLICATIONS FOR CHEMISTRY EDUCATION IN THE IYPT continued

INQUIRY-BASED SCIENCE EDUCATION PEDAGOGY

- “When trying to make sense of new experience, whether within the classroom or outside, learners start from the ideas they already have, as indeed scientists do..”
- “In science, understanding of the natural and made world is developed through seeking answers to questions by collecting data, reasoning and reviewing evidence....” By engaging in such activities and making them conscious, students develop their ideas *about* science. (ASE 2012)

IMPLICATIONS FOR CHEMISTRY EDUCATION IN THE IYPT concluded

- “The crisis of sustainability, the fit between humanity and its habitat, is manifest in varying ways and degrees everywhere on Earth....Sustainability is about the terms and conditions of human survival, and yet, we still educate at all levels as if no such crisis existed...” [Quoted in ACS Sustainable Chemistry & Engineering, 2014]
- The story “From Chemistry’s Big Bang to One-world Chemistry” is one that can be exploited in a new school science curriculum which is conceived in terms of the Big Ideas of Science Education, Inquiry-based Science Education and Systems Thinking and clearly linked with the SDGs.

RECOMMENDATIONS

- In view of the urgent imperatives of the SDGs, NSTF should convene a Discussion Forum devoted to the Reconstruction of Science Curricula in South Africa
- As a contribution to the urgent need to create awareness, NSTF should support and coordinate development of materials for teachers and teacher educators in South Africa that exploit the story behind the IYPT