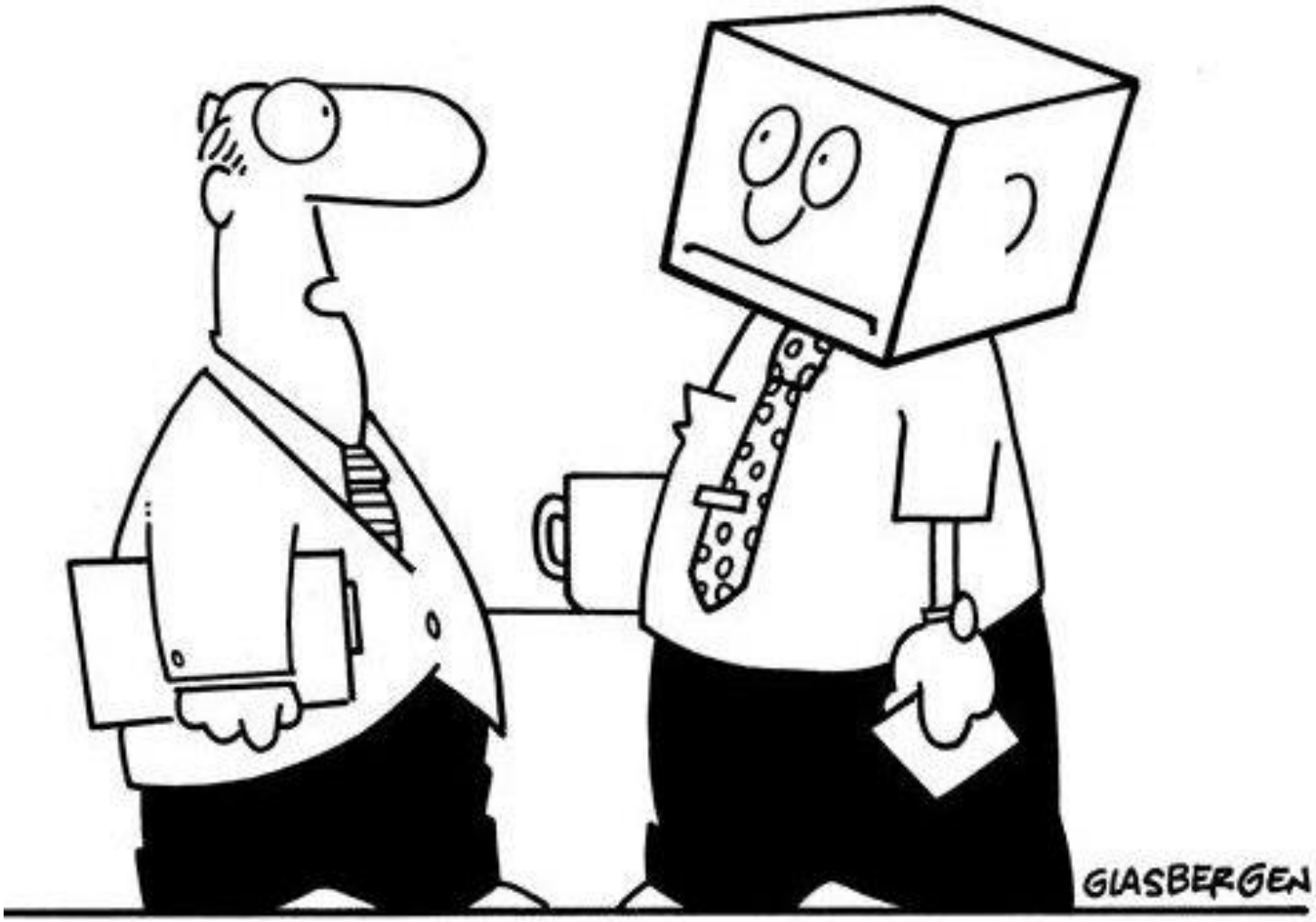


"Thinking outside of the box is difficult for some people. Keep trying."

Creativity in the Sciences

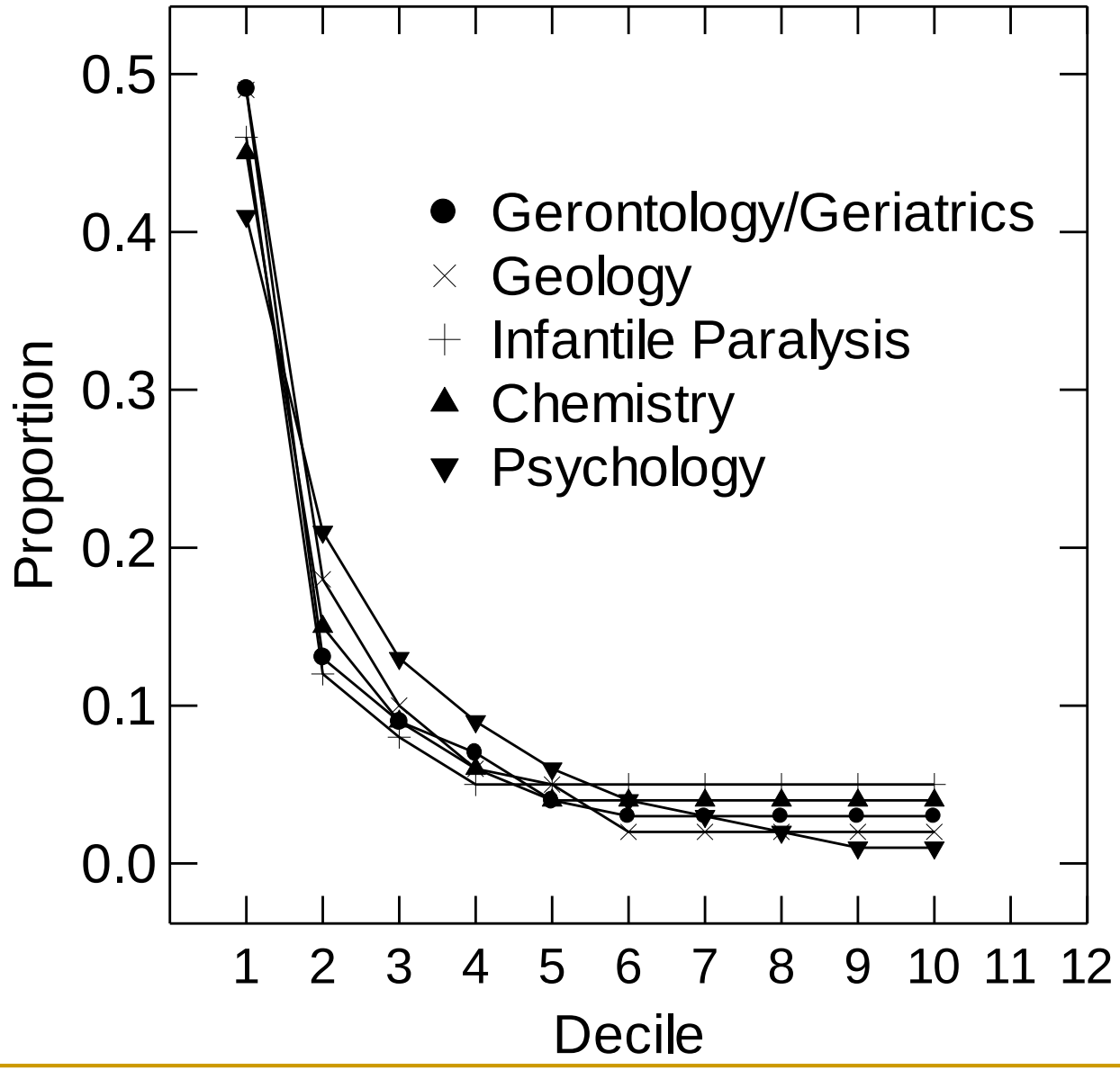
Creative Ideas, Scientists, Processes, and Disciplines

Creative Ideas

- Two requirements
  - *Novelty:* an idea must be original
  - *Utility:* an idea must be useful
- Let *Novelty* and *Utility* be hypothetical variables ranging from 0-10
- Then *Creativity* = *Novelty X Utility* ranges between 0-100

Creative Scientists

- Productive Output
  - Lokta's Law: $f(n) = c/n^2$
  - Price's Law: $k^{1/2}$ 🕓 50%


0.5
0.4
0.3
0.2
0.1
0.0
Proportion
1
2
3
4
5
6
7
8
9
10
11
12
Decile
Gerontology/Geriatrics
Geology
Infantile Paralysis
Chemistry
Psychology

Creative Scientists

- Scientific Impact
  - Productivity 🕓 Citations
  - Citations 🕓 Recognition

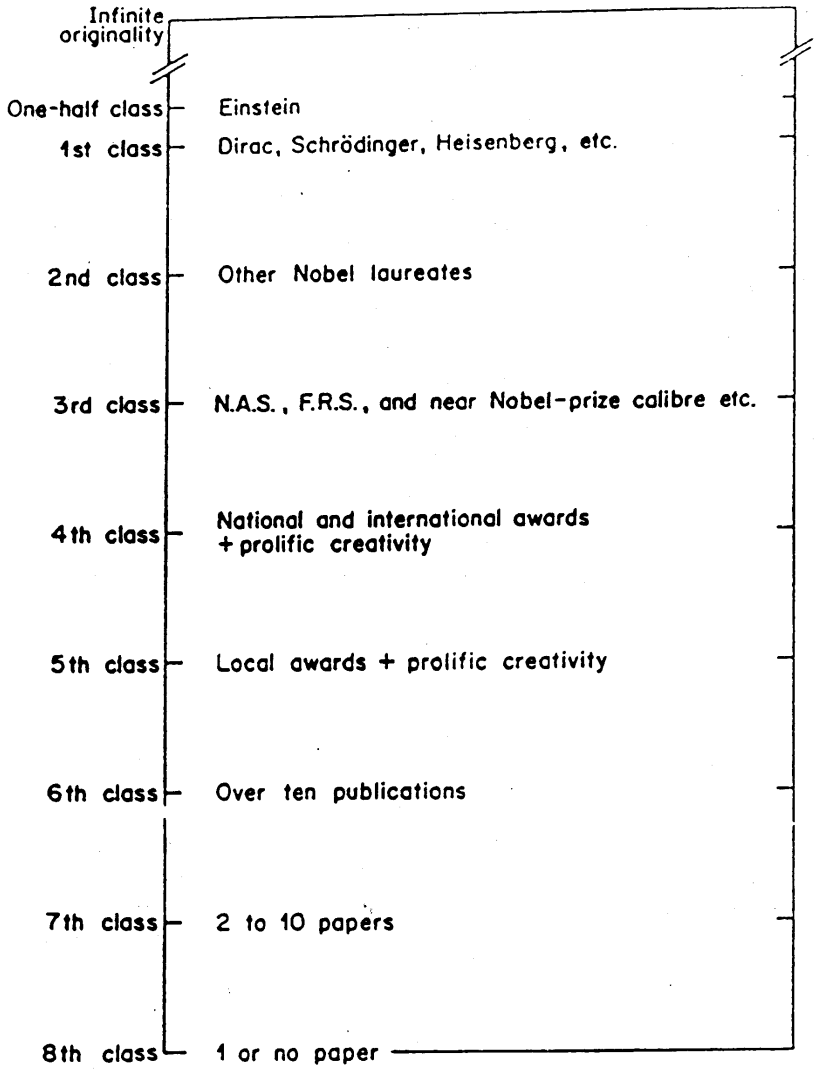
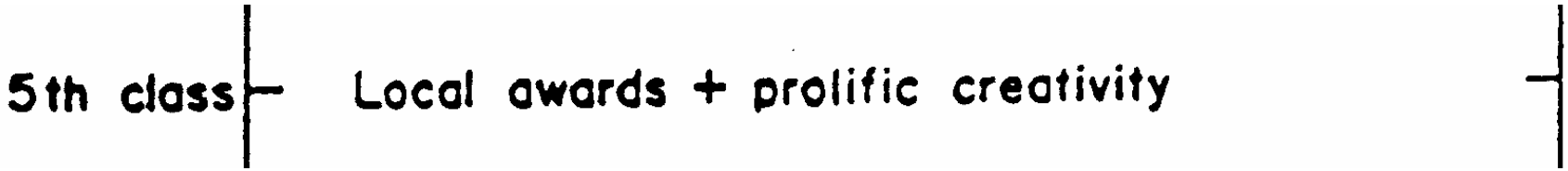


Fig. 2 The Landau-Lotka diagram depicting the logarithmic scale on which the widely varying extremes of scientific accomplishment (counting *both* the quality and the quantity of scientific papers) may be represented.

8th class — 1 or no paper

7th class	2 to 10 papers

6th class — Over ten publications


5th class
Local awards + prolific creativity

4th class — National and international awards + prolific creativity

3rd class — N.A.S., F.R.S., and near Nobel-prize calibre etc.


2nd class
Other Nobel laureates

1st class — Dirac, Schrödinger, Heisenberg, etc.

One-half class Einstein

Creativity = 100

Creative Processes

- No one single “creative process” but rather a mix of methods that range from
  - “Strong” or “algorithmic” methods:
    - largely domain specific,
    - heavily expertise driven,
    - and have a high likelihood of providing useful solutions,
    - but are less likely to produce highly novel solutions

Creative Processes

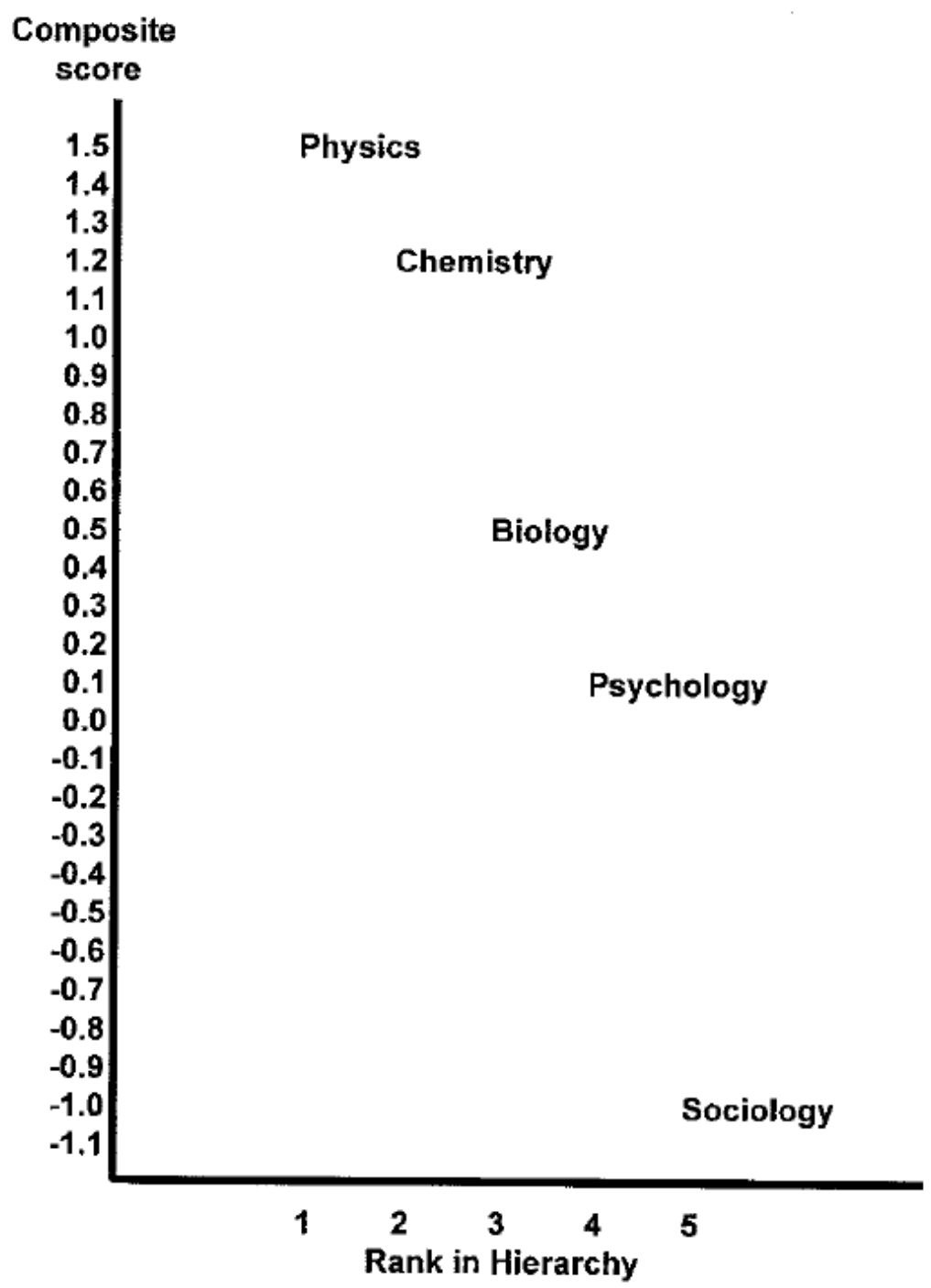
- No one single “creative process” but rather a mix of methods that range from
  - “Strong” or “algorithmic” methods to
  - “Weak” or “heuristic” methods:
    - largely generic across domains,
    - highly contingent on personal traits related to creativity,
    - and have a low likelihood of providing useful solutions,
    - but are more likely to produce novel solutions

Creative Processes

- No one single “creative process” but rather a mix of methods that range from
  - “Strong” or “algorithmic” methods to
  - “Weak” or “heuristic” methods
  - Hence, most creative thought requires an integration of these strong and weak methods

Creative Disciplines

- Similarly, creativity does not operate the same way in all scientific disciplines
- Instead, disciplines differ regarding:
  - the relative role of strong versus weak methods
  - the degree of conceptual precision and rigor
  - the magnitude of consensus
- In Kuhnian terms, the extent to which research in the domain is paradigmatic
- Hence, a hierarchy of the sciences …


Composite score
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
Physics
Chemistry
Biology
Psychology
Sociology
1
2
3
4
5
Rank in Hierarchy

Positive Indicators

- Peer evaluation consensus
- Citation concentration
- Early impact rate
- Citation immediacy
- Anticipation frequency
- Obsolescence rate
- Graph prominence
- Rated disciplinary hardness

Negative Indicators

- Consultation rate
- Theories-to-laws ratio
- Age at receipt of Nobel prize
- Lecture disfluency
- Confirmatory hypothesis tests
- Objectivity in the scientist rather than in the research process

Final Observations

- The disciplinary hierarchy can be extended to encompass the arts and humanities
- Creators active in a given discipline will display dispositional traits and developmental experiences appropriate to that discipline
- But the most creative persons in any discipline will tend to have traits and experiences more typical of creators active lower in the hierarchy!