“Materials” Innovation in Technological Progress

Organizing Questions

- How might one bridge the “Gap” between economic (sociological, historical, etc.) and technological capability (engineering science) approaches to technical progress?
- Can we quantitatively study the progress of technological capability at “a higher level of abstraction” than has been done previously ? What to observe and how categorize?
- Can we learn *anything new* from such an approach to technological progress?

- Can we explain/model important findings/facts from the studies at the higher level of abstraction?

- Is there practical utility from the findings/facts?

Some issues and background

- “Finding” data
- “ Higher” level of abstraction – What can we do if we want to avoid measuring progress in 1000s of individual TASAs?
- Generic Functional Approach

Terminology - Functional Performance

- Function- **what** a system, device etc. **does**

- Performance- **How well the function is achieved** and measured by a FPM (Functional Performance Metric) :

  Tradeoff metric- Output/Input

Scope of approach to technological progress

- Emphasizes ***functional performance*** or technical capability ***but not diffusion*** of technological approaches or artifacts
- Focuses on measurable technical progress and thus on engineering metrics for technical capability over time
- FPMs include **all technical** improvements whether having large or fairly small social/economic impact*;*
- Includes engineering/invention ***at all levels of a technology improvement hierarchy***
- Models when developed must be consistent with understanding on a more detailed level

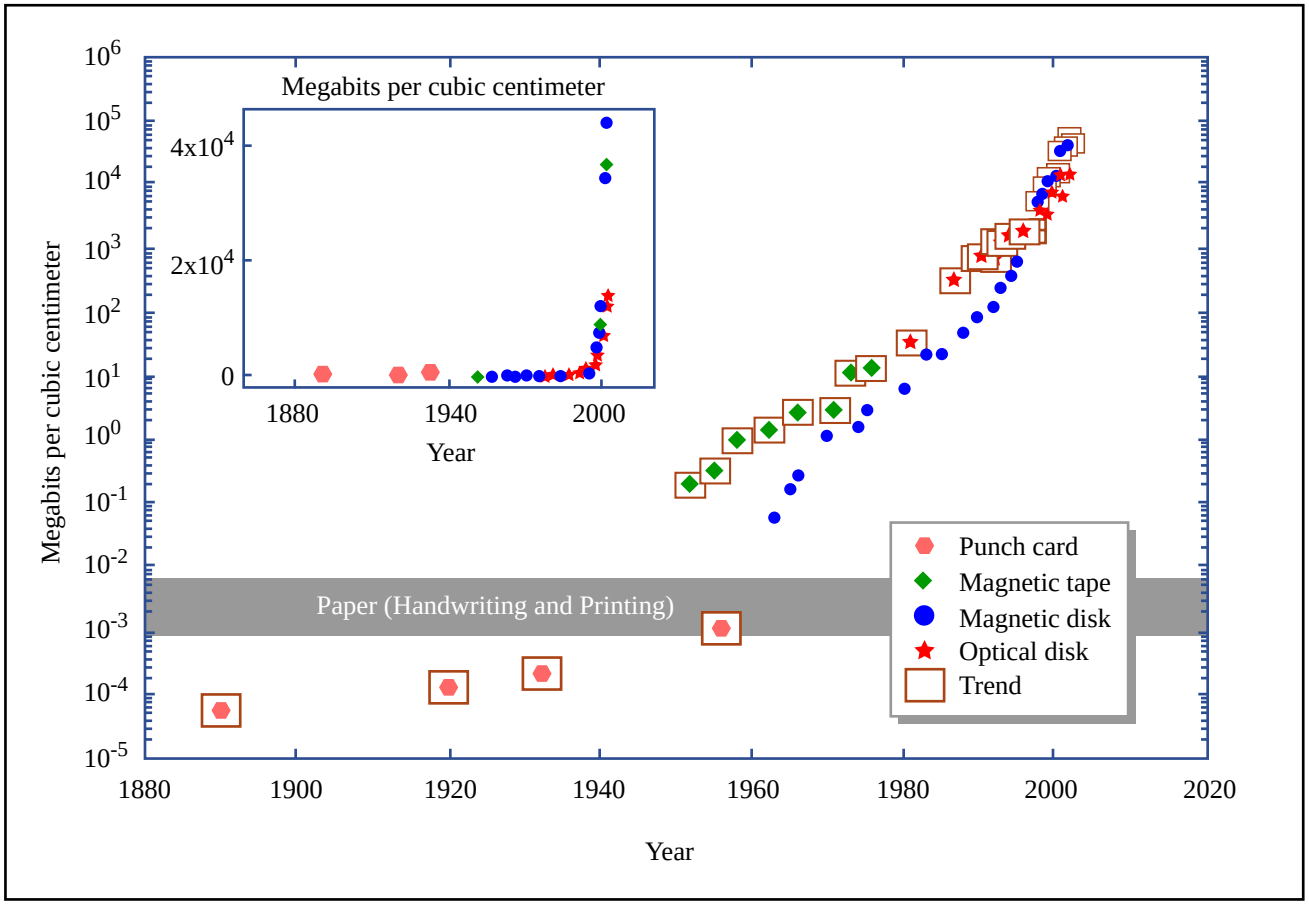


Figure by MIT OpenCourseWare.

Organizing Questions -PRELIMINARY ANSWERS

- Can we quantitatively study technological progress at “a higher level of abstraction” than has been done previously ? YES

- Can we learn *anything new* from such an approach which is essentially a “a higher abstraction level” than other quantitative studies of technological progress? YES

- Can we explain/model important findings/facts from the studies at the higher level of abstraction? I THINK SO

- Is there practical utility from the findings? Can the work help in closing the academic “Gap”? PROBABLY

History of invention plus cognitive science

- “Invention always occurs in the combined social, economic, institutional and cultural contexts and must be understood in terms of these contexts. Inventors must ‘negotiate’ their work on two fronts. On the one hand, with nature, they must ground their work in an understanding of what materials, natural processes and so on afford. On the other hand with society, they must arrive at inventions that have a practical and valued place.”

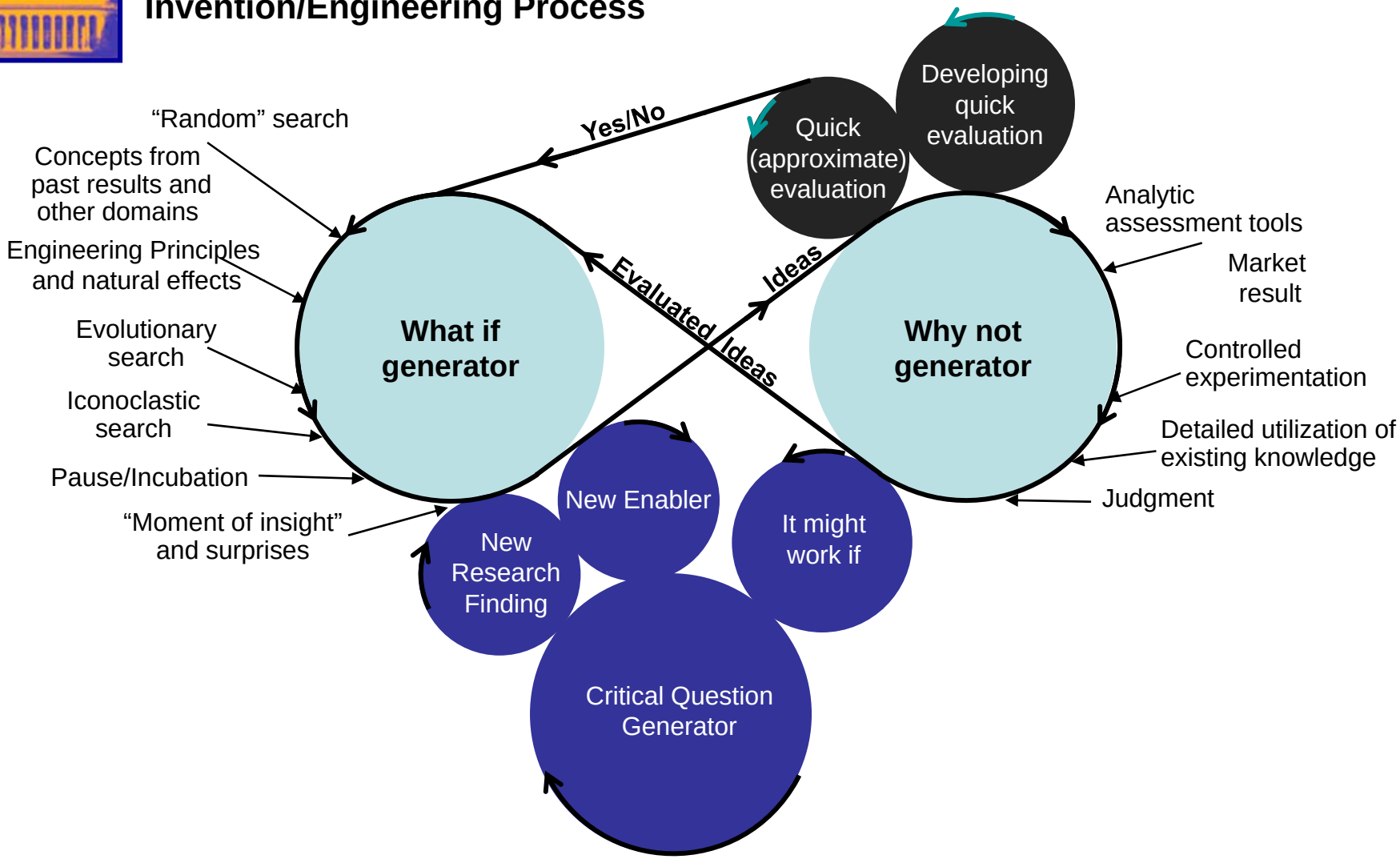
2003/4 Lemelson invention workshops

Negotiation Fronts or requirements for engineering/invention

- Natural law (Mother Nature's laws apply everywhere)
- Society (perceived as valuable by others who act upon their perception)
- Imagination/creativity-independent invention
- Existing knowledge/capability (**technology, science** (*inventions "ahead of their time"*)
  - Babbage
  - da Vinci
  - IPOD

    numerous others

Invention/Engineering Process

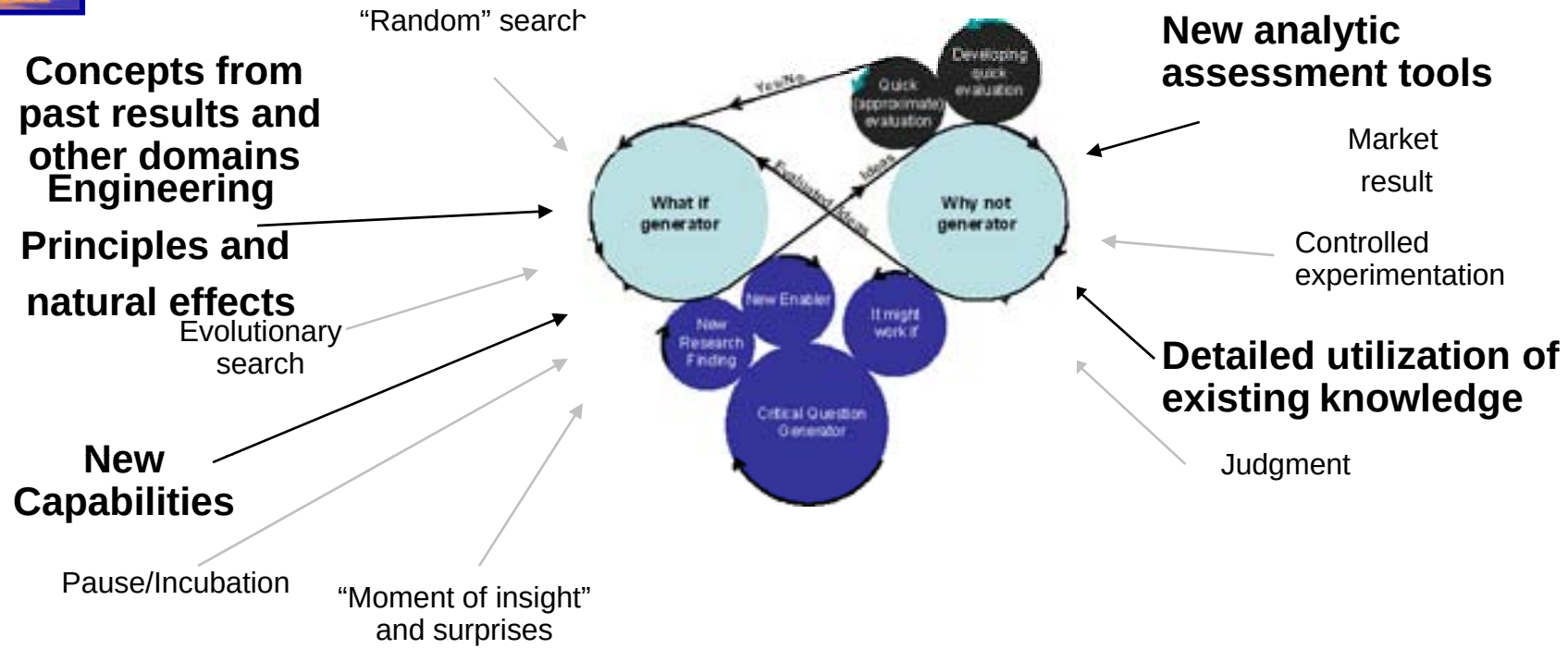


Accumulating Knowledge

Search techniques
Preparation or prototyping skill

Results from assessing
Evaluation techniques
Limits and tradeoffs

Invention/Engineering Process



Accumulating Knowledge

- Search techniques
- Preparation or prototyping skill

- **New science**
- Critical questions
- **New enabling approaches**

- **New combinations**
- **New capabilities**
- **New design principles**
- **Previously impossible actions**

- **Results from assessing**
- **New evaluation techniques**
- Limits and tradeoffs

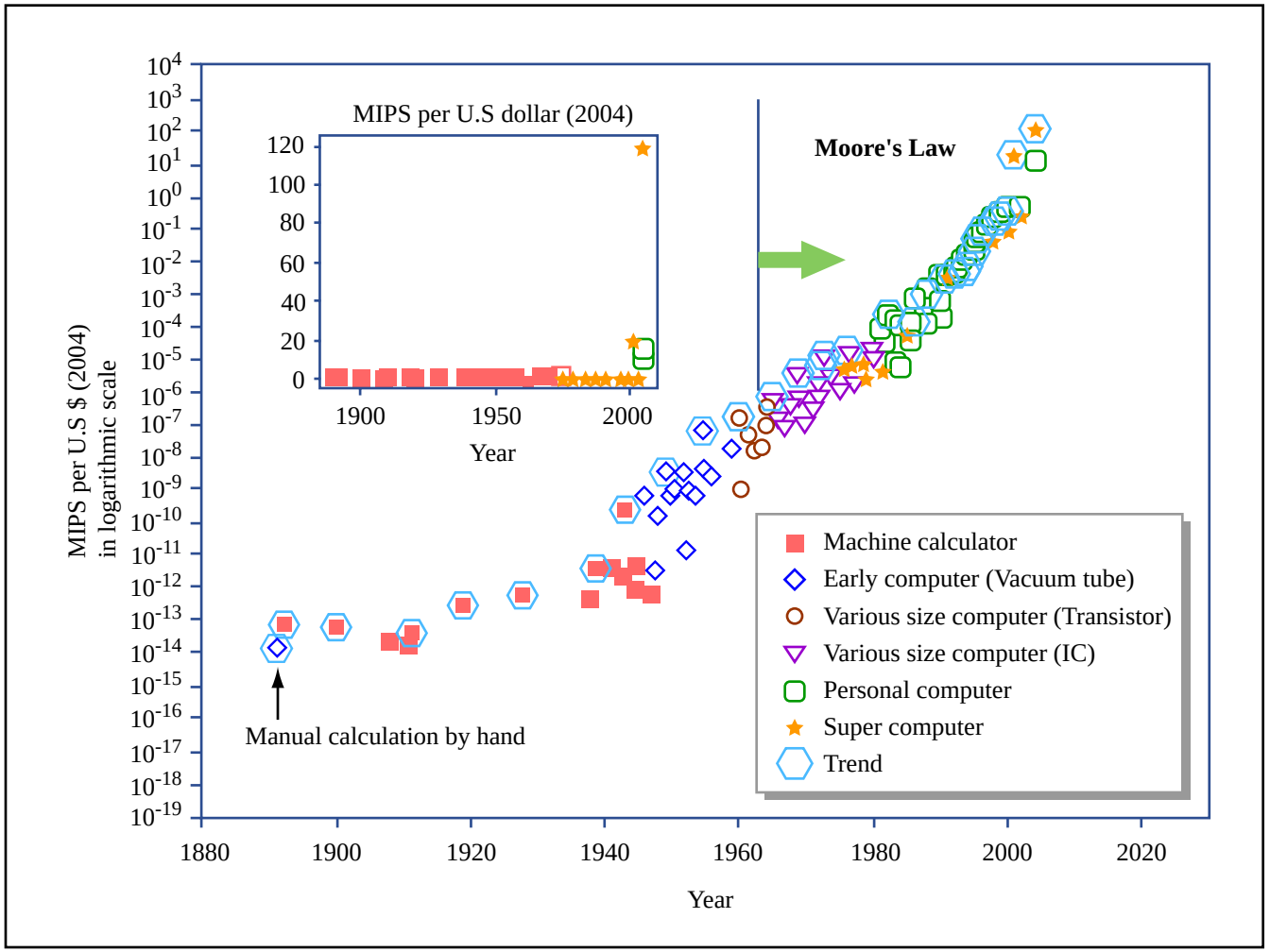
Some issues and background

- “Finding” data
- “ Higher” level of abstraction – What can we do if we want to avoid measuring progress in 1000s of individual TASAs?
- Generic Functional Approach
- An opportunistic move to “Materials”

Chemical Heritage Foundation

- **Robert W. Gore Materials Innovation Project**

- **Patterning the World: The Rise of Chemically Amplified Photoresists**
  by David C. Brock
- **Innovation and Regulation on the Open Seas: The Development of Sea-Nine Marine Antifouling Paint**
  by Jody A. Roberts
- **Sun & Earth and the "Green Economy": A Case Study in Small-Business Innovation**
  by Kristoffer Whitney



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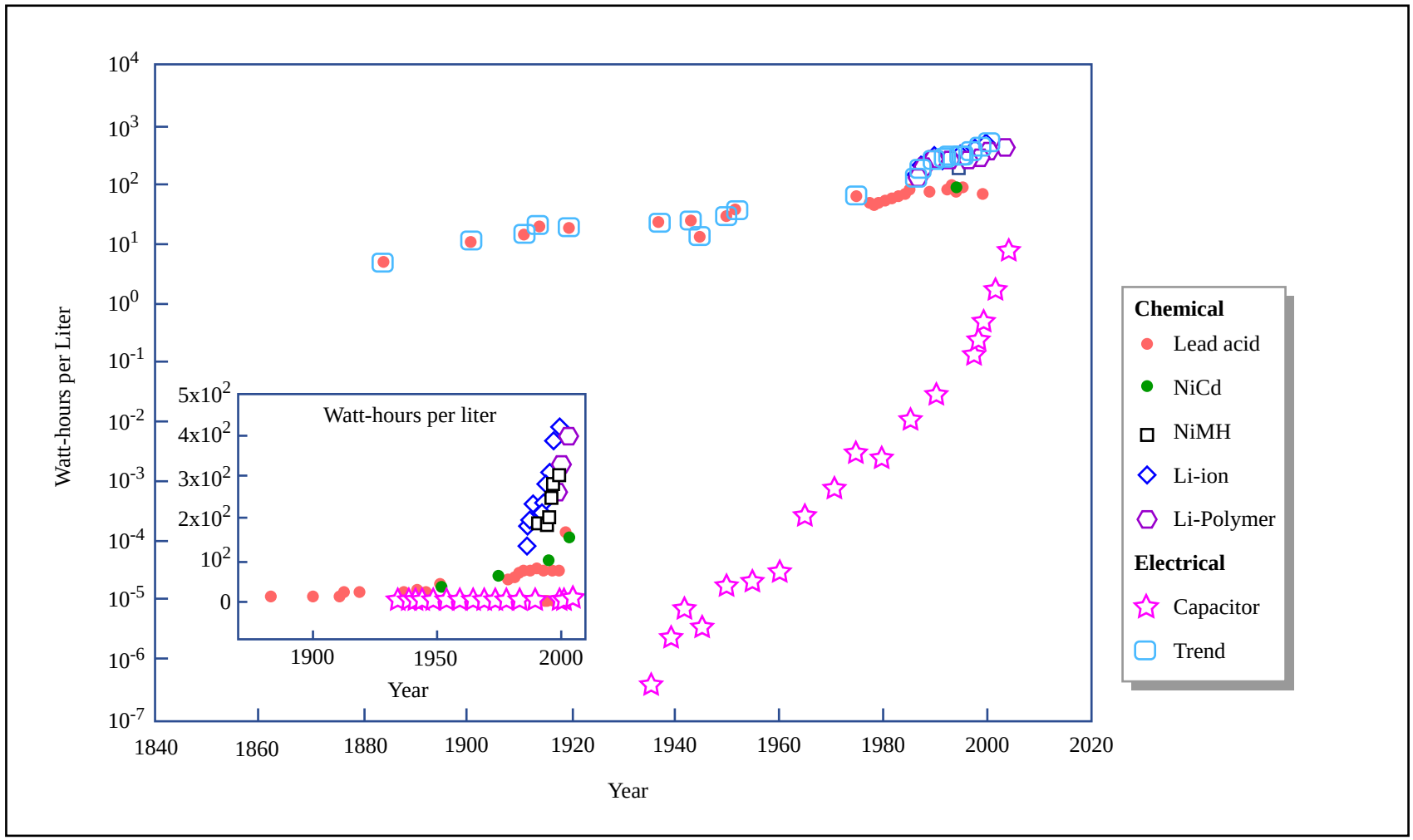

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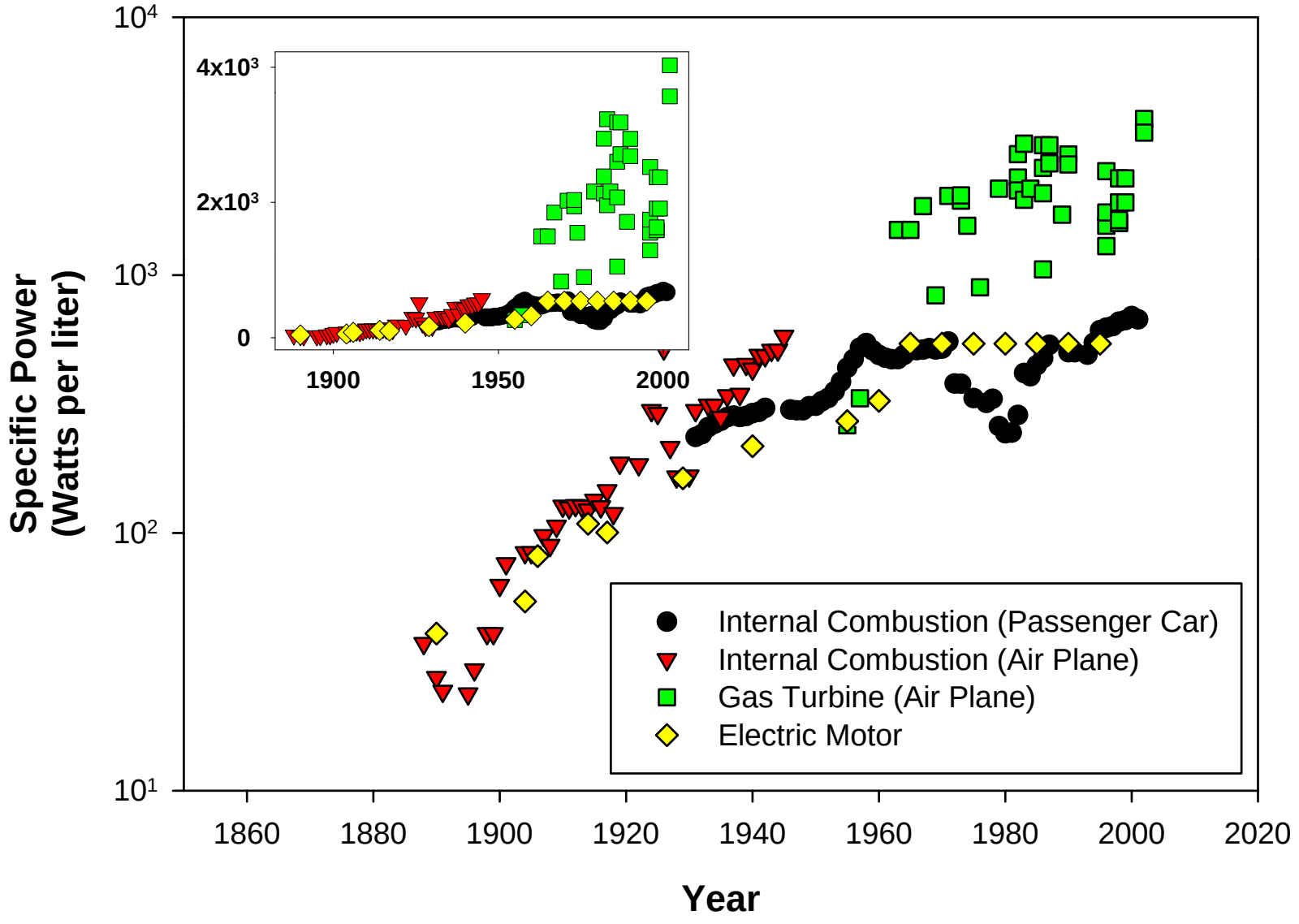
Specific Power
(Watts per liter)
10^4
10^3
10^2
10^1
4x10³
2x10³
0
1900
1950
2000
1860
1880
1900
1920
1940
1960
1980
2000
2020
Year
Internal Combustion (Passenger Car)
Internal Combustion (Air Plane)
Gas Turbine (Air Plane)
Electric Motor

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