

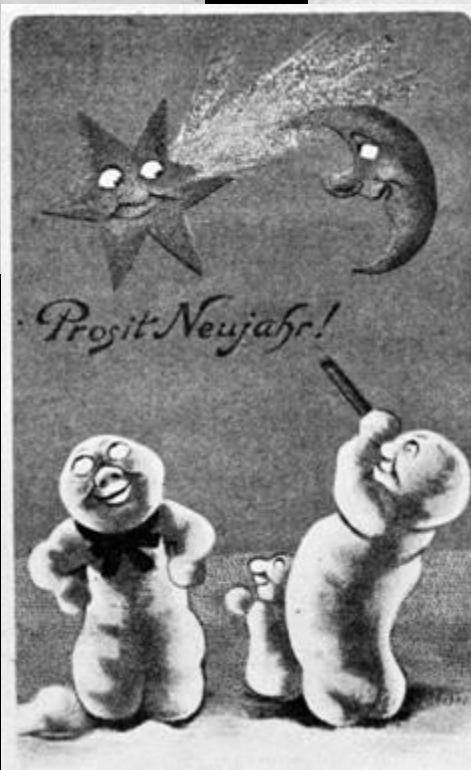
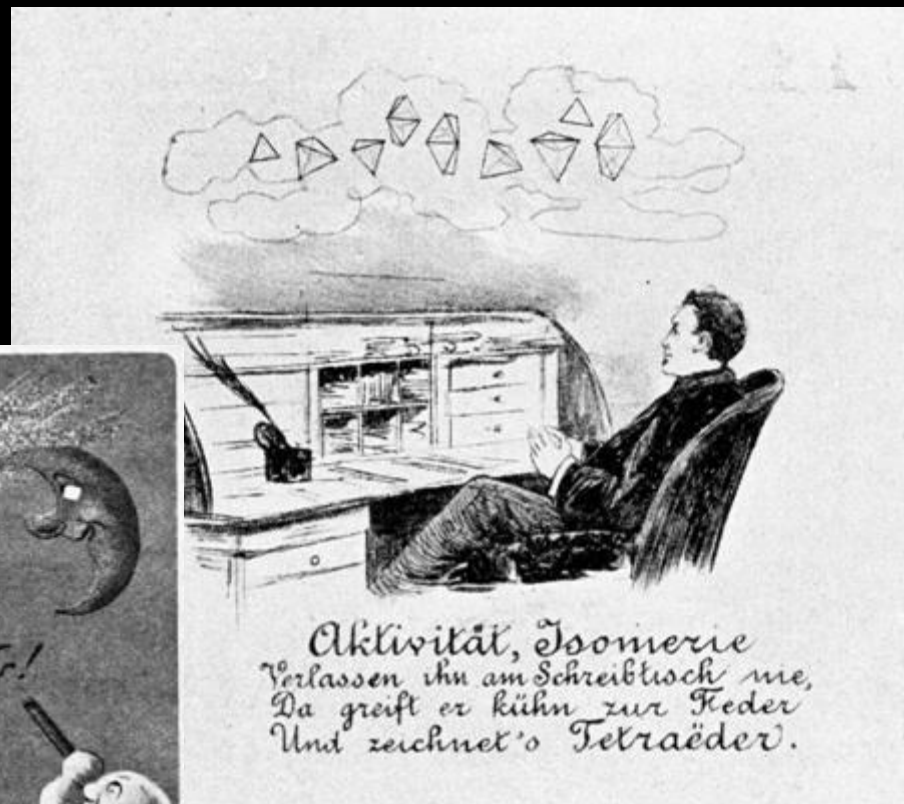
ArtSmart

Robert Root-Bernstein, Ph. D.
Department of Physiology
Michigan State University
East Lansing, MI 48824 USA
rootbern@msu.edu

Root-Bernstein
“Building Blocks
of Life 2”
Exploration of My
Complementarity
Theory of
Evolution



J. H. van't Hoff, the 1st Nobel Laureate in Chemistry: Flautist, Poet, Artist



POLYMATHY AS THE BASIS OF IMAGINATION IN SCIENCE

- ‘Imagination plays a role both in the ability to do scientific research as well as in the urge to exploit this capability.... I have been prompted to investigate whether or not this [imaginative] ability also manifests itself in famous scientists in ways other than their researches. A study of more than two hundred biographies showed that this was indeed the case, and in large measure.’

J. H. van't Hoff, “Imagination in Science,” 1878
trans by G. F. Springer, *Molecular Biology,
Biochemistry and Biophysics* 1: 1-18, 1967.

Polymathy Predicts Career Success

- R. K. White. The versatility of genius, *Journal of Social Psychology*, 2: 482, 1931.
- Brook Hindle, *Emulation and Invention*, 1981.
- Milgram RM, et al., *Journal of Secondary Gifted Education*, 8: 11-120, 1997. Paul Cranefield, The philosophical and cultural interests of the biophysics movement of 1847, *Journal of the History of Medicine* 21: 1-7, 1966.
- R. S. & M. M. Root-Bernstein, Artistic scientists and scientific artists: the link between polymathy and creativity. In: R. J. Sternberg, E. L. Grigorenko, J. L. Singer, eds. *Creativity: From Potential to Realization*, American Psychological Association, 2004, pp. 127-151.

Correlations Between Avocations, Scientific Style, Work Habits, and Professional Impact of Scientists

Robert S. Root-Bernstein

*Department of Physiology
Michigan State University*

Maurine Bernstein and Helen Garnier

*Department of Psychiatry and Biobehavioral Sciences
University of California, Los Angeles*

Arts Foster Scientific Success: Avocations of Nobel, National Academy, Royal Society, and Sigma Xi Members

Robert Root-Bernstein, PhD

Department of Physiology, Michigan State University, East Lansing

*Lindsay Allen
Leighanna Beach
Ragini Bhadula
Justin Fast
Chelsea Hosey
Benjamin Kremkow
Jacqueline Lapp
Kaitlin Lonc
Kendell Pawelec
Abigail Podufaly
Caitlin Russ
Laurie Tennant
Eric Vrtis
Stacey Weinlander*

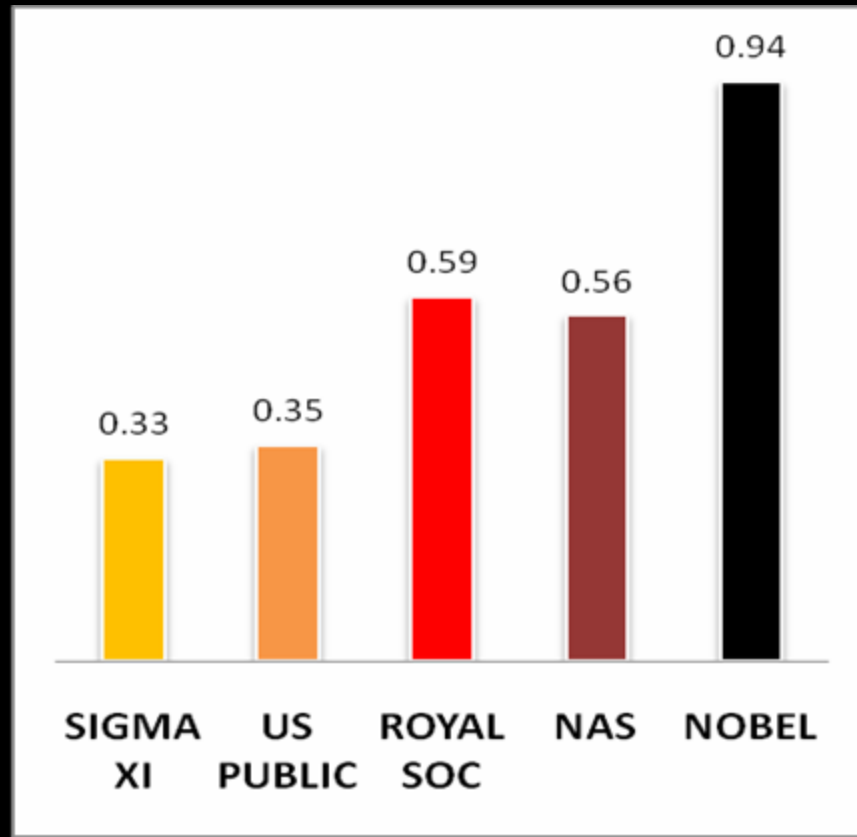
Honors College, Michigan State University, East Lansing

Various investigators have proposed that "scientific geniuses" are polymaths. To test this hypothesis, autobiographies, biographies, and obituary notices of Nobel Prize winners in the sciences, members of the Royal Society, and the U.S. National Academy of Sciences were read and adult arts and crafts avocations tabulated. Data were compared with a 1936 avocation survey of Sigma Xi members and a 1982 survey of arts avocations among the U.S. public. Nobel laureates were significantly more likely to engage in arts and crafts avocations than Royal Society and National Academy of Sciences members, who were in turn significantly more likely than Sigma Xi members and the U.S. public. Scientists and their biographers often commented on the utility of their avocations as stimuli for their science. The utility of arts and crafts training for scientists may have important public policy and educational implications in light of the marginalization of these subjects in most curricula.

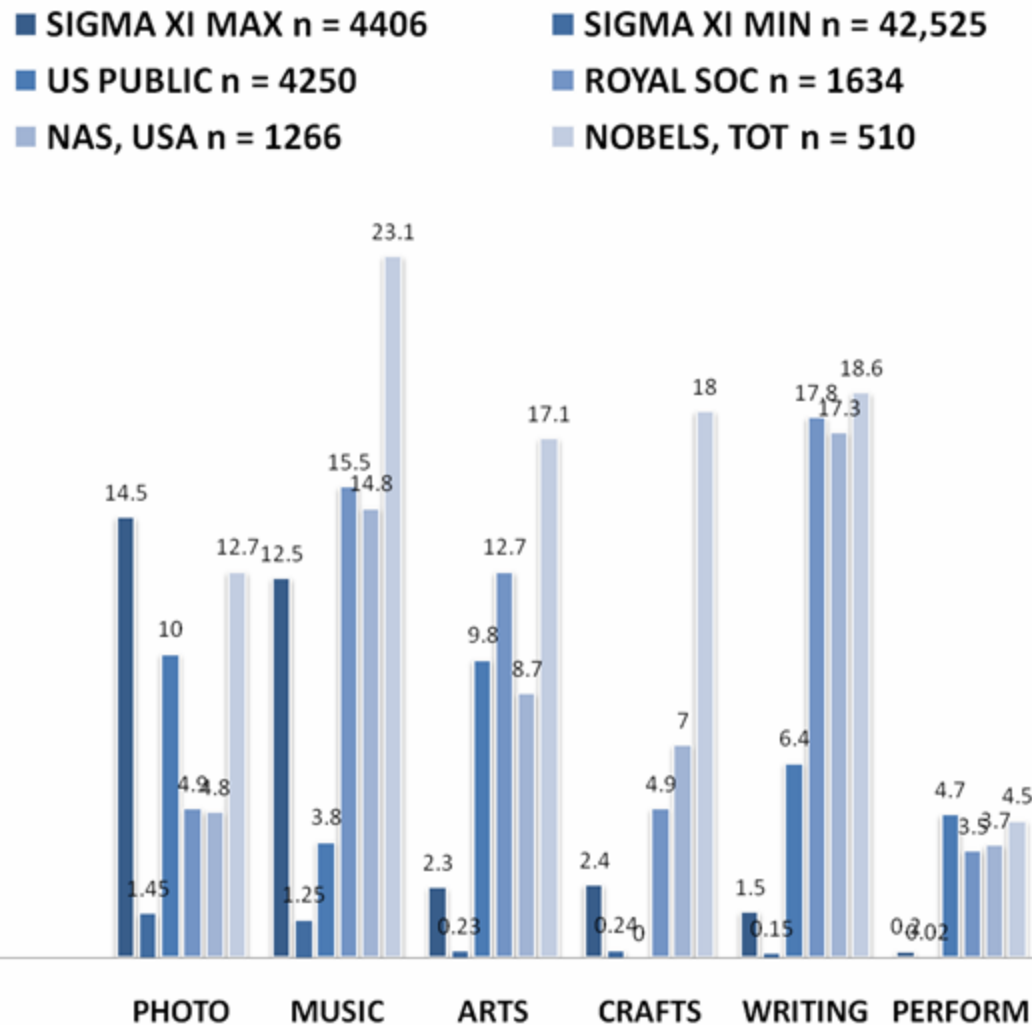
Keywords: hobbies; music; writing; performing; painting; polymaths

- *Root-Bernstein, et al., Journal of Psychology of Science and Technology, Vol 1, no. 2, pp. 51-63 (2008)*

The More Successful a Scientist, the More Likely He or She Is to Have One or More Adult Arts and Crafts Avocations



Adult Avocations Correlate with Scientific Success



Compared with typical scientist, Nobel laureates are at least:

- 2X photographers
- 4X musicians
- 17X artists
- 15X craftsmen
- 25X writers
- 22X performers

Root-Bernstein, et al.,
2008

Cultural Economy Research Team:

ArtSmarts And Innovators

In Science, Technology, Engineering And Mathematics (STEM)

Robert Root-Bernstein, Ph.D., Professor of Physiology

Rex LaMore, Ph.D., Director Center for Community & Economic Development

James Lawton, MFA, Professor and Studio Artist, College of Arts & Letters

John Schweitzer, Ph.D., Professor, Center for Community & Economic Development

Michele Root-Bernstein, Ph.D., Adjunct Faculty, College of Arts and Letters

Eileen Roraback, Ph.D., College of Arts and Letters

Amber Peruski, MSU Honors College Undergraduate

Megan VanDyke , MSU Honors College Undergraduate

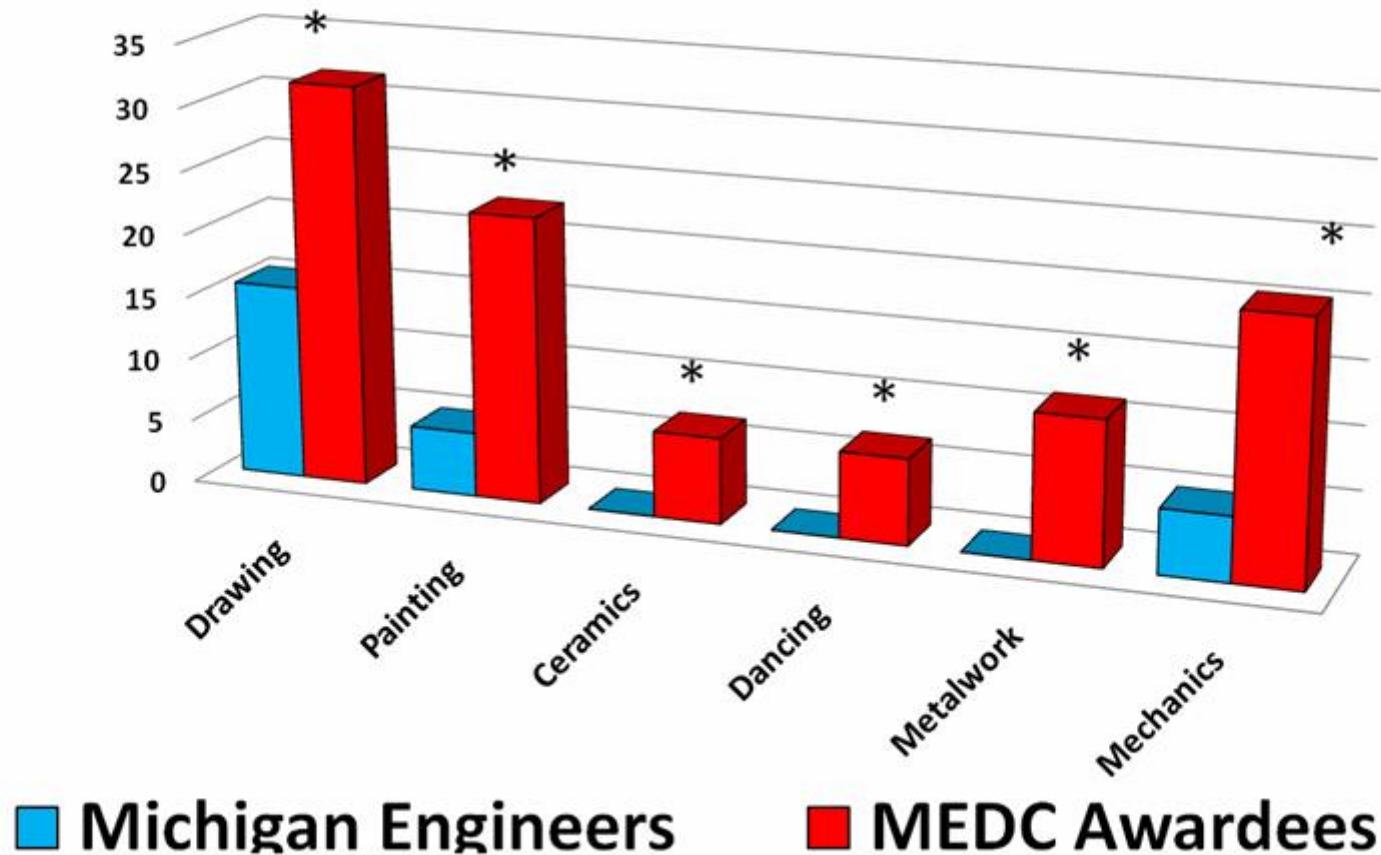
Laleah Fernandez, Doctoral student, College of Communication Arts & Sciences

Acknowledgements:

Michigan State University's Honors College

The Institute for Public Policy and Social Research

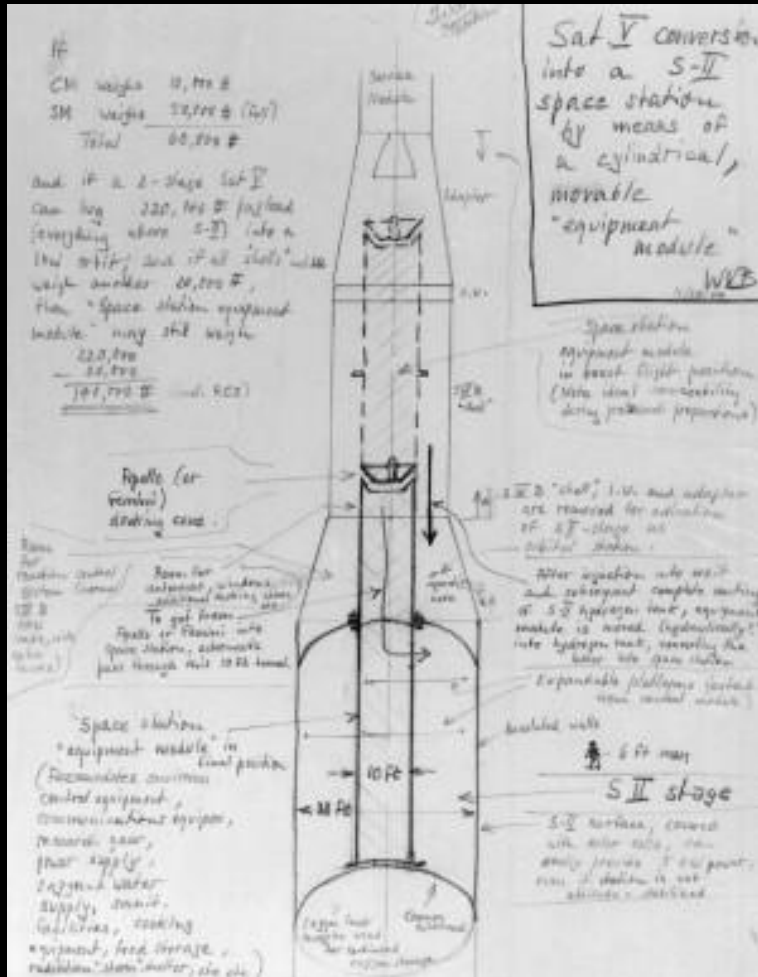
Continuous Arts Participation Correlates w/ Patents & Companies



In Sum, Best Scientists & Inventors Have More Skills Associated With Making And Communicating

- Musical scientists duet (and do it) better
- Artistic scientists have more image to their imagination
- Crafty scientists are more handy
- Literary scientists have the making of pundits
- And performing scientists perform better
- Moreover, successful scientists know this!

Visual Thinking Training Improves Science and Engineering Ability



T. R. Lord, *J. Res. Sci. Teach.* 22, 395 (1985).

J. A. Deno, *Eng. Design Graphics J.*, 5 (autumn, 1995).

S. A. Sorby, B. G. Baartmans, *Eng. Design Graphics J.* 60, 13 (1996).

M. Alias, T. R. Black, D. E. Grey, *Inter. Ed. J.* 3, 1 (2002).

S. Sorby, *Cogn. Proc.* 10 (suppl. 2), S312,

10.1007/s10339-009-0310-y (2009).

Physicist, Historian and

Novelist MITCHELL WILSON

- "The particular kinds of sensibilities required by a scientist are [even] more complicated," and include an "intense awareness of words and their meanings.... [He must be] capable of inventing new words to express new physical concepts. He must be able to reason verbally by analogy.... The scientist must also think graphically, in terms of dynamic models, three-dimensional arrangements in space... Formulas and equations printed on a two-dimensional page have three-dimensional meaning, and the scientist must be able to read three dimensions to 'see the picture' at once."
- Mitchell Wilson, *A Passion to Know*, 1972, pp. 11-12.)

Need to Train Scientists and Engineers In ALL Thinking Tools!

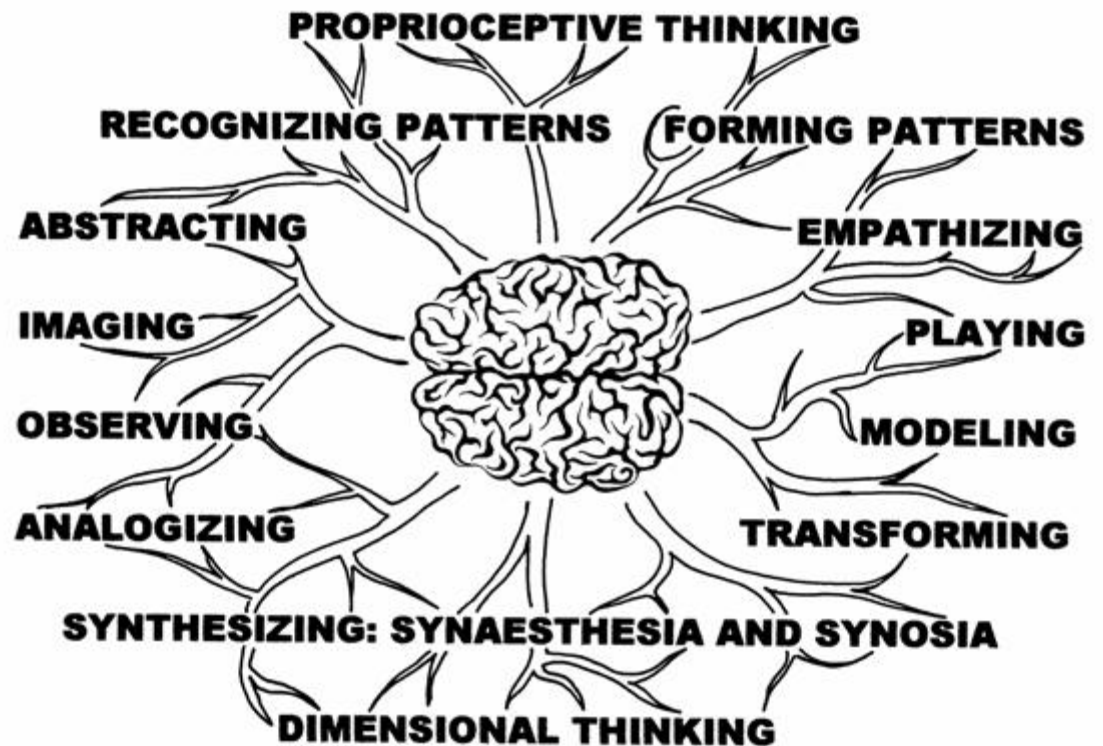
ROBERT AND MICHÈLE ROO T-BERNSTEIN

SPARKS *of* GENIUS

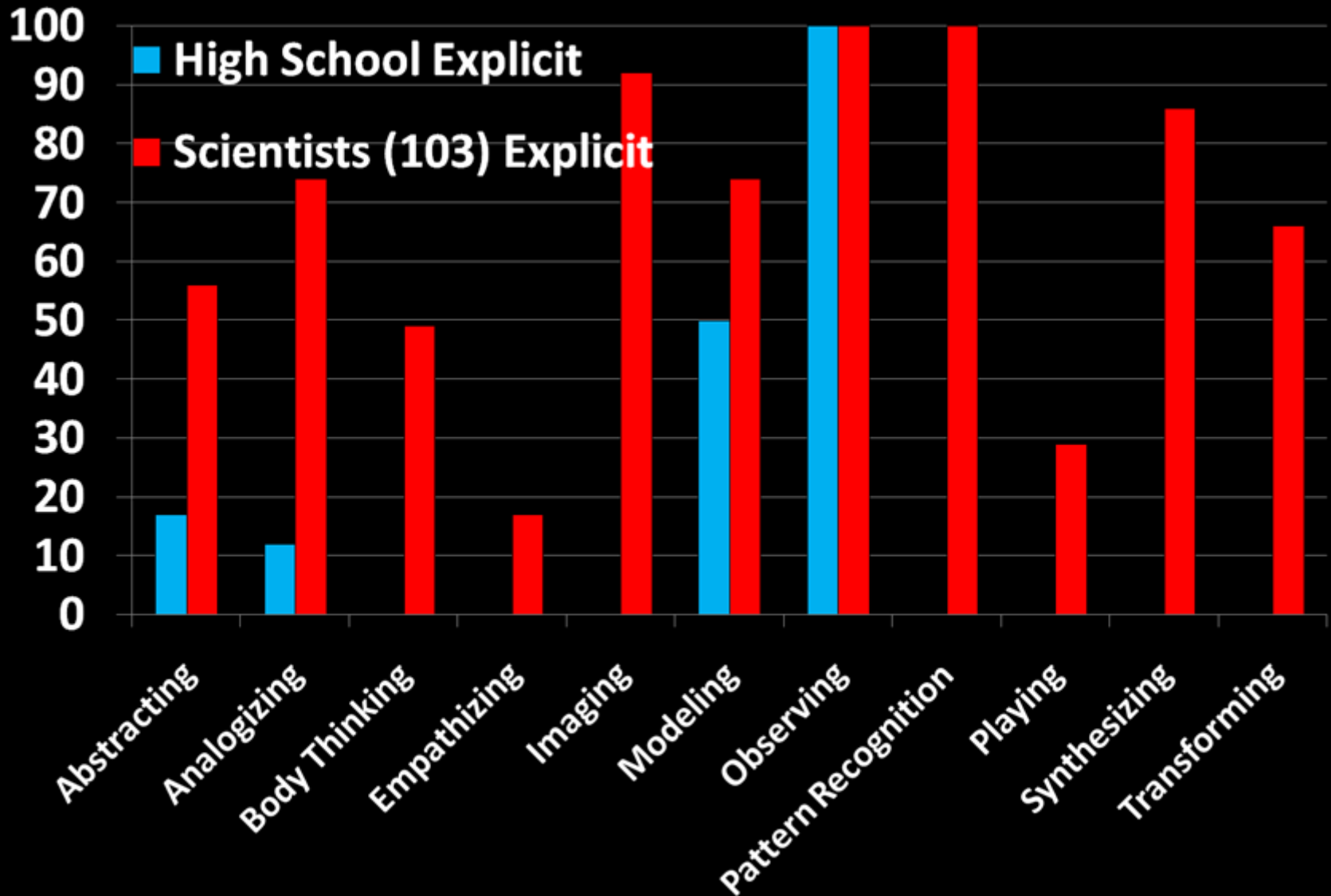
THE 13 THINKING TOOLS
of the
WORLD'S MOST CREATIVE PEOPLE

"A four-de-force tool kit for exploring the world of creativity."
—TODD SILER, author of THINK LIKE A GENIUS

WARNER BOOKS



The “Tools for Thinking” Taught By Scientists Are INSUFFICIENT!

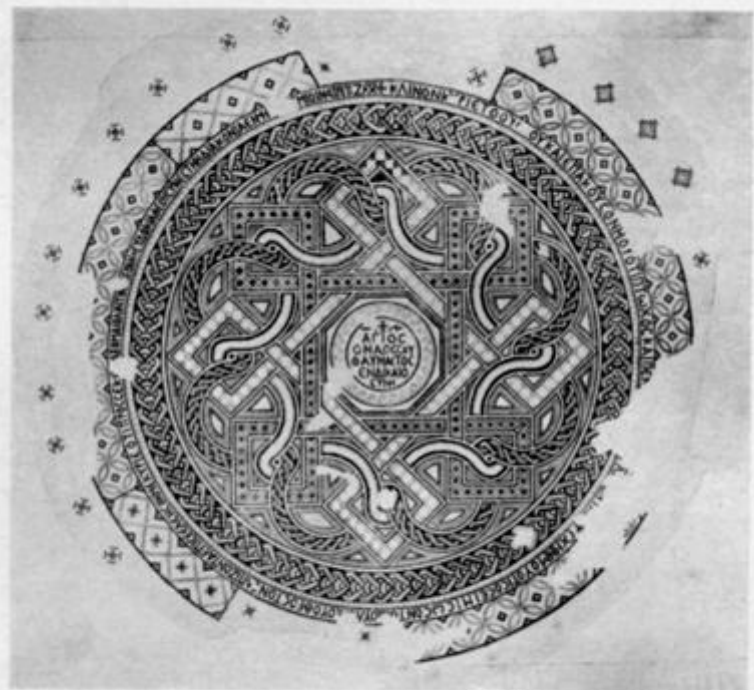


George Washington Carver



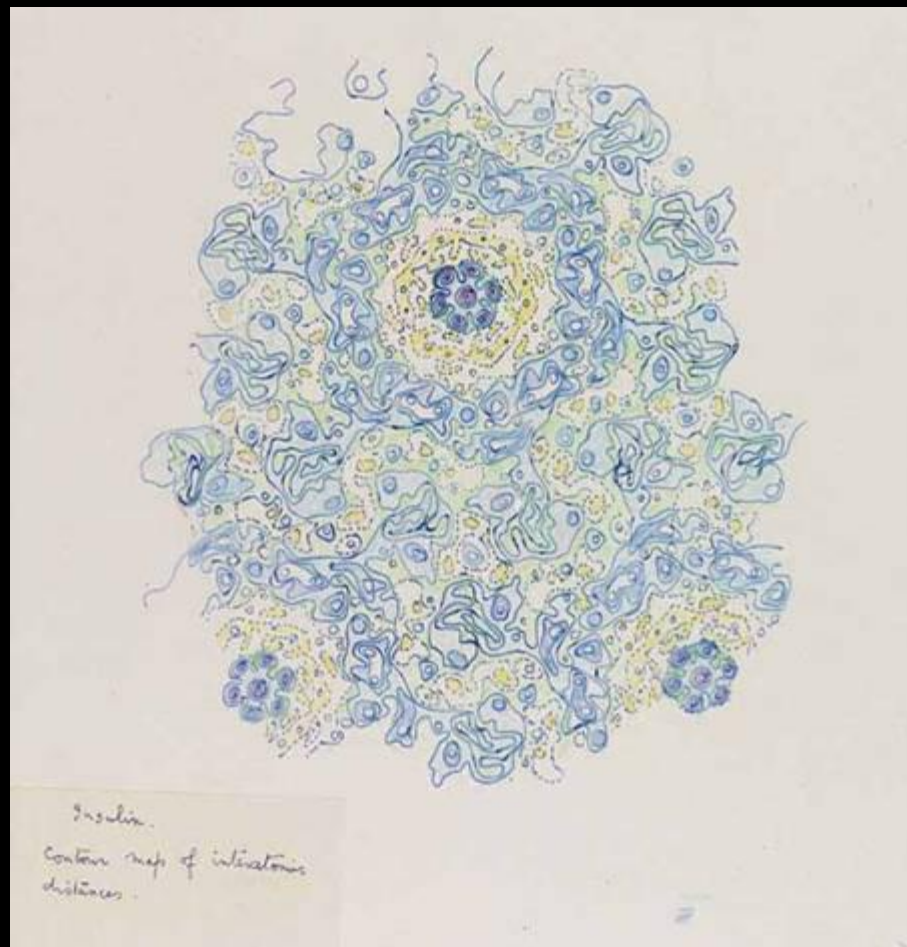


Dorothy Hodgkin, Nobel Laureate in Chemistry



[Painting : D. M. Crowfoot.

(b) MOSAIC IN DIACONIA IN PROPYLAEA CHURCH.

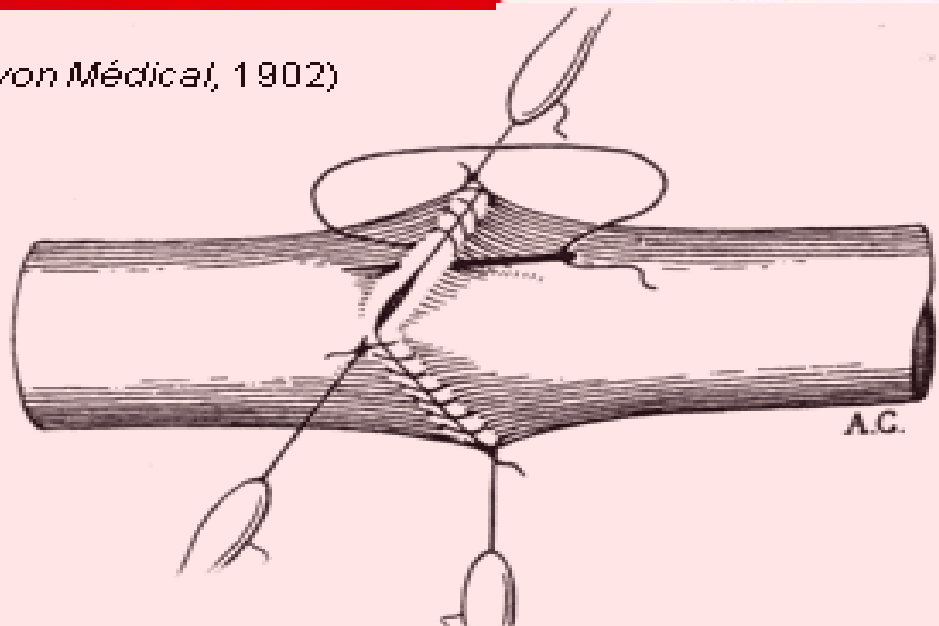


- Alexis Carrel, the 1912 Nobel Laureate in Medicine or Physiology, "learned [as a child] the intricate stitching required for his [later surgical experiments] from the renowned lace makers of Lyon, one of whom was his mother."

Michael Bishop, *How to Win a Nobel Prize*, 2003, p.140).



(*Lyon Médical*, 1902)



Técnica de anastomosis vascular, según Carrel

Alexander Fleming played at painting...



with a
twist!

“This is not
written
with ink
but with
bacteria
which
develop
colour as
they
grow.”

This is not
written with ink
but with bacteria which
develop colours as they grow.

(1) *B. violaceus*

(2) *B. prodigiosus*

(3) *Staphylococcus*

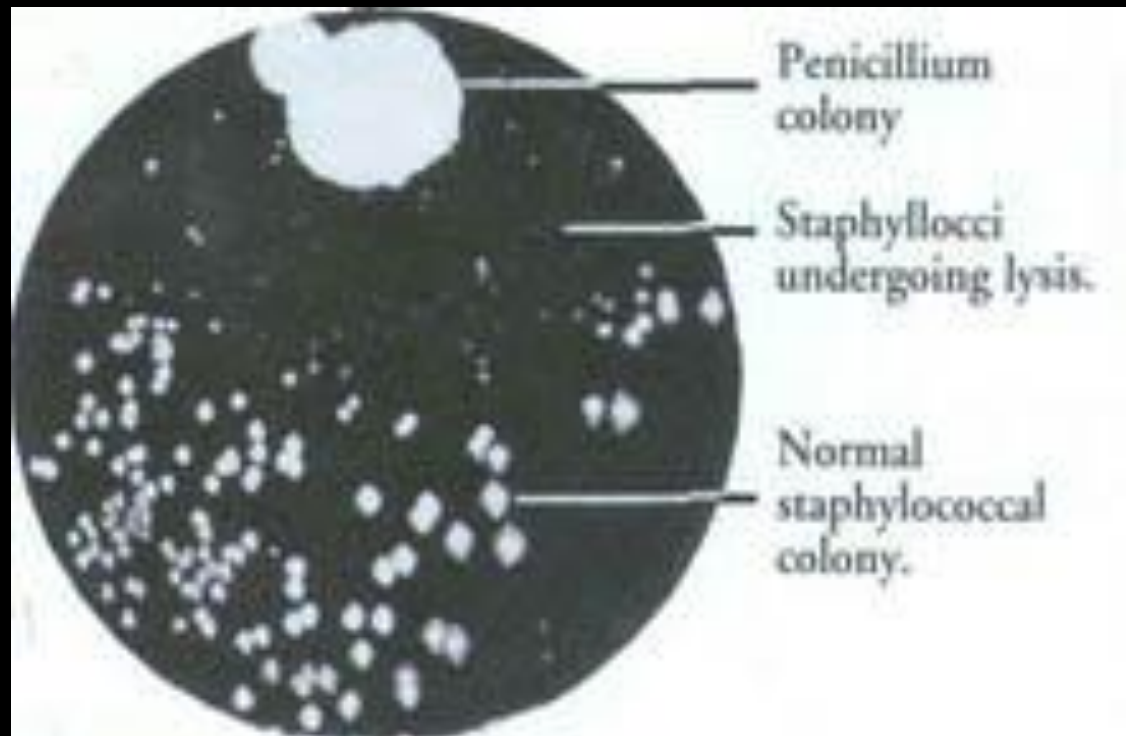
4 *A. bacillus*

5 *Sarcina*

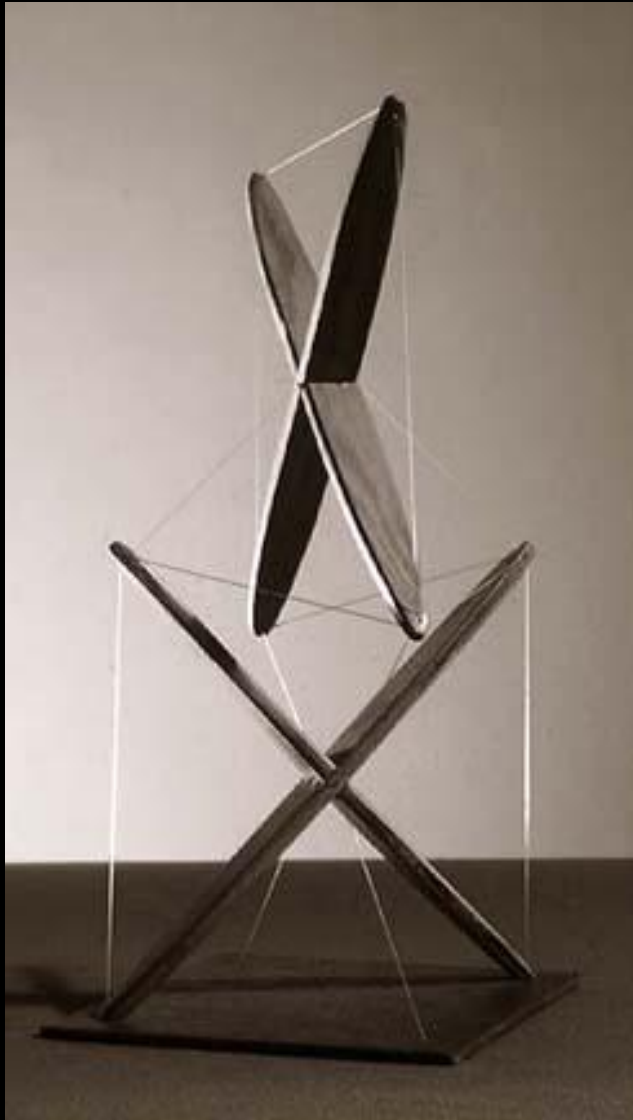
Fleming Left His Petri Dishes Open to Collect Microbes for His Palette



Result Was PENICILLIN, Which Depended on Practices Forbidden by Bacteriology

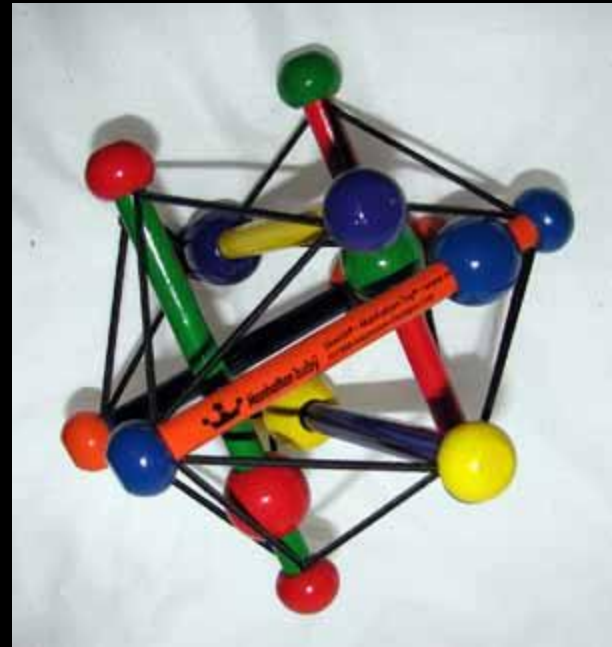


Kenneth Snelson: Tensegrity



- **PLAY**: What would happen if I combined a Buckminster Fuller Geodesic dome structure with an Alexander Calder mobile?
- **Tensegrity** = structural integrity resulting from tension of flexible elements acting upon inflexible ones producing compression

Skwish": Kid's Play with Tensegrity

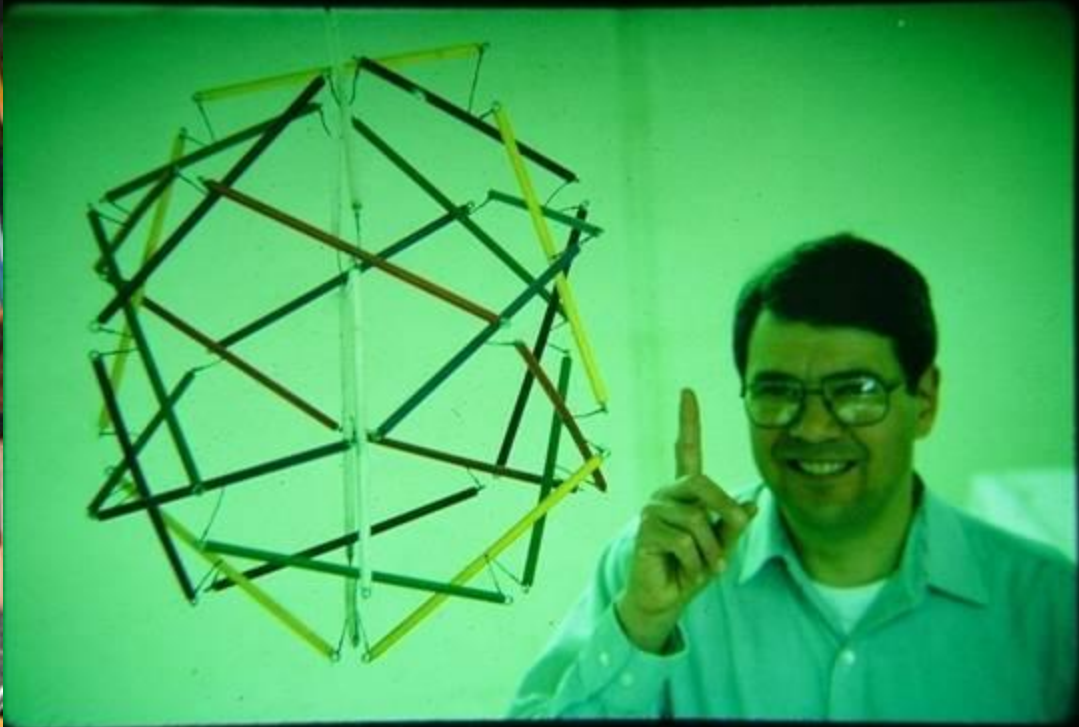
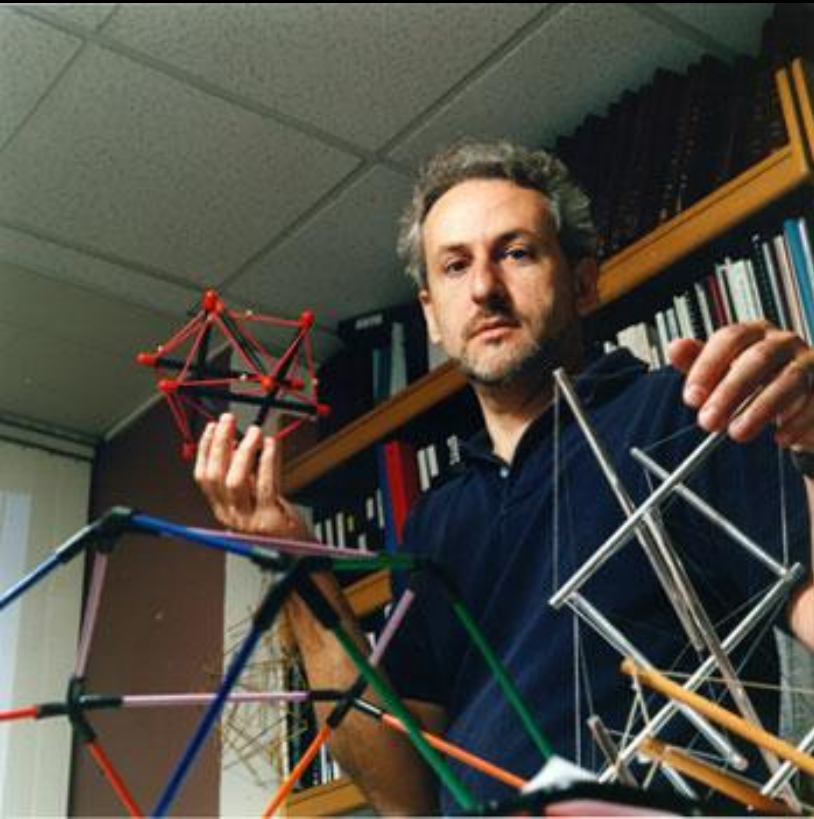


Tensegrity Engineering: The Kurilpa Bridge in Brisbane, Australia

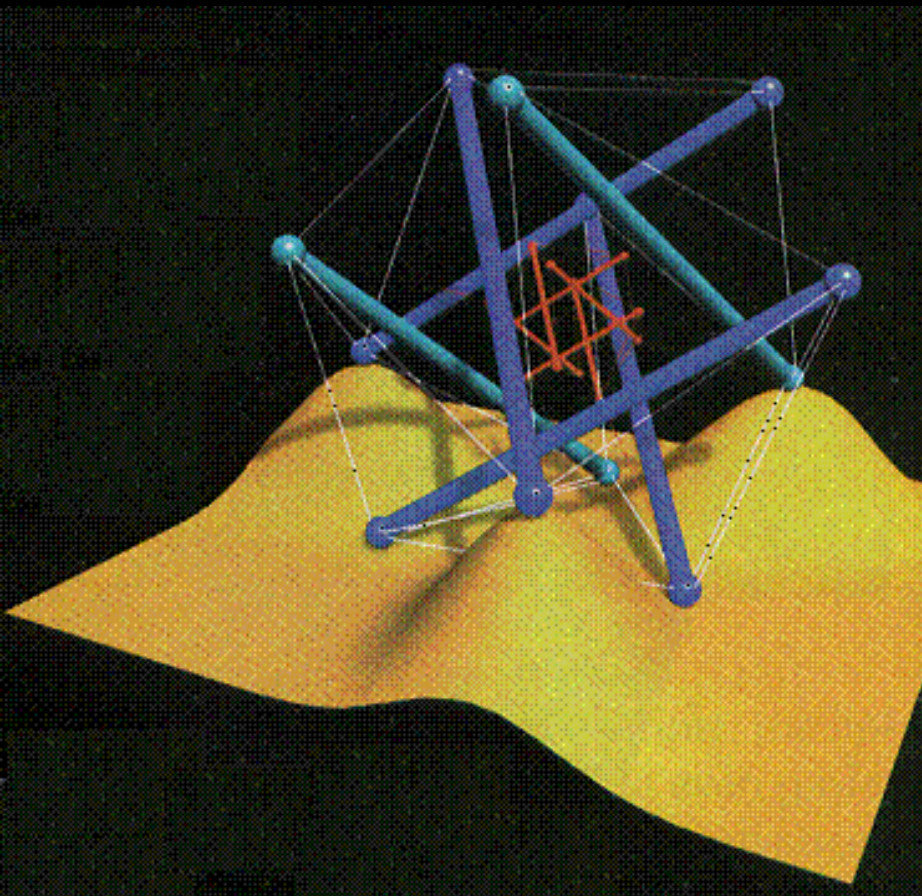


The suspension Bridge - Waterloo

Don Ingber (Harvard) & Steve Heidemann (Michigan State)

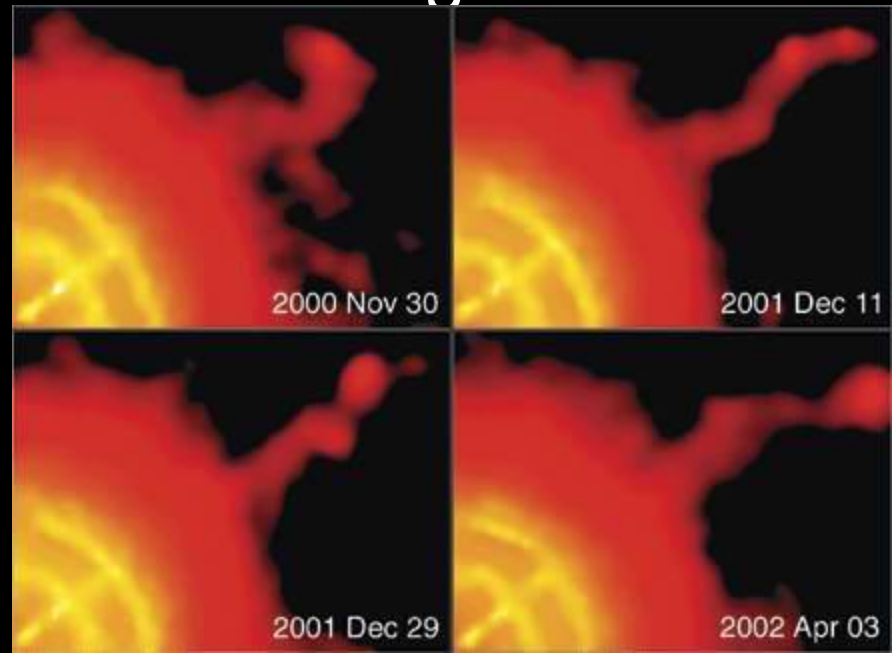


TENSEGRITY MODEL OF CELL ARCHITECTURE



Acting Brings Words – And Equations! – to Life: PHYSICIST JACOB SHAHAM

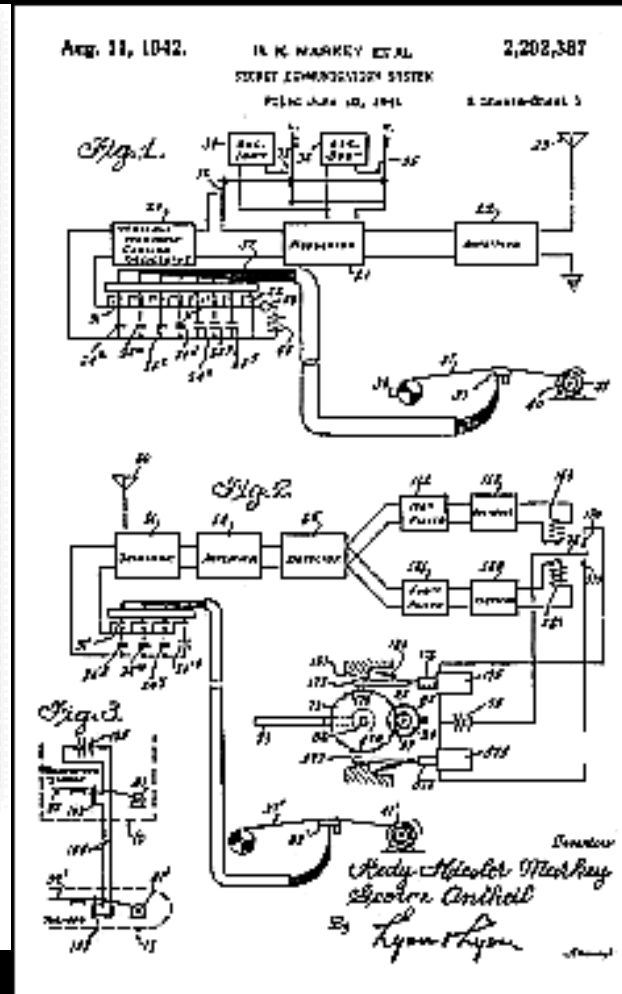
“Acting taught me how to
read equations like a
script with characters I
had to bring to life...”



George Antheil & Hedy Lamarr Invented Frequency Hopping



Hedy Lamarr and George Antheil. Photo of Hedy Lamarr courtesy of the Academy of Motion Picture Arts & Sciences. Photo of George Antheil courtesy of the Estate of George Antheil.



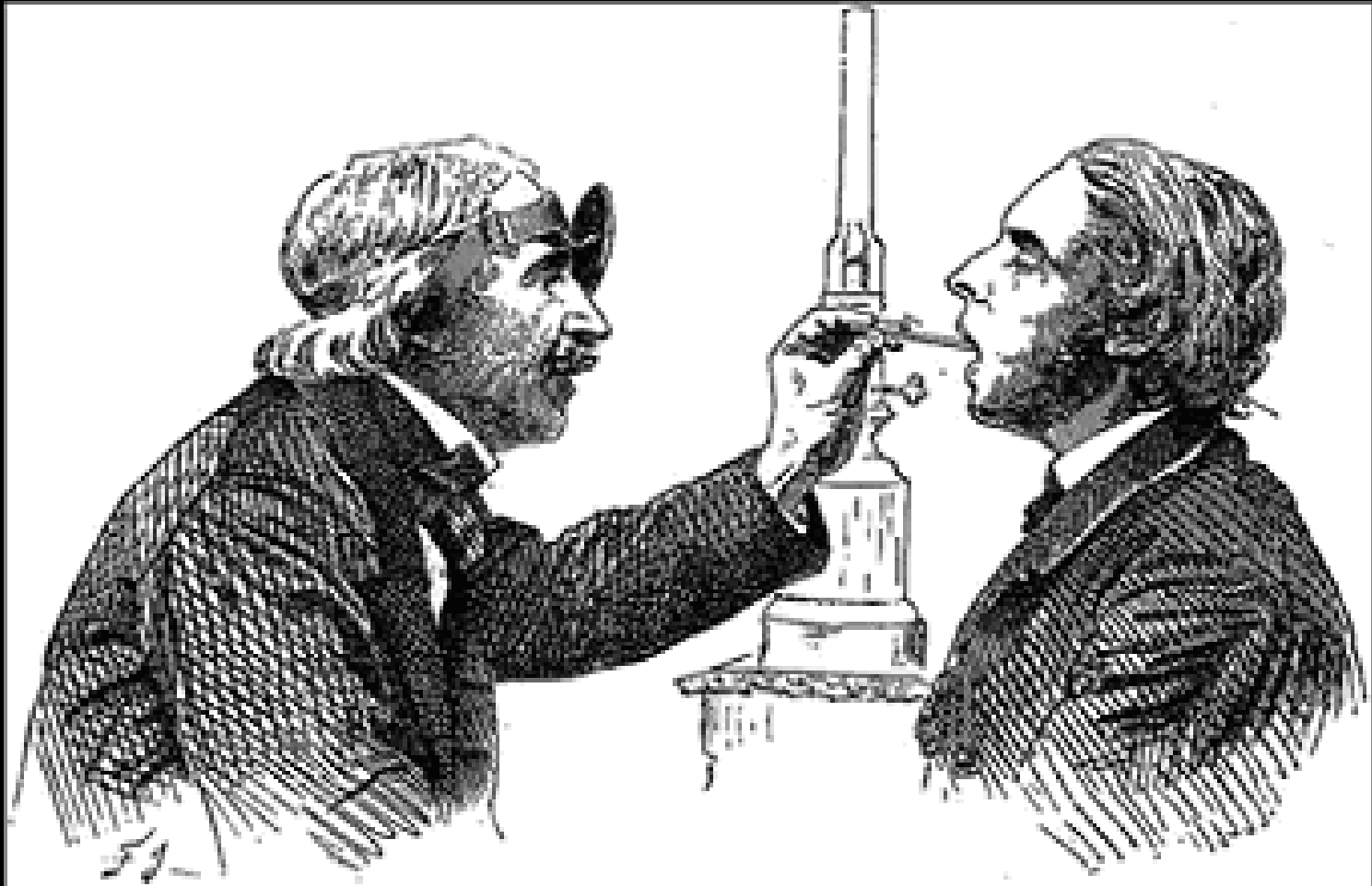
Sommer Gentry: Teaching Robots To Dance At MIT



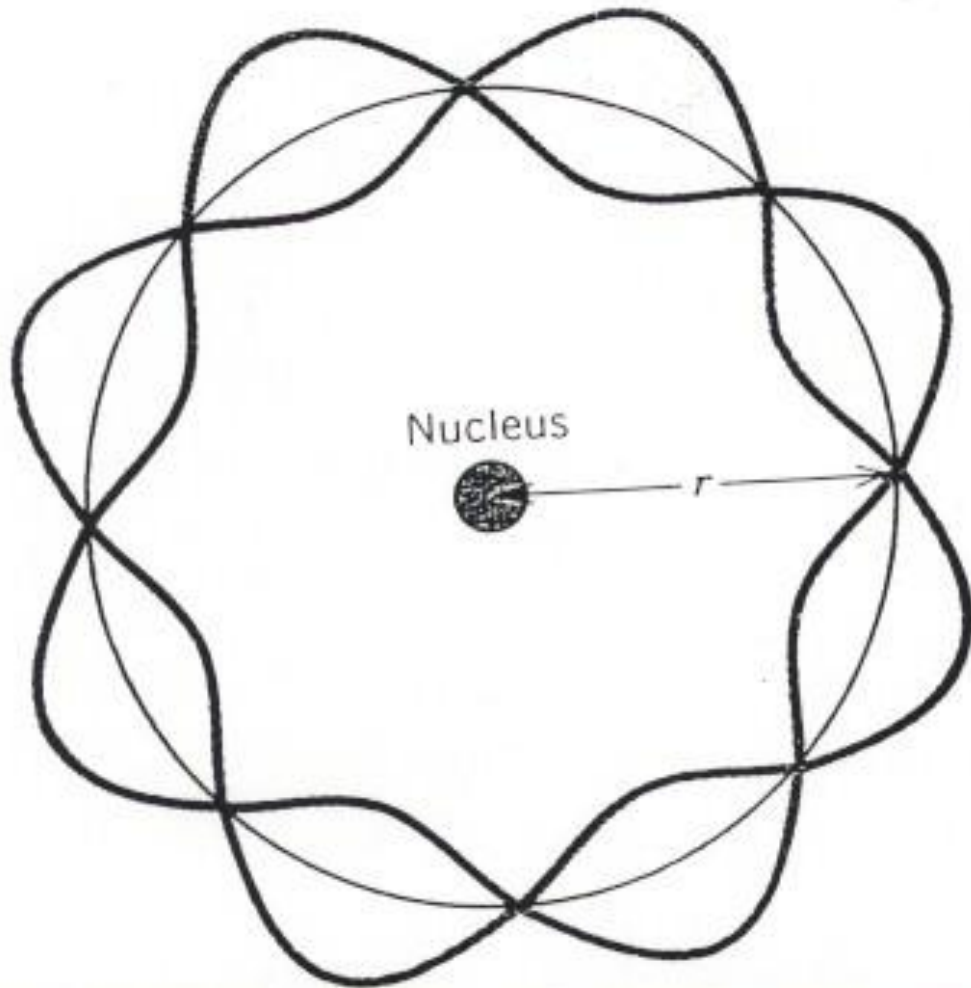
James Dewar: Ultra-Low Temperature Physicist

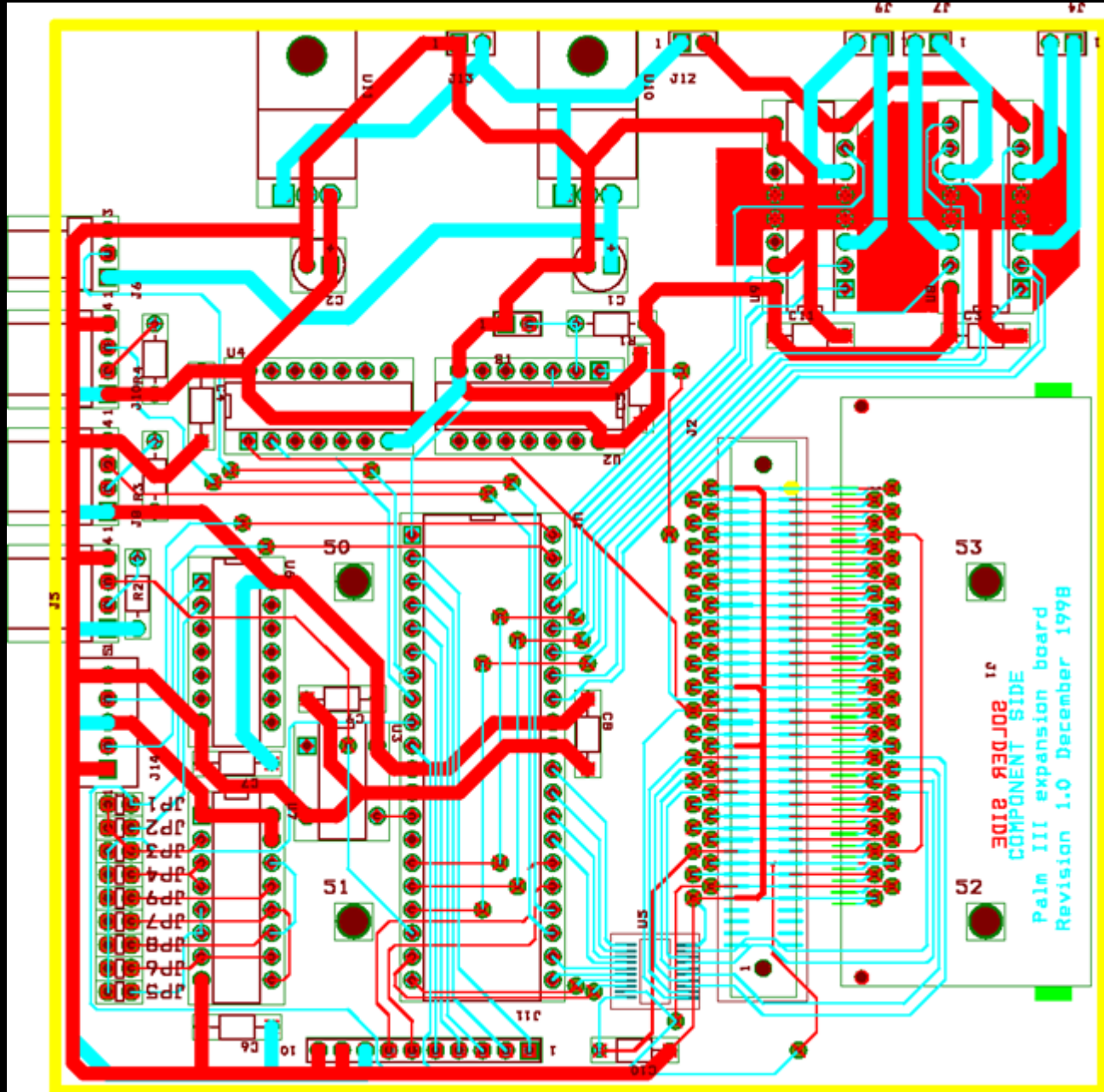


Singer Manuel Garcia Invented the Laryngoscope



Louis de Broglie: Harmonics of Electrons





53

52

PCB ORDER SIDE
COMPONENT SIDE
Palm III expansion board
Revision 1.0 December 1998

In Sum, Arts Provide STEM:

- Tools for Creative Thinking
- Practice with the Creative Process
- Transferable Skills
- Effective Techniques and Methods
- Useful Knowledge
- Fruitful Analogies
- And much, much more!