



**International Organization
for Chemical Sciences
in Development**

**Imperial College
London
Institute of Global Health Innovation**

Chemistry Education for the 21st Century

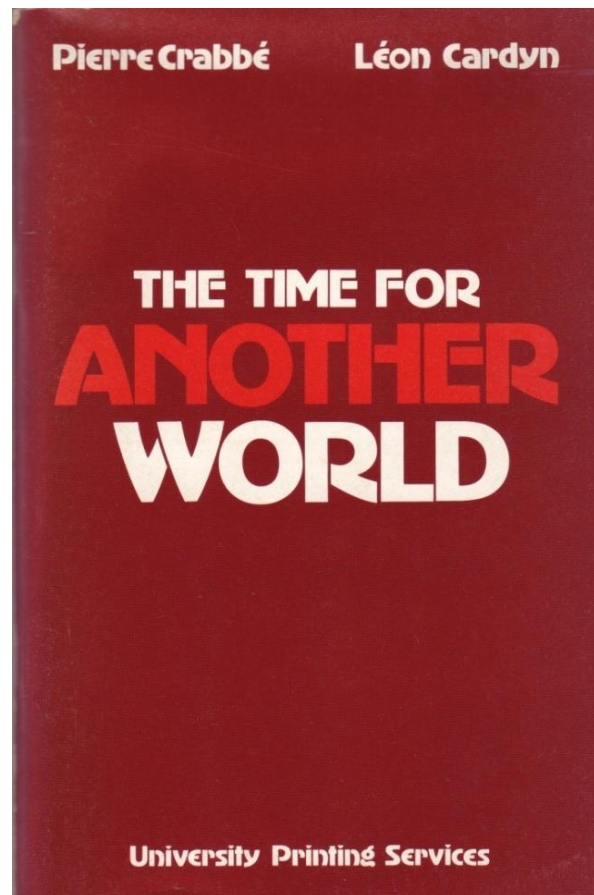
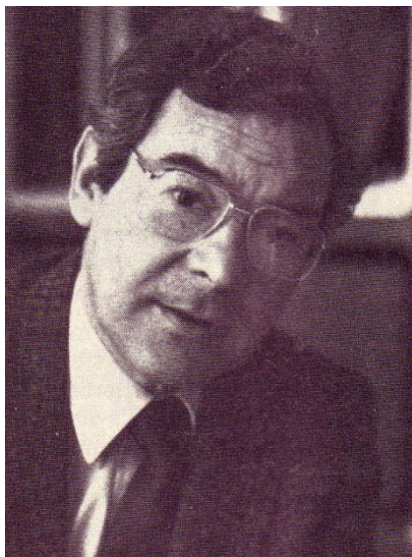
Stephen Matlin

**Education in Chemistry: Scoping the Future
CHEMRAWN-IOCD Meeting: Namur, Belgium, 13-15 January 2014**



International Organization for Chemical sciences in Development

Pierre Crabbé
1928-1987



*One does not go to a country to "assist" people, but to work with them ...
We should keep in mind that in cooperative programmes we learn more than
we teach and receive more than we give.*

International Organization for Chemical Sciences in Development

First phase 1981 - 1995

1981 Founded at UNESCO, Paris

1983 Registered as NGO, Belgium

1985 Secretariat moved to Mexico

1987 Death of Pierre Crabbé

Appointment of Robert Maybury (USA) as Executive Director

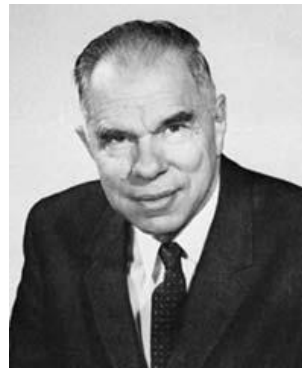
IOCD Working Groups and Programmes:

- **Chemotherapy of Tropical Diseases**
- **Chemistry for Male Fertility Regulation**
- **Utilization of Natural Products**
- **Analytical Services**
 - Service centres initially in Europe, Mexico, USA
 - Network for Analytical and Bioassay Services in Africa – NABSA
- **Education**
 - IOCD panel for chemical education/ International Centre for Chemical Studies Ljubljana: meetings 1982 Ljubljana; 1983 Montpellier
 - ❑ concentration on programmes involving interactions between universities and the industrial sector
 - ❑ creation of an International Network for Chemical Education (INCE) to implement the panel's programmes

International Organization for Chemical Sciences in Development

First phase 1981 - 1995

- research projects
- research facilitation
- capacity building – mainly individual



Robert Maybury



**IOCD Executive Director
1987 - 2010**

Second phase 1995 – 2010

- **Less money**
- **New Working Groups & Projects**
- **Shift from research projects to meetings, seminars, workshops**
- **Capacity building – individual
institutions
networks
policy**

IOCD Working Groups & Programmes 2011

- 1. Biotic Exploration Fund**
- 2. Environmental Analytical Chemistry**
- 3. Plant Chemistry**
- 4. Tropical Diseases**
- 5. Medicinal Chemistry**
- 6. Books for International Development**
- 7. Medicinal Chemistry: Open and Distance Learning**
- 8. Organic Chemistry: Online Tutorials (Spanish)**
- 9. Global Microscience Programme**

World has changed since 1981

- **Economically**
- **Politically**
- **Socially**

International development:

- **Moved from ‘international aid’ (‘redistribution’, ‘charity’) to ‘development cooperation’; from MDGs to global sustainable development**
- **Concept of ‘developed’ and ‘developing’ countries outmoded: replaced by World Bank classification ‘high-income’ and ‘low- and middle-income’ countries (HICs and LMICs)**
 - **Need to have recipient countries in greater control of aid and for aid to be more focused on impact**
 - **Shared responsibility**
 - **Inclusion**
 - **Co-development & opportunities for “reverse innovation”**
 - **‘South-South’ cooperation: LMIC + LMIC**
 - **‘Triangular’ cooperation:
traditional donor (HIC) + an emerging (LMIC) + a beneficiary country (LMIC)**

Alain Krief



**IOCD Executive Director
2010 -**

Third phase 2011 – 2020

- **In a changing world, IOCD must renew its strategy, methods and membership**
- **New Strategy 2011 – 2020**

IOCD Strategy 2011 – 2020

Three Strategic Priorities

1. **Chemistry for better health**
2. **Chemistry for a better environment**
3. **Capacity building in chemistry education**

IOCD's strategy:

Support ownership, partnership and capacity building for the use of the chemical sciences globally, but especially in and for the benefit of LMICs

IOCD's approach:

Going beyond scientific aid for LMICs to fostering **science applied to equitable global development**

IOCD's function:

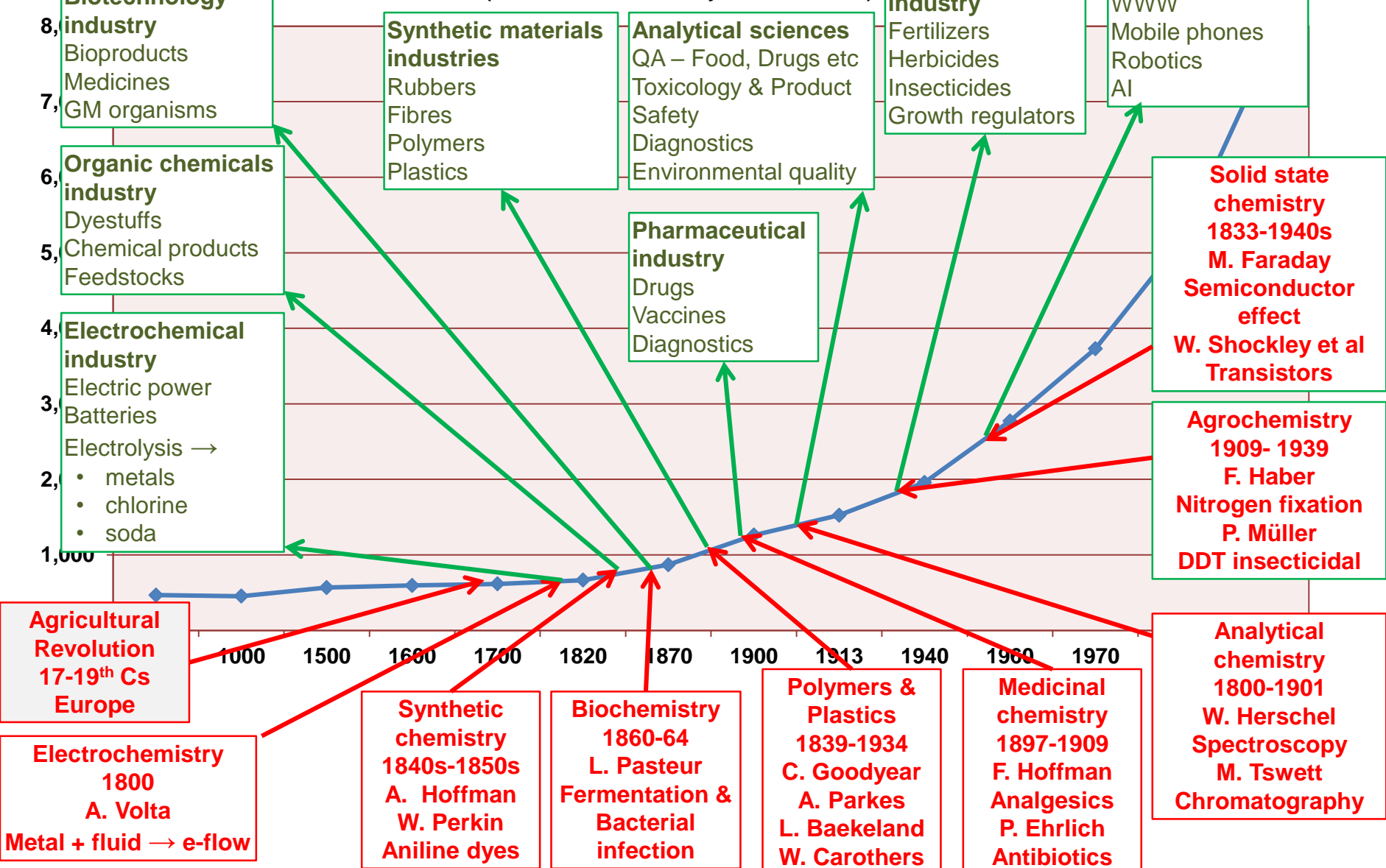
Increasingly to serve as an **umbrella and facilitator** for programmes and funding for research, education and capacity building in the chemical sciences

Chemistry Education for the 21st Century

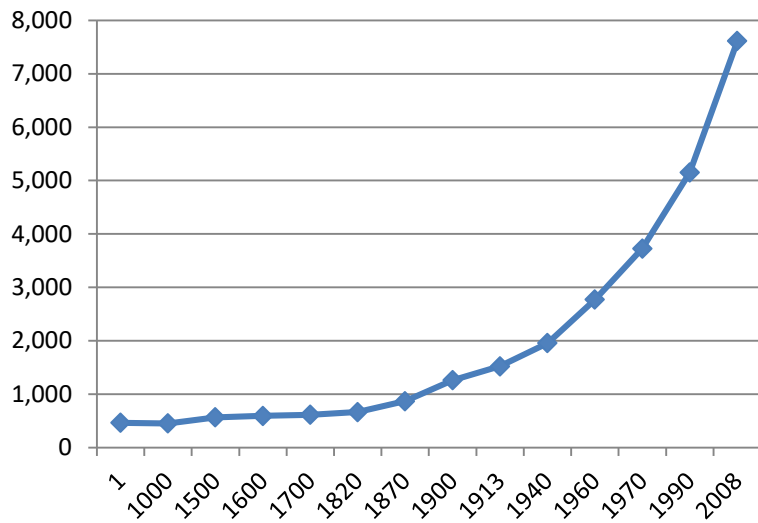
- 1. The chemical sciences have been good for wealth and health (up to a point, for some)**

Global GDP per capita

(1990 International Geary-Khamis dollars)

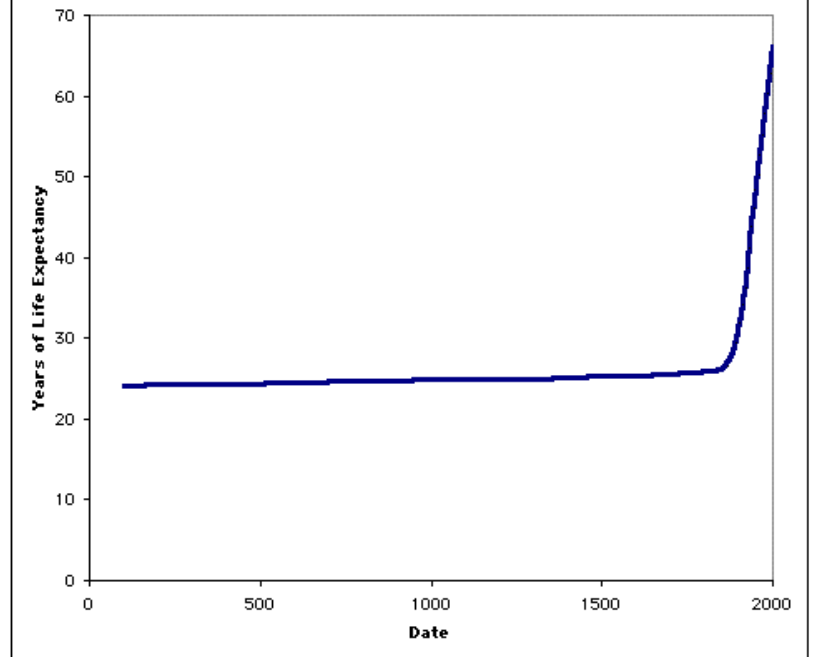


Global GDP per capita



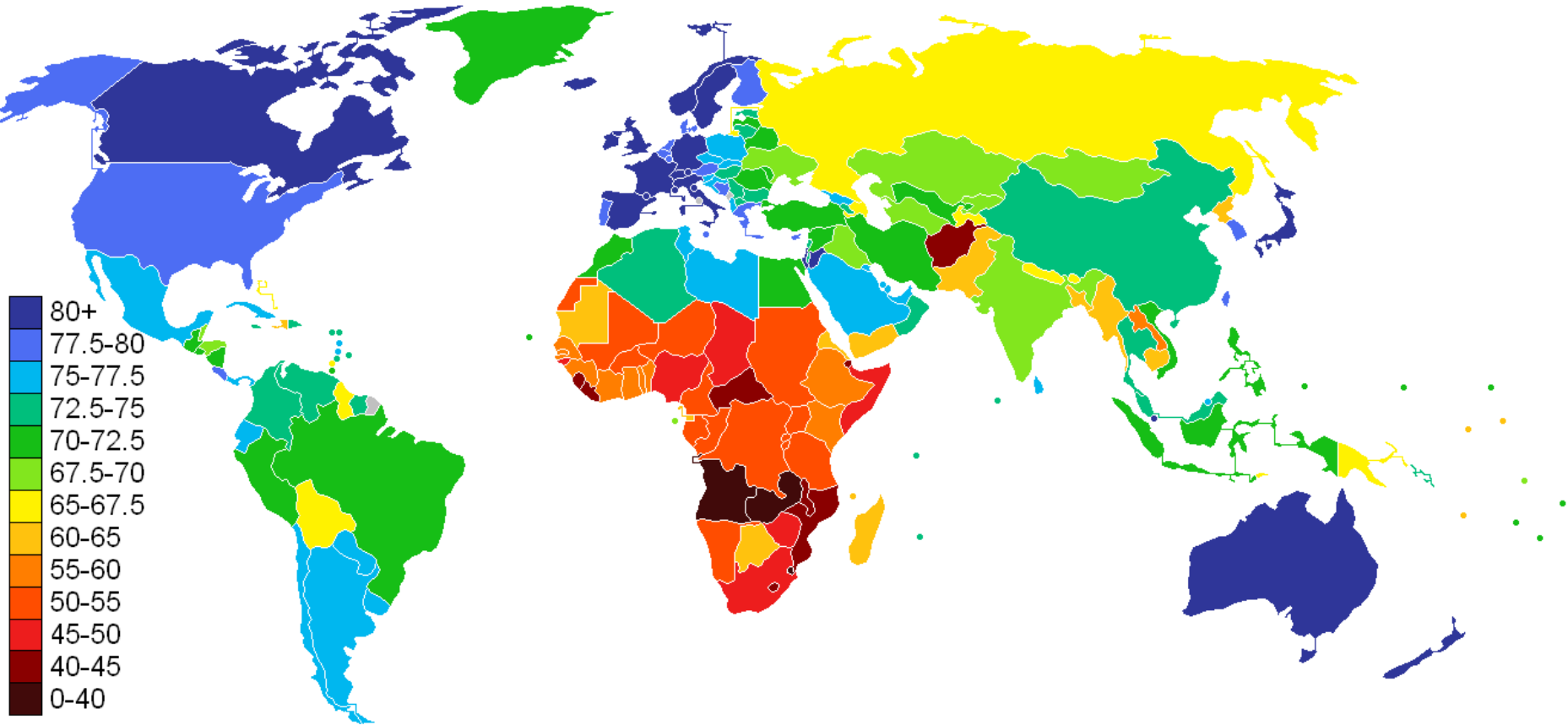
GDP data from:
A. Maddison, *Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD*. www.ggdc.net/MADDISON/oriindex.htm

World Life Expectancy



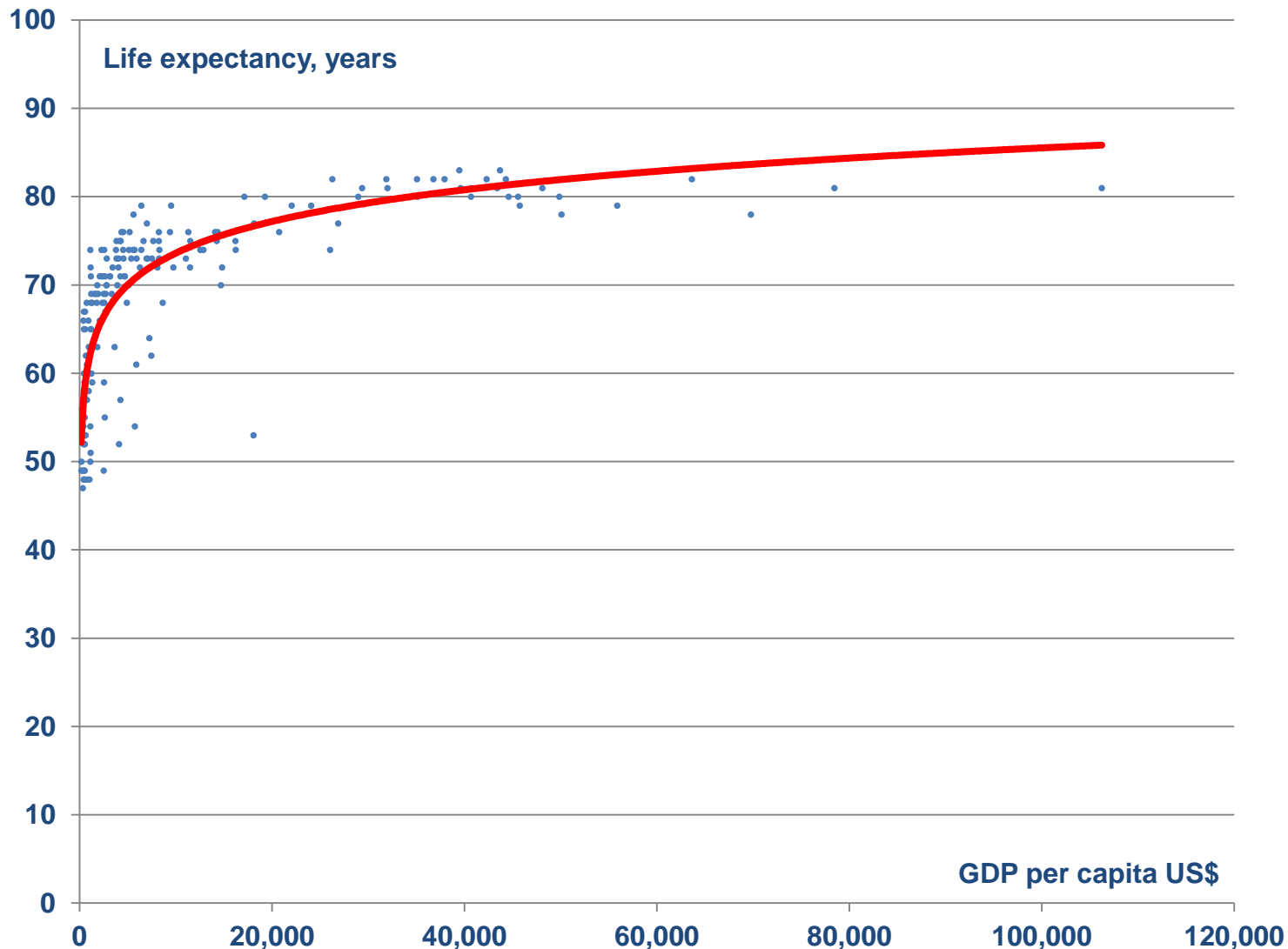
Life expectancy graph from:
http://www.j-bradford-delong.net/movable_type/images2/Life_Expect_Long.gif

Life Expectancy at Birth by Country: 2011 Estimates



How much health do you get for your wealth?

Preston curve: Life expectancy vs GDP per capita 2009



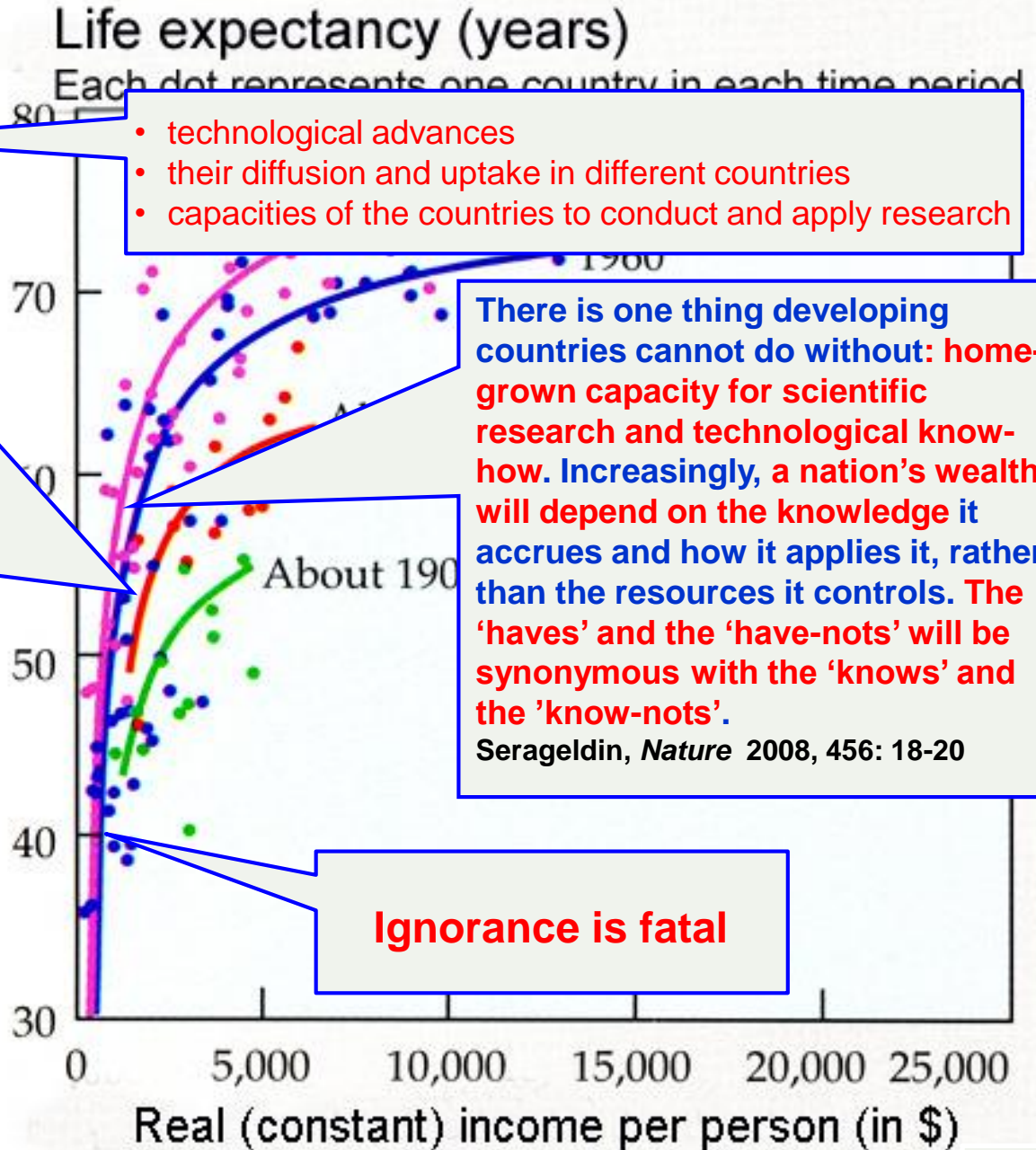
Preston curves 1900-1990

- 20th century mortality decline had its origin in technical progress

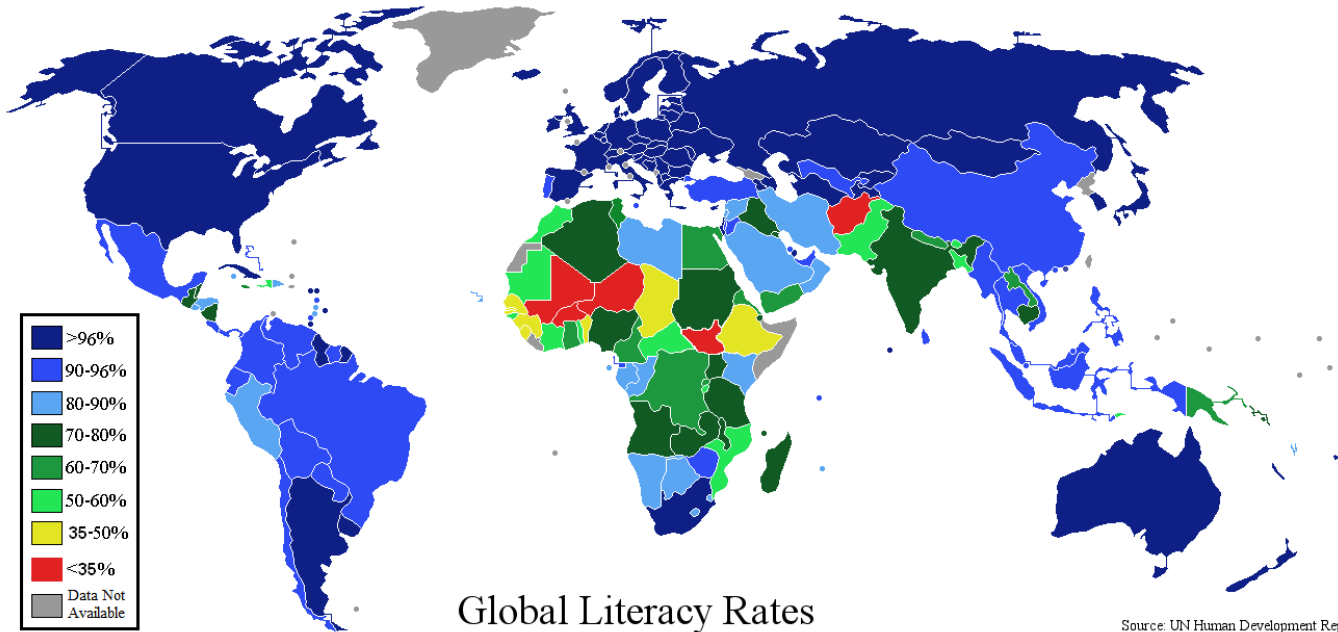
Easterlin, *European Review of Economic History* 1999, 3: 257-94

- Much of the variation in country outcomes results from very substantial cross-country variation in the rate of technical progress

Jamison, *Disease Control Priorities in Developing Countries (DCP2)*, World Bank 2006



Literacy



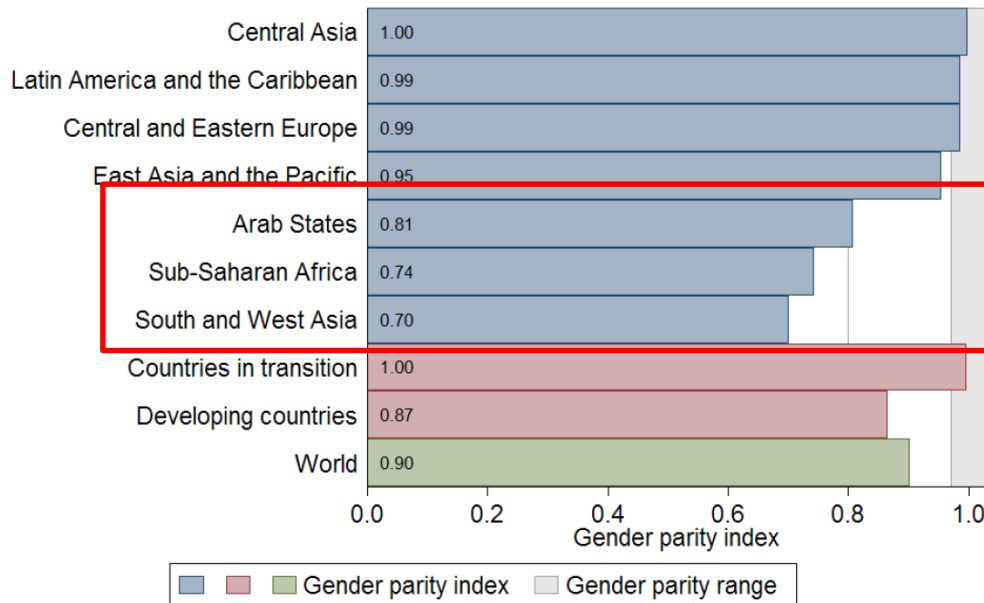
- 775 m illiterate adults 15+
75% in ten countries:

- India
- China
- Pakistan
- Bangladesh
- Nigeria
- Ethiopia
- Egypt
- Brazil
- Indonesia
- Democratic Rep Congo

- Globally:
M+F lit. rate 15+ = 84.1%
2/3 illiterate adults women

www.cia.gov/library/publications/the-world-factbook/fields/2103.html#xx

Source: UN Human Development Report 2011



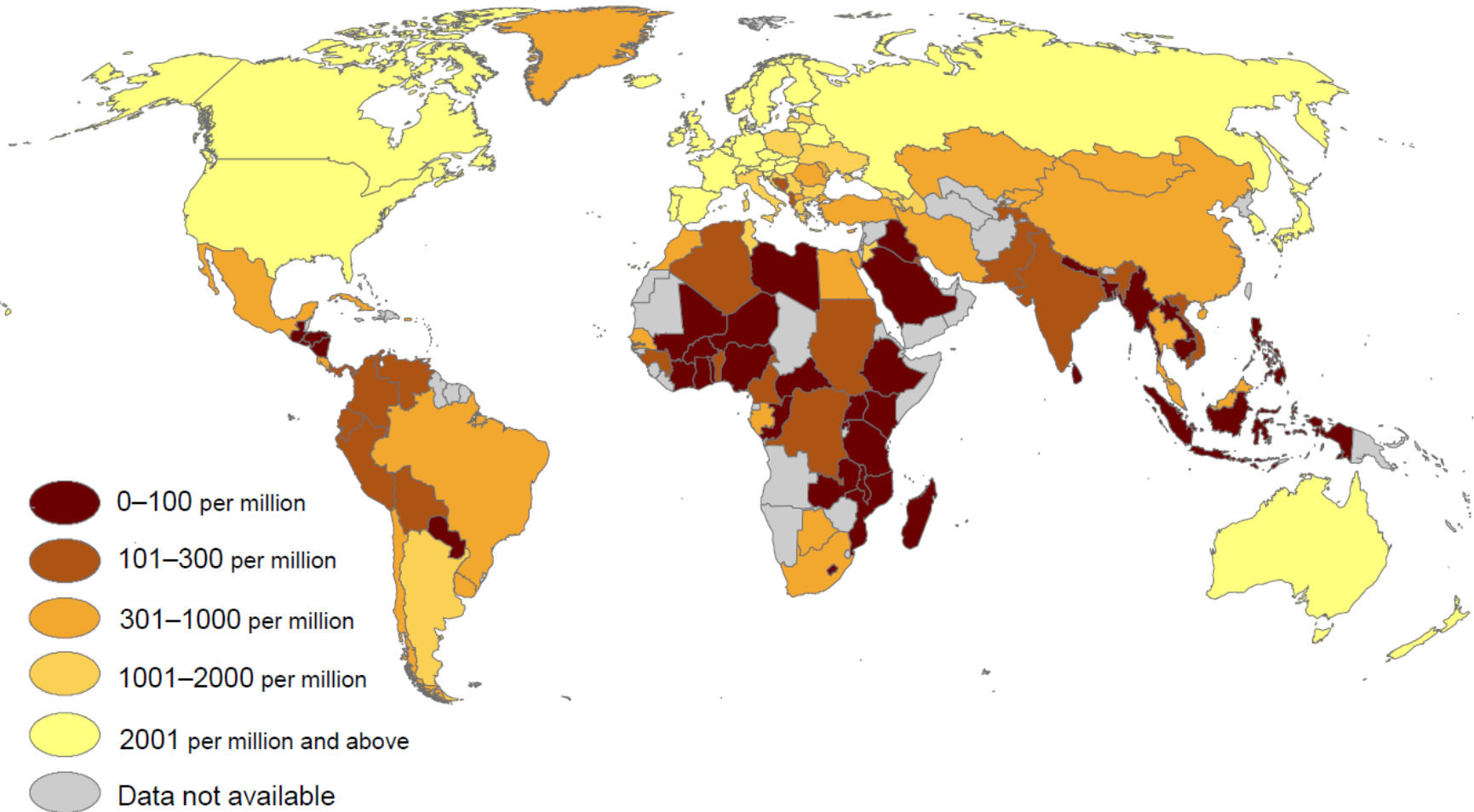
Gender parity index of the adult literacy rate by region, 2011

2011 data refer to the period 2005-2011.

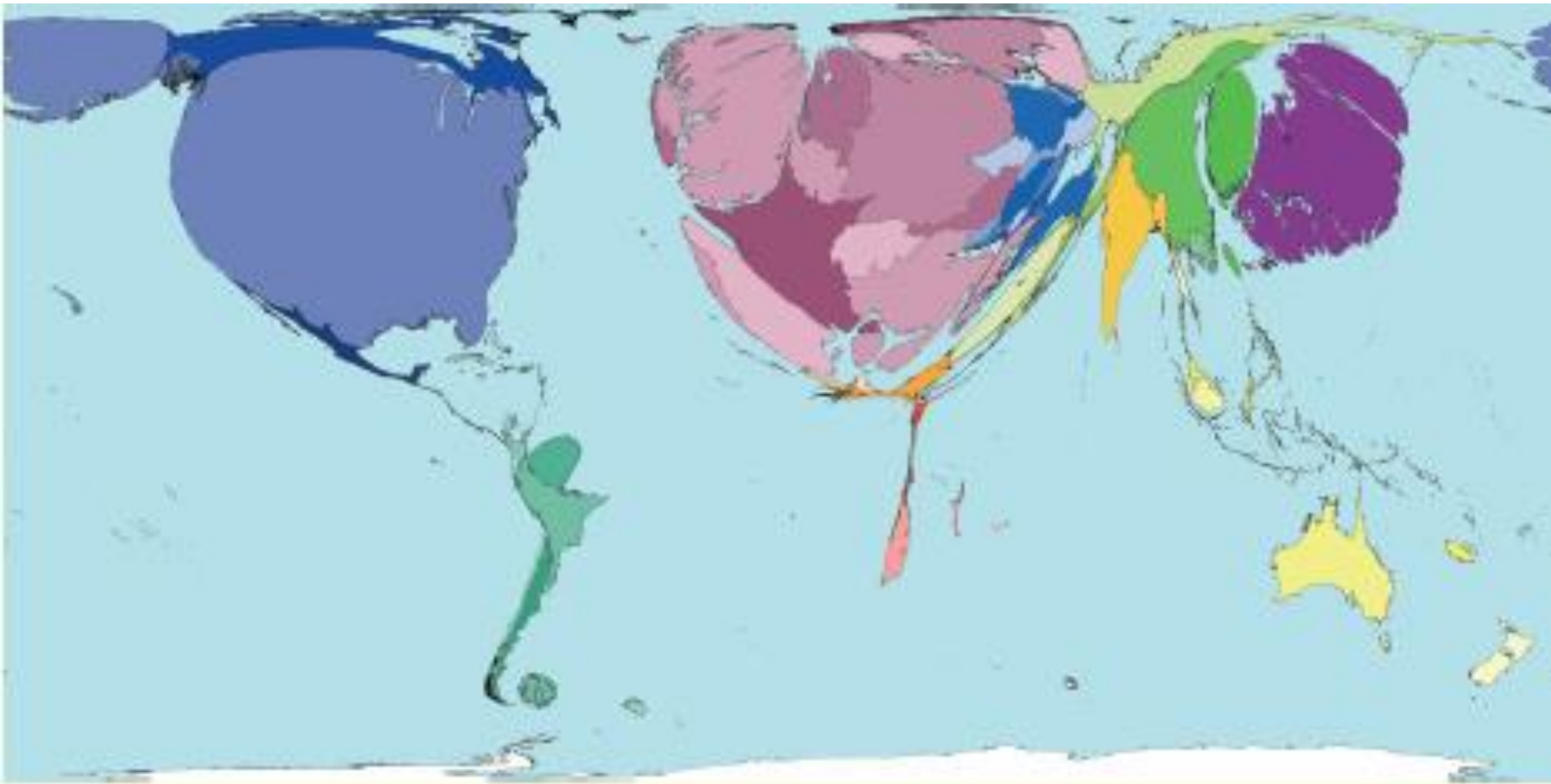
Source: UNESCO Institute for Statistics, May 2013.

Science capacity: R&D activity

Researchers per million inhabitants:
2010 or latest available year



Science capacity: Scientific publications by countries, 2001



Territory size shows the proportion of all scientific papers published in 2001 written by authors living there. Scientific papers cover physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering, technology, and earth and space sciences.

Science literacy

➤ Scientific literacy as a goal of science education

PD Hurd, Educational Leadership, 1958, 16, 13–16

➤ Although 350 years have now elapsed since it was first proposed that a purpose of science education ought to be the contributions that science makes to public life and the common good, **the appropriate curricula have yet to emerge.**

➤ Science curricula need to be reinvented to harmonize with changes in the practice of science/technology, an information age, and the quality of life.

PD Hurd, Scientific Literacy: New Minds for a Changing World, Sci Ed 1998, 82, 407-416

The curriculum is like a graveyard:

- **it's full of dead bodies**
- **but they have lots of friends who are still alive**

Chemistry literacy

Procedural competences:

- Understanding the **nature of chemistry, its norms and methods**
- Understanding the **key theories, concepts and models** of chemistry
- Understanding how **chemistry and chemistry-based technologies relate** to each other
- Appreciating the **impact** of chemistry and chemistry-based technologies on society

Degrees of chemical literacy

- **Practical or functional** chemical literacy: that is needed for a person to function normally in respect of food, health and shelter in everyday life
- **Civic** literacy: that is needed for an informed debate about matters with a chemistry or chemical technology-related dimension
- **Cultural** chemical literacy: being able to appreciate chemistry as a major aspect of scientific endeavour: implies an ability to enter into professional-level dialogue with a chemist

Chemistry literacy

The **substance of chemistry** as a field of scientific enquiry is made up of four components:

- The **processes** used to obtain (discover or create) chemical knowledge
- The **general concepts and specific facts** so produced
- The **applications** of that knowledge in understanding and changing the world
- The **implications** of that understanding and change for individuals and societies

Gujarat school replaces heavy bags with tablets

Vijaysinh Parmar | TNN

Rajkot: Books are no more a burden for students of the government primary school in Gujarat's Rajkot district as their heavy school bags have been replaced by tablets.

The Sanganwa school has become first one run by the Gujarat government to go bag-less. All 70 students of class V to class VII have been given tablets that contain the entire syllabus.

"The hazards of heavy school bags are well known. I wanted to bring in the latest technology in education aids so that children of a government school too can compete with others," principal Subhash Rathod told TOI.

The school has carved a niche for itself with a Wi-Fi campus and smart classrooms with digital teaching aids provided by Rathod who donated the entire Rs 5 lakh insurance money received after the death of his son



USHERING IN THE NEW: Heavy bags have made way to tablets in the primary school in Sanganwa

in a road accident in 2011. At present students are being taught in using the tablets. The syllabus and study material available in Gujarati tutorial software. "Besides all the internal exams conducted on the tablets," Rathod said. Impressed with Rathod's initiatives, Rajkot-based in-

st Javanti Patoliva has decided



PM to Launch Total e-literacy Drive

The drive to be inaugurated on January 4 aims at ensuring that benefits of IT are accessible to even the lower strata of society

Express News Service

T'Puram: Prime Minister Manmohan Singh will inaugurate the state's drive to achieve 100 per cent e-literacy within 33 months, at a function to be held at Kanakakunnu Palace here on January 4.

The drive aims at coordinating technology and ensuring that the benefits of information technology are accessible to even the lower strata of society.

noted by the Department of General Education. The first stage of the e-literacy project will be implemented in 10 panchayats districts through 9th Jan Vigyan had passed a resolution last year.

aims at turning 15 lakh computer illiterates into e-literates.

The project implemented with the full support of the parliament aims at turning 15 lakh computer illiterates into e-literates.

E-literacy Project Launched

Express News Service



Chief Minister Dhanu Chandy presenting a bunch of paddy spikes to Prime Minister Manmohan Singh at the inauguration of the total e-literacy programme organised by P N Panicker Vigyan Vikas Kendra in Thiruvananthapuram on Saturday. Governor Nikhil Kumar, Minister of State for IED Shashi Tharoor and Education Minister P K Abdu Rabb are also seen | BHASKAR HANVELIL

Kerala is the first state in the country to launch a total e-literacy drive. The drive is aimed at ensuring that the benefits of IT are accessible to even the lower strata of society, said Prime Minister Manmohan Singh today.

At Kerala took the lead in e-literacy has been a long process. It does well in the areas of human resources and literacy is a key to economic growth, he observed. The e-literacy drive here, for the first time, is being implemented in 10 panchayats districts through 9th Jan Vigyan had passed a resolution last year.

much to late P N Panicker. His initiative, the Grandhasala Sangham, ignited a popular cultural movement in Kerala at the end of which the State acquired total literacy in the 1990s, he noted. Many social historians consider the library movement to be the cornerstone of the so-called Kerala model of development, he said. The Grandhasala Sangham began humbly with 47 libraries in 1945 and grew into a network of more than 6,000 libraries spreading across Kerala.

"Panicker also established the Kerala Association for

an institution to perpetuate Panicker's memory, he said that the P N Panicker Vigyan Vikas Kendra is taking the lead to make Kerala the first e-literate state of the country, in collaboration with the Central and State Governments and civil society organisations.

The e-literacy programme will also help the common man of Kerala to participate in the exchange of ideas and information that social media enables. It will help the youth to be better equipped for making use of productive employment opportunities. It will also help in building

CAPITAL CENTRE OF CUK UNVEILED

T'Puram: Kerala is ahead of other states in terms of human resource development and progress in education, Prime Minister Manmohan Singh said here on Saturday. Singh was speaking after unveiling the plaque of the capital centre of Kasaragod-based Central University here. He called the setting up of the capital centre as a new stride made by the state in an international level. The centre offers integrated graduate and post-graduate courses in

Chemistry Education for the 21st Century

1. The chemical sciences have been good for wealth and health (up to a point, for some)

How to make good quality, relevant chemistry education available, accessible and affordable to all?

2. Education is changing rapidly

How must chemistry education also change?

- modes of teaching and learning
- relevance
 - scientific
 - world of work
 - social responsibility

Gender issues in teaching and learning

Chemistry Education for the 21st Century

- modes of teaching and learning



- Teacher-learner direct interactions in real time
- Age of the classroom & textbook



- Open & Distance Learning
- Age of the correspondence course; then age of the broadcast & mailed supporting materials



- Open & Distance Learning
- Age of computer-based learning with web-based supporting materials



- Massive open online courses (MOOCs)
“education for everyone” / “education at scale”
 - Udacity
 - Coursera
 - edX



- Age of the smartphone

Chemistry Education for the 21st Century

2. Education is changing rapidly

□ **Chemistry education must also change**

Challenges

- **Course content: scope, depth, relevance**

Diverse forces shaping teaching and learning of chemistry at beginning of 21st Century:

- **fundamental changes in the contours of chemistry as defined by new interfaces and research areas;**
- **changes in our understanding of how students learn, and how that applies to chemistry education;**
- **widespread implementation of computer and information technologies to visualize complex scientific phenomena;**
- **external forces, such as**
 - **global concerns** about energy and water resources and the environment
 - **the level of chemical literacy and public understanding of science**

Chemistry Education for the 21st Century

2. Education is changing rapidly

– chemistry education must also change

Situating **chemical concepts, symbolic representations, and chemical substances and processes** in the authentic contexts of the human beings who create **substances, the culture that uses them, and the students who try to understand them**

Each of the 4 vertices (and the corresponding faces connecting them) should be emphasized at different points of the curriculum, and in different ways for majors and non-majors

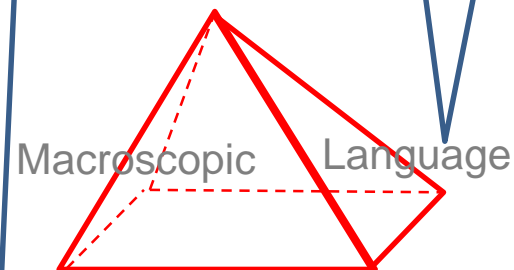
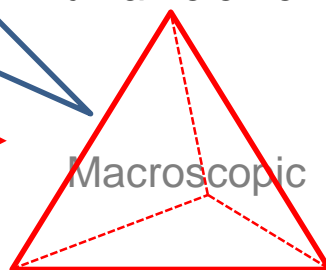
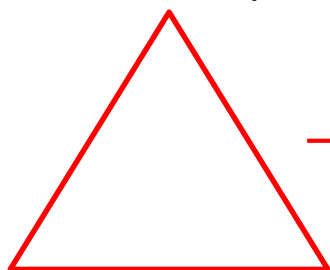
factor influencing students' understanding of complex science concepts

representing the linkage between macroscopic and microscopic world

Macroscopic

Human element

Human element



Sub-Micro

Symbolic

Molecular

Symbolic

Meso

Symbolic

Triangular chemistry

AH Johnstone, 1982

Tetrahedral chemistry

Pyramidal chemistry

M-H Chiu, 2012

Chemistry Education for the 21st Century

2. Education is changing rapidly

❑ Chemistry education must also change

Challenges

- **Course content: scope, depth, relevance**
 - **Role of the chemistry educator**
 - instructor; tutor; mentor; facilitator
 - **Conceptualization; visualization; modelling ability**
 - **Standards; assessment; accreditation**
 - Knowledge
 - Skills (theoretical; practical)
 - Chemistry literacy
 - **Experimentation**
 - vital (?) as
 - a way of learning: chemistry as experimental science which uses observations to create and test theories and to help train the learner in deductive reasoning
 - a way of developing the practical skills of the future 'chemist'/'technologist'
- X Poor availability of equipment, chemicals, laboratory facilities in some places
- X Poor availability of practical teachers, laboratory technicians
- X Challenge for distance learners
- ✓ OU: home experimental kits + summer school lab work
- ✓ Microscale science

Chemistry Education for the 21st Century

2. Education is changing rapidly

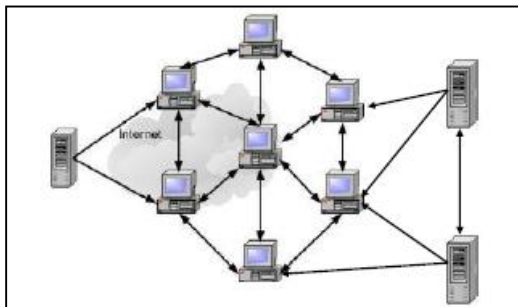
❑ **Chemistry education must also change**

Challenges

- **Course content: scope, depth, relevance**
- **Role of the chemistry educator**
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- **Standards; assessment; accreditation**
- **Experimentation**
- **Materials supporting the teacher and learner**

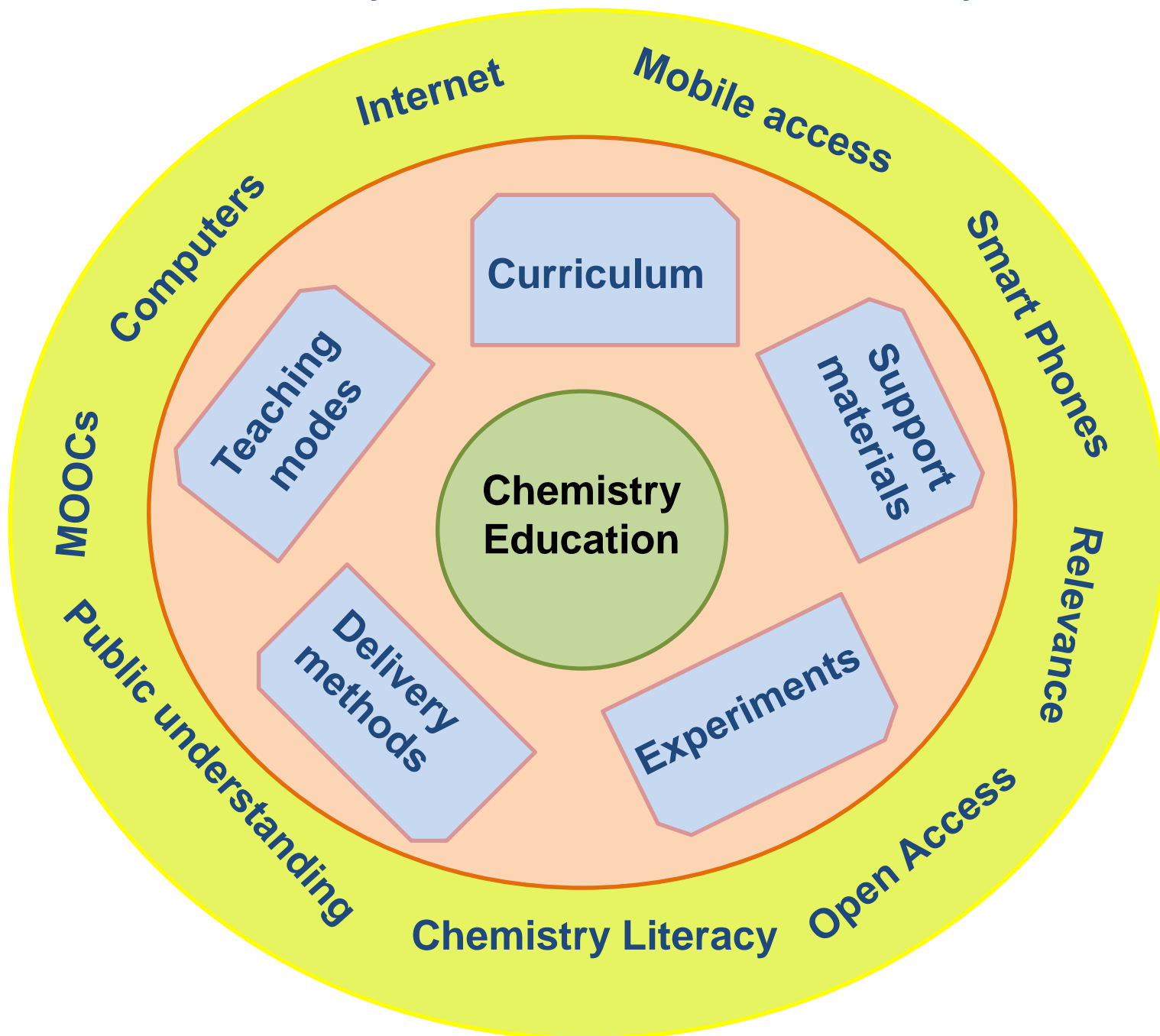


***Chemistry
KnowLedge***

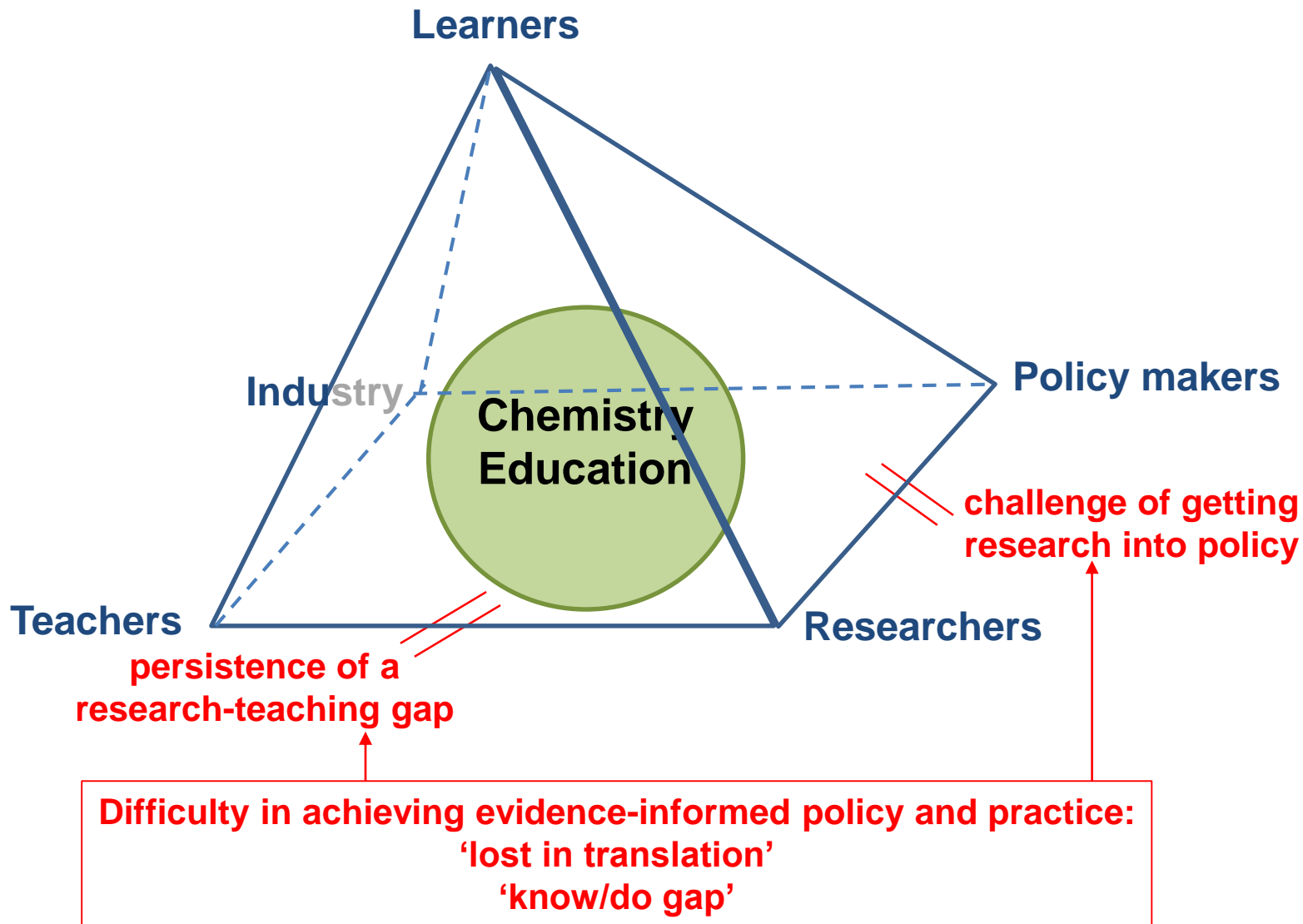


***Chemistry
KnowBase***

Chemistry Education for the 21st Century



Chemistry Education for the 21st Century



Chemistry Education for the 21st Century

Objectives

- 1. Reflect on recent, current and prospective changes in chemistry education**
 - **Inputs to a paper on *Education and chemistry: meeting the challenge of access for all***
- 2. Advise on the establishment of an *IOCD Working Group on Chemistry Education***
 - **Consider the key characteristics for a *Chemistry KnowBase* to support teachers and learners**
- 3. Consider the need for an *International Conference on Chemistry Education for the 21st Century***