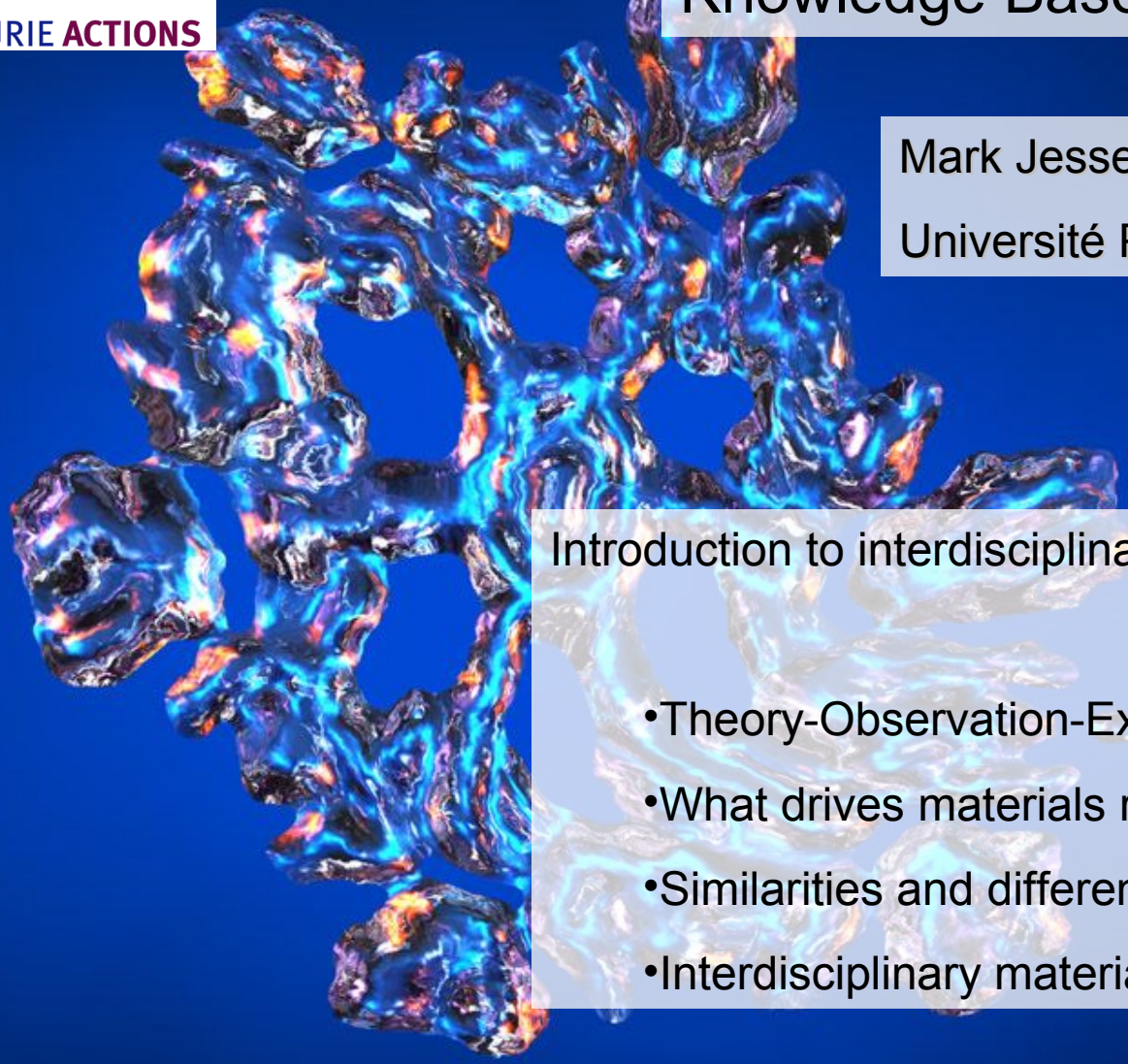
MARIE CURIE ACTIONS

Marie Curie Summer School: Knowledge Based Materials



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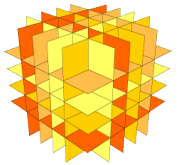
Introduction to interdisciplinary Materials Science:

- Theory-Observation-Experiment-Simulation
- What drives materials research
- Similarities and differences between materials
- Interdisciplinary materials science language

Philosophy

"Learn" from nature. *The objective is to consider the study of nature and learn from its vast paradigms, to increase the understanding in complex physico-chemical and biological phenomena relevant to mastering and processing novel materials.*

"Future Needs and Challenges for Materials and Nanotechnology Research" Report prepared by Materials Unit, European Commission, Research Directorate General, Directorate G / Unit 3. October 2001.



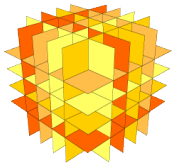
What drives material science research?

- Main aim of technical sciences is to develop
  - Materials with better (& cheaper) performance and properties
  - Better (& cheaper) synthesis and processing techniques

    →Emphasis on DESIGN and DEVELOPMENT

- In natural sciences (geology, medicine, biology), performance and properties are usually given
  - What are the performance and properties?
  - How were the materials synthesised and processed?

    →Emphasis on PREDICTION and FORENSICS



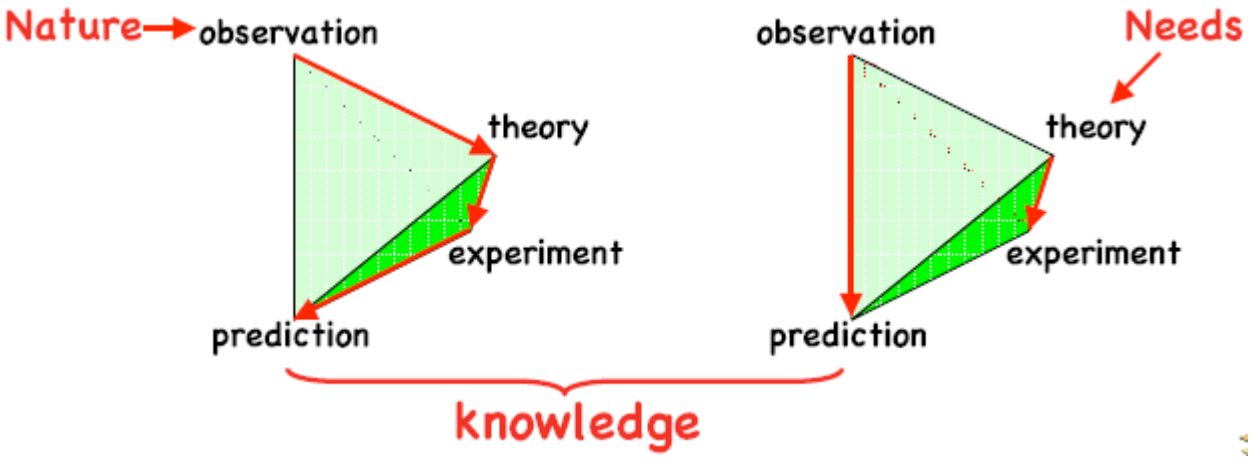
Different approaches

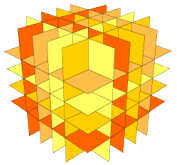
- Natural sciences are driven by observation:

  Nature → Observation → theory → experiment → prediction

- Technological/engineering by needs:

  Needs → theory → experiment → observation → prediction

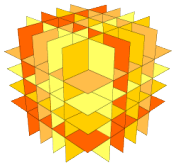




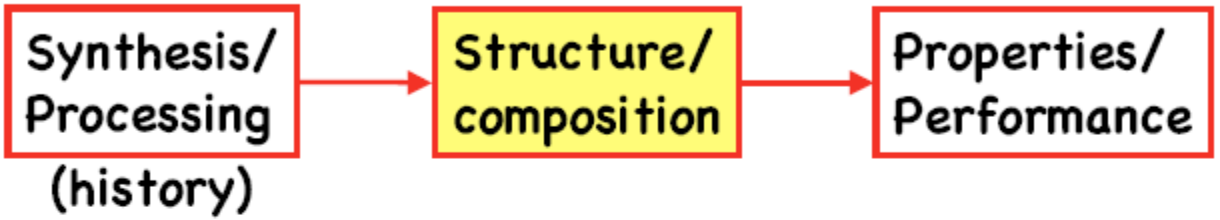
What drives materials research?

New materials
Improved materials (performance, processing)

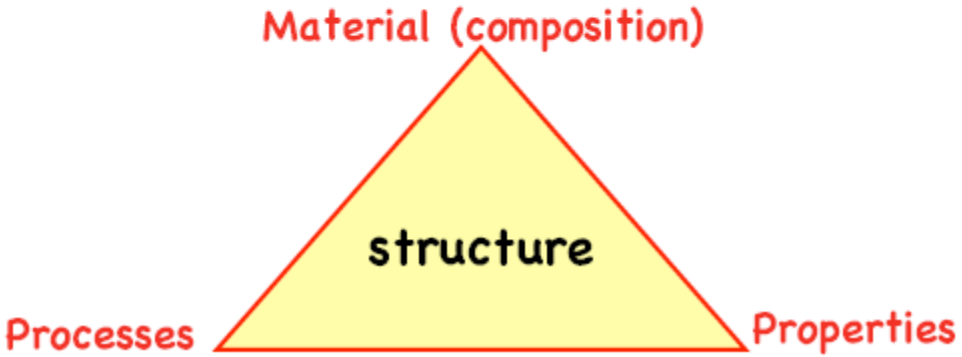
- Surface, Interface, and Thin Film Science
- Nanoscale Synthesis and Mesoscale Engineering
- Complex Materials Systems
- Solid-Liquid Interface Science and Confined Fluids
- Complex Adaptive Matter
- Silicon carbide electronics
- Biointerface Science
- Organic-based Photovoltaics
- Solid-State Memory Technologies
- Electronic Noses and Tongues
- Superconductor Wires
- Scanning Probe Microscopy
- Molecular Electronics
- Construction Materials
- Carbon Nanotubes
- High Res. 3-D X-Ray Microscopy
- Colloid Science
- Multi-scale simulation techniques
- Geotextiles
- Carbon Sequestration

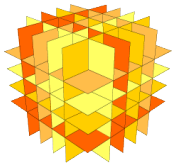


Common link



- Gottstein 2005: "[Micro-] structure is the state variable of materials properties"





Properties and performance

Mechanical:
- Tensile strength, fracture toughness, fatigue strength, creep strength, hardness, etc.

Electrical:
- Conductivity or resistivity, ionic conductivity, semiconductor conductivity, etc.

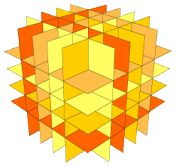
Magnetic:
- Magnetic susceptibility, Curie Temperature, Neel Temperature, saturation magnetization, etc.

Optical and Dielectric:
- Polarization, capacitance, permittivity, refractive index, absorption, etc.

Thermal:
- Coefficient of thermal expansion, heat capacity, thermal conductivity, etc.

Environmental Related:
- Corrosion behavior, wear behavior, etc.

Biocompatibility:
- Toxicity, stability



Synthesis and processing (history)

Solidification Processing (utilizes the liquid state in the process)

- The structural processing of most metals begins by forming an alloy in the molten state.
- Formation of rocks from magmas.

Powder Processing (utilizes powders in the process)

- Slip casting, powder pressing, hydroplastic forming followed by drying and firing or hot pressing
- Snow accumulation followed by conversion of Ice from firn,
- Sedimentation followed by compaction in sedimentary basins.

Deposition Processing (utilizes evaporation and/or condensation in the process)

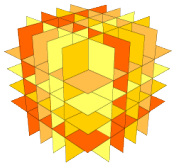
- Electroplating, spray coating, sputtering, laser ablation, chemical vapor deposition (CVD), etc.
- Mineralisation around volcanic vents

Deformation Processing (utilizes crystal plasticity or a viscous flow in the process)

- Rolling, forging, drawing, extrusion, spinning, cutting, turning, milling, etc.
- Glacier flow, mountain building

Geological Processing

- Solid-state chemical reaction (metamorphism)
- Water related mechanical, biological and chemical segregation of materials



Historical Perspective

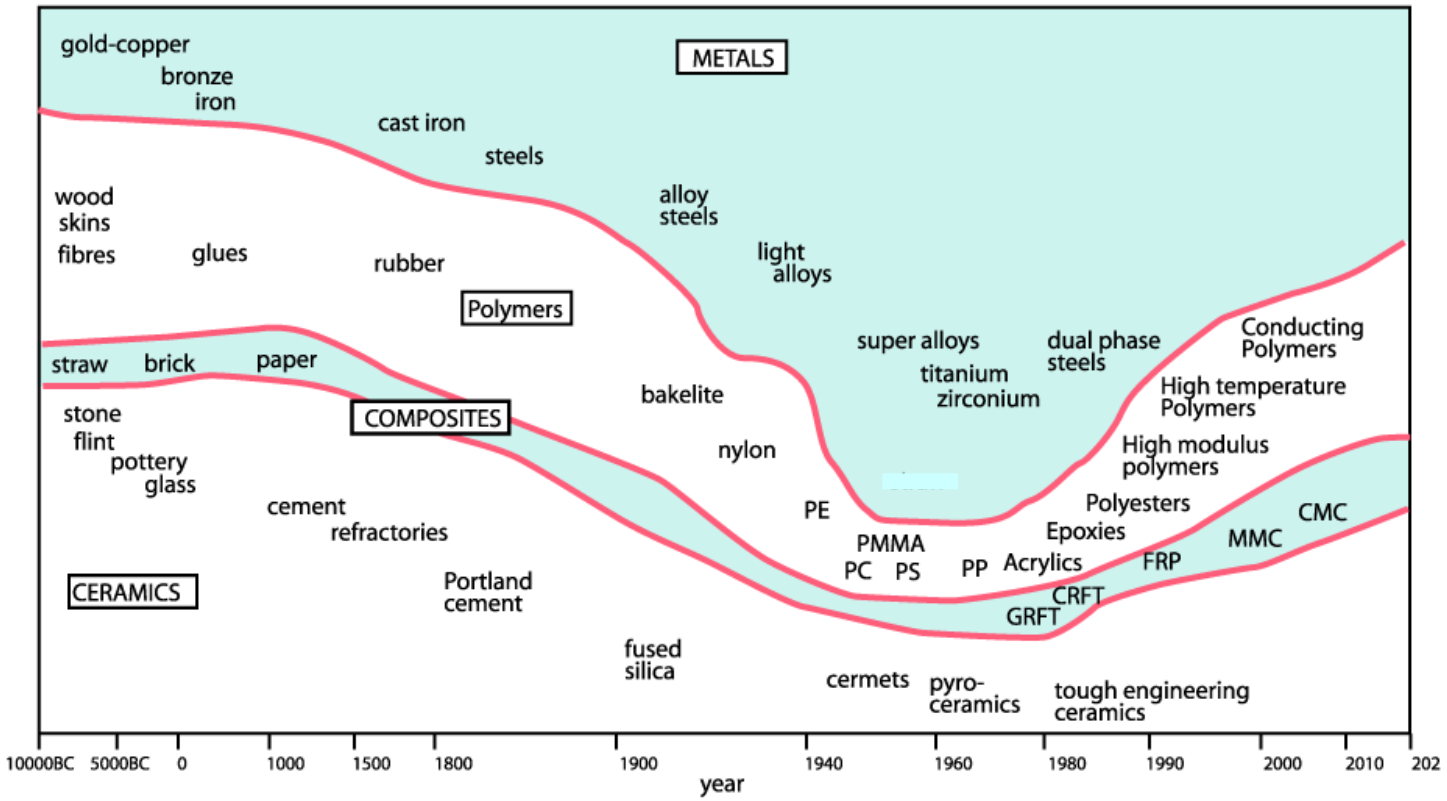
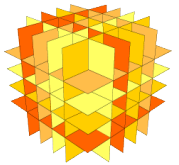
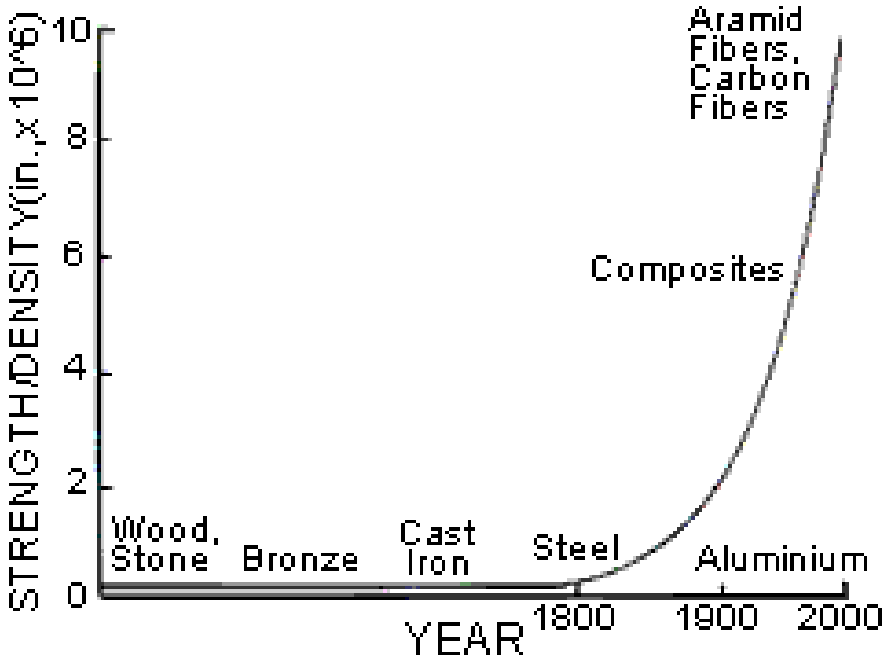


Figure5-1: Historical and projected development of materials categories

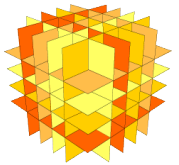
The following diagram by Prof. M.F. Ashby of Cambridge University in the UK shows clearly the historical and projected development of different categories of materials from pre history into the next century. It shows that the trend is for a return to major importance of ceramics, polymers and composites with a relative decline in the importance of metals.



Strength



http://www.crc4mse.org/what/MSE_history.html

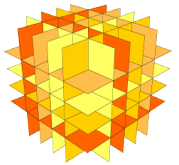


Competitiveness 2010

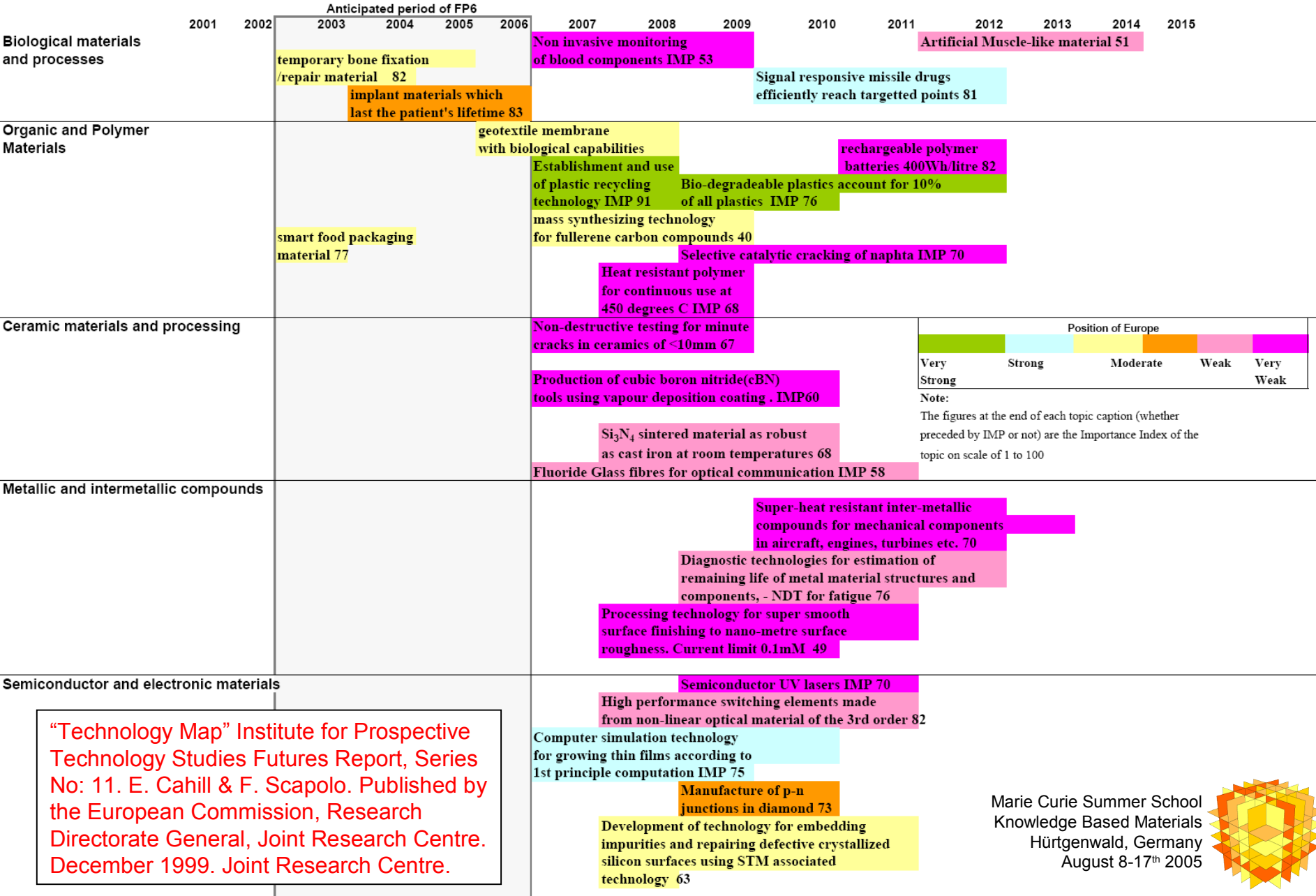
Indicative Position of Europe			
Technology Sector	EU	US	Japan
ICTs	☆ ☆+	☆ ☆ ☆ ☆	☆ ☆ ☆
Life Sciences	☆ ☆+	☆ ☆ ☆ ☆	☆ ☆
Energy	☆ ☆ ☆	☆ ☆ ☆	☆ ☆ ☆
Environmental and Clean Production	☆ ☆ ☆	☆ ☆ ☆	☆ ☆ ☆
Materials	☆ ☆	☆ ☆ ☆ ☆	☆ ☆ ☆
Transport	☆ ☆ ☆	☆ ☆ +	☆ ☆ ☆

☆ The star symbol indicates strength in the sector. The number of stars indicate the approximate level of the strength. The + sign indicates higher but less than an additional star.

"Technology Map" Institute for Prospective Technology Studies Futures Report, Series No: 11. E. Cahill & F. Scapolo. Published by the European Commission, Research Directorate General, Joint Research Centre. December 1999. Joint Research Centre.



Materials Technology Map



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- Many disciplines address similar questions
  - What are the different languages?
  - Are there unique aspects to certain disciplines
  - What are the different scales?