Materials Science and Corporate Research

Steven C. Freilich
Director, Materials Science (emeritus)
DuPont Central Research & Development
Materials Science and human development

Handaxe
~ 1.66 million years old
Majuangou, China

Omo Kibish Point
~ 110,000 years old
Omo Kibish, Ethiopia

Bone and ivory needles
~ 25,000 years old
Xiaogushan, China

Minimal processing & basic functionality

http://humanorigins.si.edu
Bronze Age Artifacts

Bronze needle,
Minoan
2000 BCE

http://www.metmuseum.org/art/collection/search/252397/

Socketed Axe
Ca. 1000 BC

http://www.weapons-universe.com/

3,000 years ago

Same application- more complex materials
Profiting from materials businesses

New, complex materials replace the old

Same performance, lower cost
- Cost of manufacture or formulation innovations
- Managing the competitive environment

Differentiated performance, same cost
- Diversified functions supporting innovation
- R&D as a means of growth-science as a business
Profiting from science as a large corporation

3 characteristics needed to enable profitable materials science

Uncertainty Management
- Balanced portfolio
- Absorption of failure

Knowledge Acquisition
- Learn/Create
- Sensing

Integrated Development
- Across divisions
- Throughout stages

The global market challenges materials companies

**Markets rapidly commoditized**
- Margins squeezed
- Research “cost” harder to absorb

**Long innovation delivery times**
- Requires funding by cash businesses
- Hard to absorb research investment

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**Materials & Chemicals Financial Performance**

<table>
<thead>
<tr>
<th>Market Familiarity</th>
<th>Technology Familiarity</th>
<th>Success Rate</th>
<th>Time of Comm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>~30-40%</td>
<td>~4 yrs</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>~30-40%</td>
<td>~11 yrs</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>~15-20%</td>
<td>~14 yrs</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>~15-20%</td>
<td>~14 yrs</td>
</tr>
</tbody>
</table>

J. Boringter, T.J. Simons, McKinsey, Commoditization in chemicals 12/16

C. Musso et al, McKinsey Chemical Innovation 5/13
Materials businesses react to investor pressure

- Businesses become “focused” - *i.e.* less diversified with shorter-term mentality
- Shift spending from research to application development
- Eliminate functions not required for short-term strategy and sales
- Violates characteristics of science-based business
  - Breaks the connection from discovery to commercialization
  - Reduces the ability to attract new talent and ideas
  - Reduces the ability to sense and incorporate new opportunities
Depending on starts-up not the perfect answer

- Large materials companies lack the sensing capability and risk tolerance
- Venture money prefers 3-5 years to exit & minimal invested capital
- No one to fill the Valley of Death
Application development drives down novelty
- Apparent in both publishing and patents

Reduces science leadership
- >45% top Mat Sci papers non-US
- Implications for competitiveness, national security, & attractiveness
Innovation can change the competitive equation

- US vs. China cost: scale & supply chain, not labor
- Can be reproduced but installed base challenges

AC Goodrich, et.al., *Energy and Environmental Science*, 2013, 6, 2811-2821
Thank you
Government role is key to optimizing the future.
The opposite is happening

Solar energy industry driven by technology and business innovation

- Rapidly moved down the experience curve
- Focus on lowering cost of manufacturing
- Dramatic improvements in scale and supply chain
- Usually results in high profit margins to support further innovation
- But……..

Source: Photon International

AC Goodrich, et.al., *Energy and Environmental Science*, 2013, 6, 2811
Plenty of Innovation Space Left- the Materials Paradox

Federal investment as % GDP dropping

- Physical sciences and engineering used as proxies for materials science
- Government spending not supporting continued growth through innovation
- Significant implications on future GDP growth

*The 2001 jump in engineering is due to reclassification of funding and is therefore artificial. Source: AAAS. Updated by the American Statistical Association Science Policy Office.*
• Reduced science leadership in both industry and universities
  – Industry not challenging universities
  – US less attractive to top students

*Source of Top 100 Mat Sci Publications*
Federal spending in Materials Science

Federal Materials/Metallurgy R&D Obligations

Increase is fundamentals almost entirely due to NNI
The example of PET\(^1\) shows how rapidly commoditization of a product can progress.

\(^1\)Polyethylene terephthalate.

\(^2\)Using naphtha as a proxy for PET raw materials.
Government intercession

Policy

Kinetics, not thermodynamics

Financial incentives

Base load markets & credits

Risk management

De-risk Valley of Death

Influence behavior

Nucleate the agenda