

Creative Science

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Celia's question:

Daddy, why is the ceiling opaque?

$i\hbar\psi = H\psi$

Erwin Schrödinger

* 12.VIII. 1887 + 4.1.1961

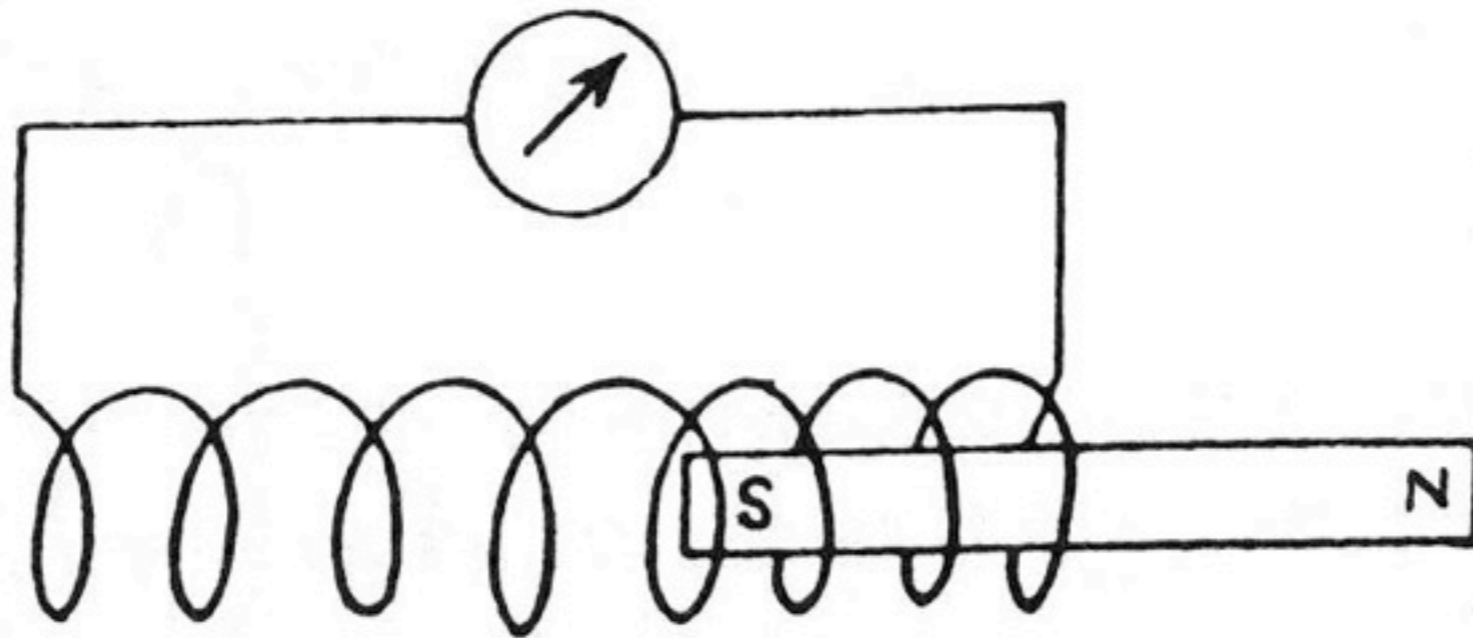
Annemarie Schrödinger

* 21.VII. 1890 + 2.V. 1965

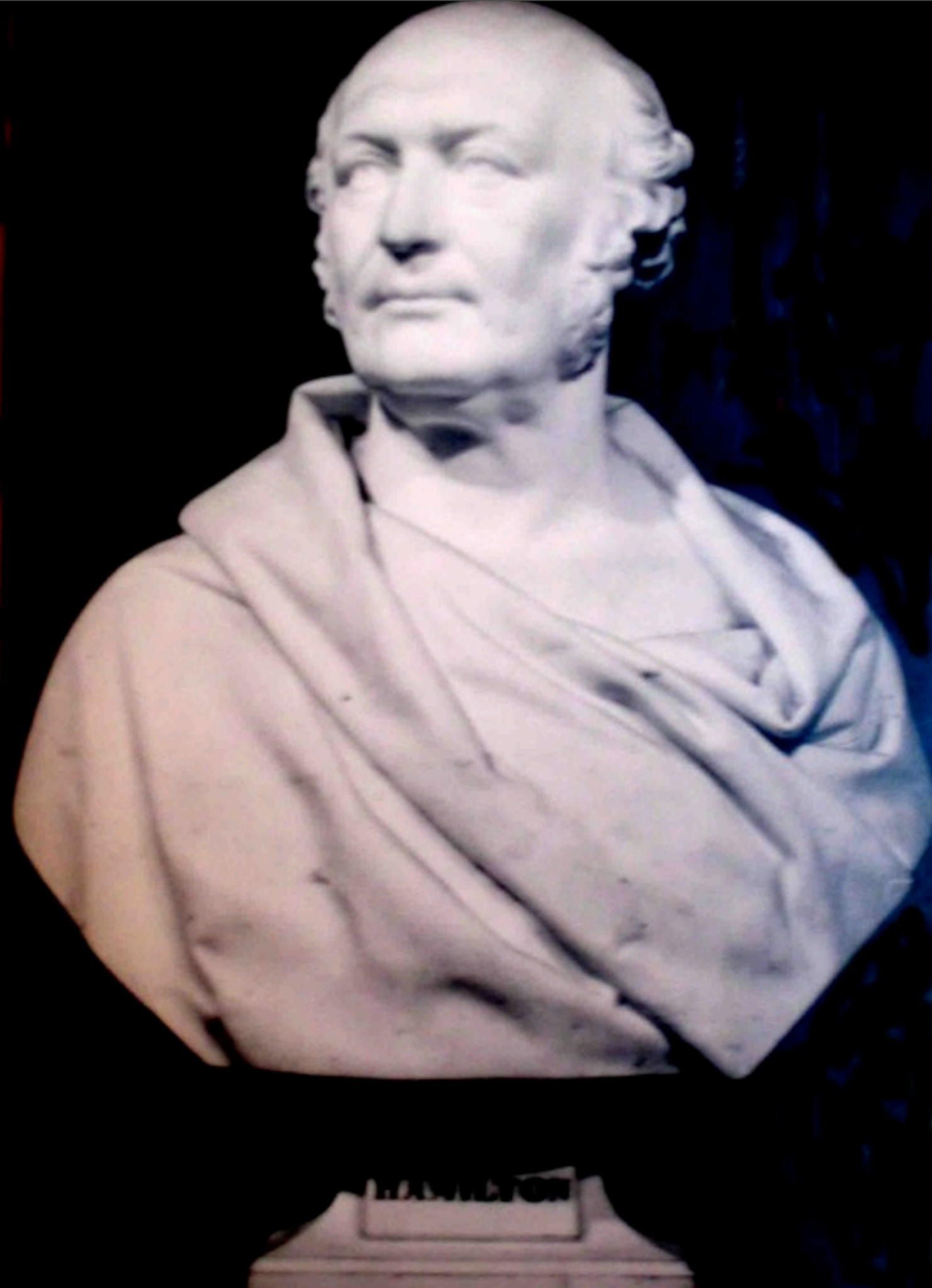
“The problem of getting the interpretation proved to be rather more difficult than just working out the equations”

P.A.M.Dirac

Faraday's magical experiment



James Clark Maxwell and the idea of the *field*
(but what's a Hamiltonian? What does ∇ mean?)



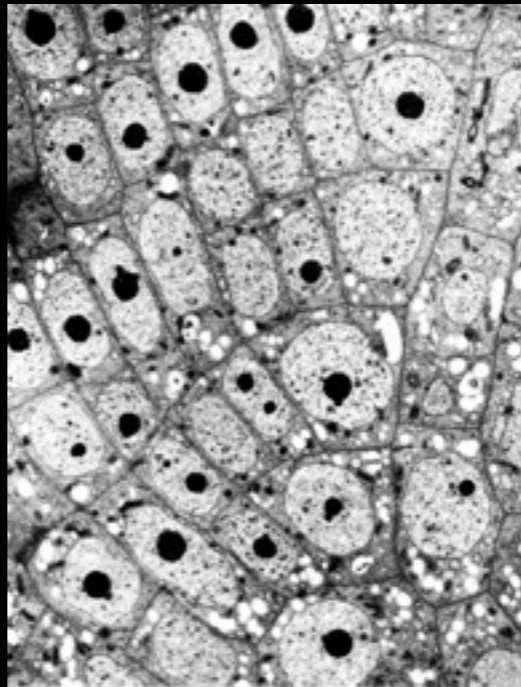
Einstein, 1905: How can we see distant stars?

“According to the assumption to be contemplated here, when a light ray is spreading from a point, the energy is not distributed continuously over ever-increasing spaces, but consists of a finite number of energy quanta that are localized in points in space, move without dividing, and can be absorbed or generated only as a whole.”

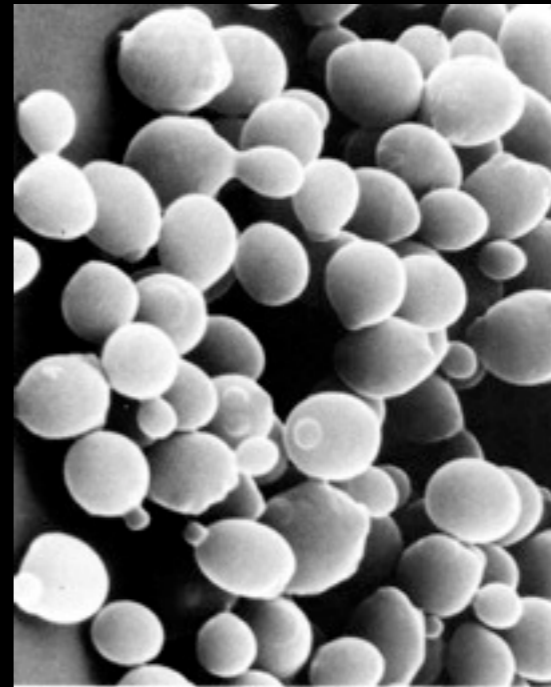
All living things are made of cells...



salamander



lily



yeast

(The atomic theory of biology)

An unbroken line of cell divisions,
stretching back billions of years, connects
us all, plants and animals alike



There is Only One Way to Find Things Out...

“The proper method for inquiring after the properties of things is to deduce them from experiments”

Isaac Newton, 1672

“Study Nature Not Books”



(A saying of Luis Agassiz, displayed prominently in the Library of the Marine Biological Laboratory, Woods Hole)

Great Discoveries Are — By Definition — Unexpected

“In forecasting the future of scientific research there is one quite general law to be noted. The unexpected always happens.

So one can be quite sure that the future will make any detailed predictions look rather silly.”

J.B.S. Haldane, The future of biology, 1927

“If politics is the art of the possible, research is surely the art of the soluble.”

(No scientist is admired for failing in the attempt to solve problems that lie beyond his competence).”

Peter Medawar, reviewing “*The Act of Creation*” by Arthur Koestler

Perhaps the most important single step in the research process is choosing a question to investigate. What most distinguishes scientists noted by posterity is not their technical skill, but that they chose **interesting problems.**

In the late 1960s, a student told me that he wanted to go into general relativity rather than elementary particle physics, because the principles of the former were well known, while the latter seemed like a mess to him.

It struck me that he had just given a perfectly good reason for doing the opposite

Particle physics was where creative work could still be done.

Steven Weinberg, 2003.

In the real world, it's very hard to know which problems are important, and you never know whether at a given moment in history a problem is solvable...

Steven Weinberg, 2003.

How Can We Encourage Creativity?

Max Perutz used to receive visits from earnest men and women armed with questionnaires and tape-recorders who wanted to find out what made the MRC Laboratory of Molecular Biology in Cambridge (where he worked) so remarkably creative . . .

“I felt tempted to draw their attention to 15th-century Florence with a population of less than 50,000, from which emerged Leonardo, Michelangelo, Raphael, Ghiberti, Brunelleschi, Alberti, and other great artists.”

“Had my questioners investigated whether the rulers of Florence had created an interdisciplinary organisation of painters, sculptors, architects, and poets to bring to life this flowering of great art?”

“Creativity in science, as in the arts, cannot be organised. It arises spontaneously from individual talent. Well-run laboratories can foster it, but hierarchical organisation, inflexible, bureaucratic rules, and mountains of futile paperwork can kill it.

Discoveries cannot be planned; they pop up, like Puck, in unexpected corners.”

Of Successful Scientific Institutes...

“The Pasteur Institute, as I got to know it, appeared a little strange, a little unusual in certain respects. A curious mixture of excellent science and *laissez faire*, of boldness and routine, of paternalism and incompetence. And also a highly flexible organisation, which differentiated it from public establishments like the Universities or the CNRS, and helped the Institute avoid stagnation and the **burden of bureaucracy**.”

François Jacob, *The statue within*, Basic Books 1988.

Clearly, patronage is crucial —
but the style is important, too.

The Variety of Pioneers



Crick and Watson. Courtesy of the Cold Spring Harbor Laboratory Archives.

Fred Sanger

Francis Crick

Jim Watson

Max Perutz

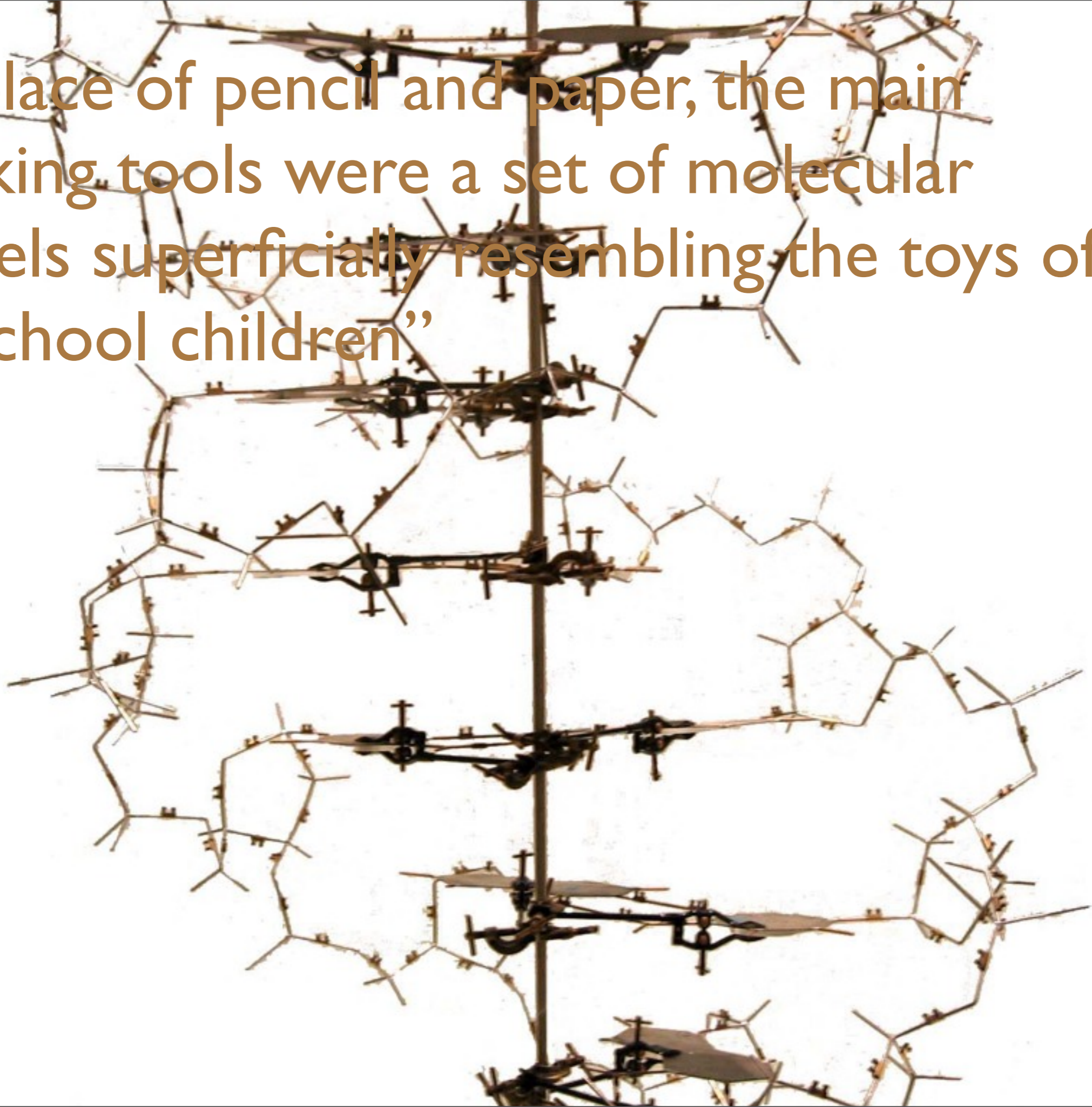
Cesar Milstein, Sydney Brenner, Bob Horvitz, John Sulston, Andy Fire, Roger Kornberg, Marty Chalfie

Max Perutz Once Said...

“When Crick and Watson lounged around, arguing about problems for which there existed as yet no firm experimental data, instead of getting down to the bench and doing experiments, I thought they were wasting their time. However, like Leonardo, they sometimes achieved most when they seemed to be working least, and their apparent idleness led them to solve the greatest of all biological problems, the structure of DNA.

There is more than one way of doing good science.”

“In place of pencil and paper, the main working tools were a set of molecular models superficially resembling the toys of preschool children”



“The path of creativity is strewn with the bones of those consumed by the vultures of mediocrity, accountability and responsibility. One cannot schedule creative breakthroughs, budget for them, or prove them to a review panel.”

Craig Loehle, 1990

If it freezes, go skating

Promoting European Science

Let's not be ashamed to be elitist.

Let's use European-wide, non-nationalistic Peer Review.

Let's not grant tenure too soon, but have clear, fair career paths.

Forget about networks, don't try to direct science, but make it easy to travel, meet and collaborate.

“You can recognise truth by its beauty and simplicity”

When you get it right, it is obvious that it is right – at least if you have any experience – because usually what happens is that more comes out than goes in. Your guess is, in fact, that something is very simple. If you cannot see immediately that it is wrong, and it is simpler than it was before, then it is right. The inexperienced, and crackpots, and people like that, make guesses that are simple, but you can immediately see that they are wrong, so that does not count. Others, the inexperienced students, make guesses that are very complicated, and it sort of looks as if it is all right, but I know it is not true because the truth always turns out to be simpler than you thought.

Richard Feynman