Science and Engineering Education in the 21st Century

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The context

- Dramatic developments in science and technology through the 20th century
- Trend continues
- Digital world a contributor to acceleration – driving new directions of enquiry

The context, continued

- The central place of education in the development agenda is unquestioned
- How do we shape science and engineering education to respond to developmental goals, in a context of rapid change?

Education at the university level

- Provide students with a thorough grounding, a knowledge base, a foundation on which to continue to build knowledge
- In addition, develop the ability to think and analyze critically
- Equip the graduate to assess and adapt to change, also contribute to change
- Bear in mind that the graduate could have a career of 40 years, and that most graduates will in fact have 2, 3 or more different careers during their working life

How to structure the curriculum?
The centrality of multi-disciplinary thinking

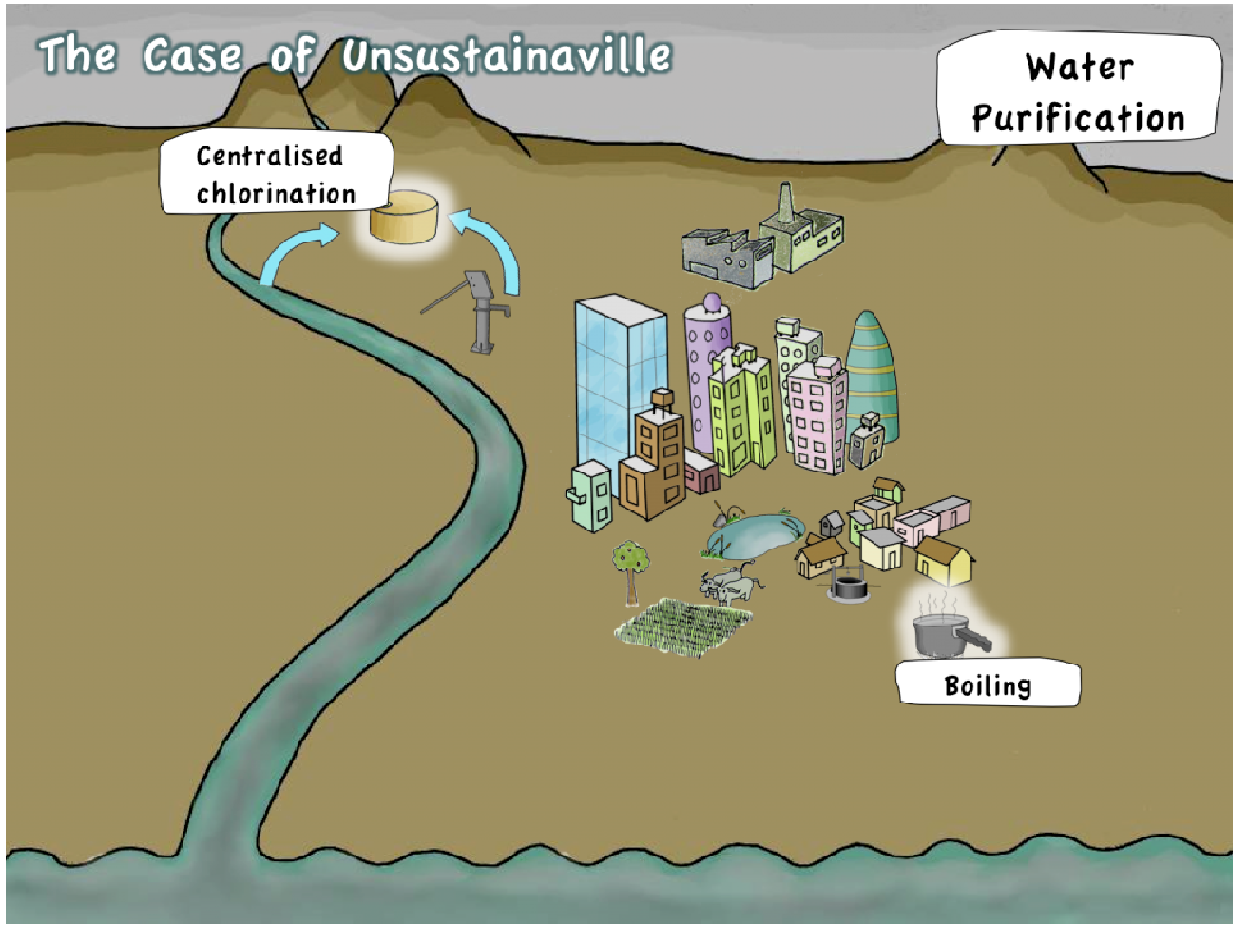
Bioprocess engineering:

- biomineral processing
- remediation of acid mine drainage
- commodity amino acids
- pigments and agricultural products

blend of chemistry, biochemistry, mathematics, scientific computing, microbiology,

…

The centrality of multi-disciplinary thinking



http://www.sswm.info/

Water purification:

- chemistry
- hydrology
- civil engineering
- public health
- the involvement of
  - environmentalists
  - local communities
  - industry, …

Multi-disciplinary curricula

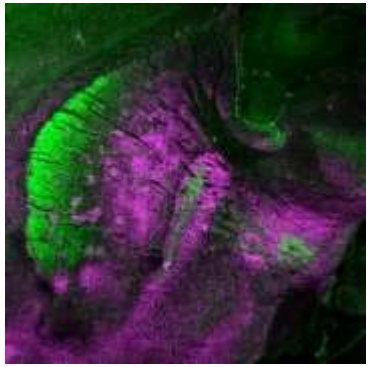
- Techniques and methodology of range of disciplines, from within a disciplinary base
- Problem formulation, problem-solving from a multi-disciplinary perspective, including collaborative project work
- Incorporation of management, human, and social sciences in a thoroughly integrated approach
- Beware of superficiality!

Moving away from the silo mentality: Okinawa Institute of Science and Technology

- Absence of organizational and physical barrier: no departments
- Graduate students trained in a highly multidisciplinary environment

http://www.oist.jp/

A 3D reconstructed "forest" of neurons

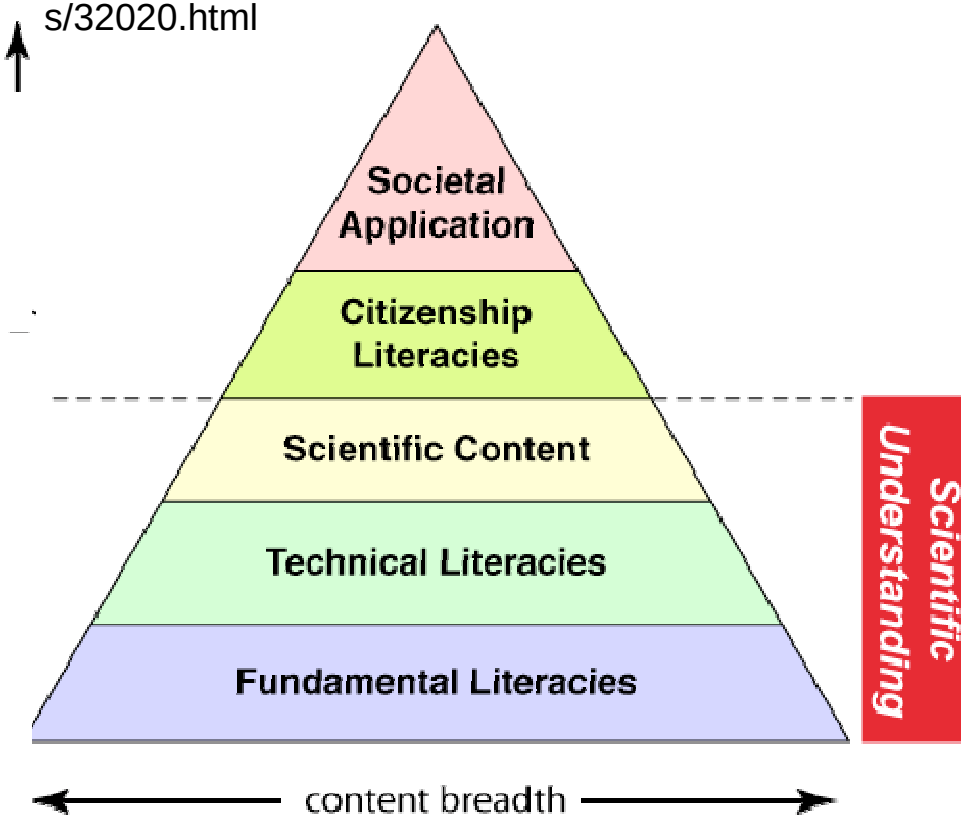


A Neuronal Network in the Basal Ganglia

Critical literacy: learning to read and write

http://esheninger.blogspot.com.br/2013/11/critical-literacy-across-curriculum.html

http://serc.carleton.edu/nnn/numeracyprojects/examples/32020.html



Preparing Students for Citizenship: Fostering Critical Thinking and Problem-solving Skills through Quantitative Reasoning and Scientific Literacy. J. D. Myers and E. A. Campbell-Stone

External perspectives: industry and the state

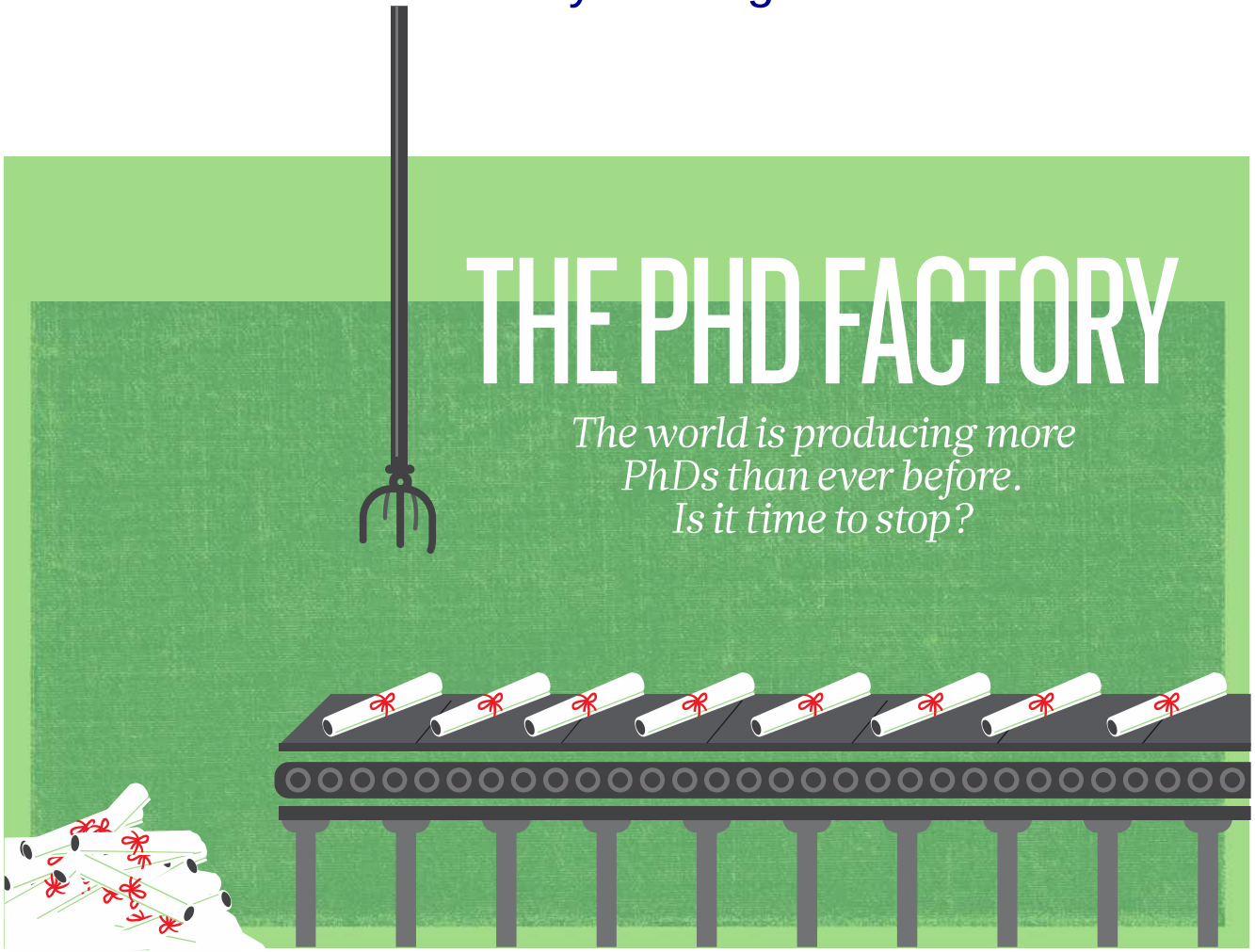
- Industry: the call is often for graduates who are able to be “hit the ground running”
- Governments can also have expectations that link graduates in a direct, short-term way to economic progress
- Important to bear in mind the dual objectives:
  - the importance of building a strong foundation with a range of skills that will serve graduates throughout their careers

    and the alternative of

  - universities as training schools: graduates with a a toolbox that will allows them to be productive in the short term
- The key is three-way communication: government, business, and academia, e.g. via advisory boards

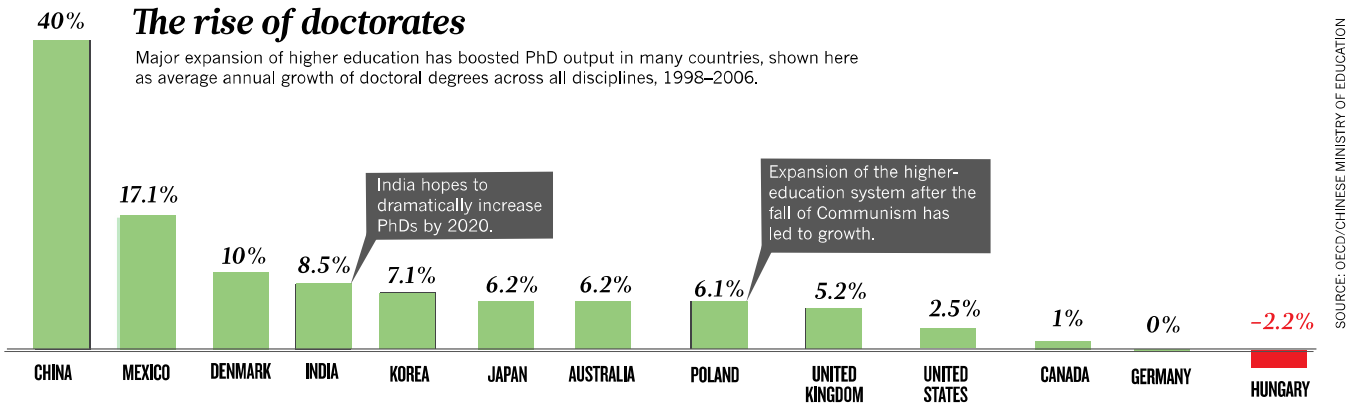
The Ph.D. degree

- No longer esoteric: a critical component of the education mix
- But: are there too many Ph.D. graduates?



Nature, April 2011

The Ph.D. degree



- OECD: 34 000; USA: 20 000 in life and physical sciences

Supply outstripping demand, but situation different in developing countries

- China: 50 000 (2009) largely absorbed

- India: 9 000, below demand particularly from industry

- Germany an exception among developed countries: programmes include development of broad skill-sets as most graduates do not go into academia

The Ph.D. degree: South Africa

- South Africa: National Development Plan sets target of 100 Ph.D. graduates per million population by 2030 (5 000 graduates p.a.)

- Currently, 30 per million (1 500 graduates)

- Target ambitious – the pipeline problem:
  - 1m children start school each year
  - 500 000 complete school
  - A small proportion (less than 10%) qualify for admission to science, engineering, health sciences, economics
  - Success rates at undergraduate level low

No time to discuss …

- Innovations in teaching methods: interactive, blended learning
- MOOCS: comprehensive access, but contact learning continues to hold may benefits

Thank you

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in the service of society