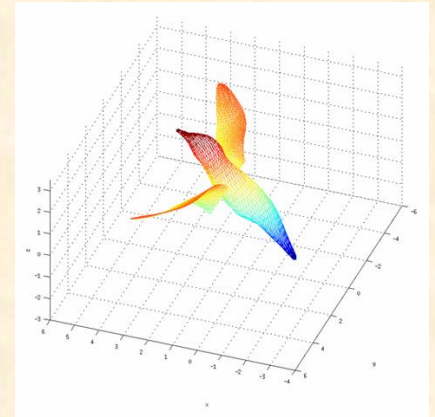


**“And now for something
completely different”**

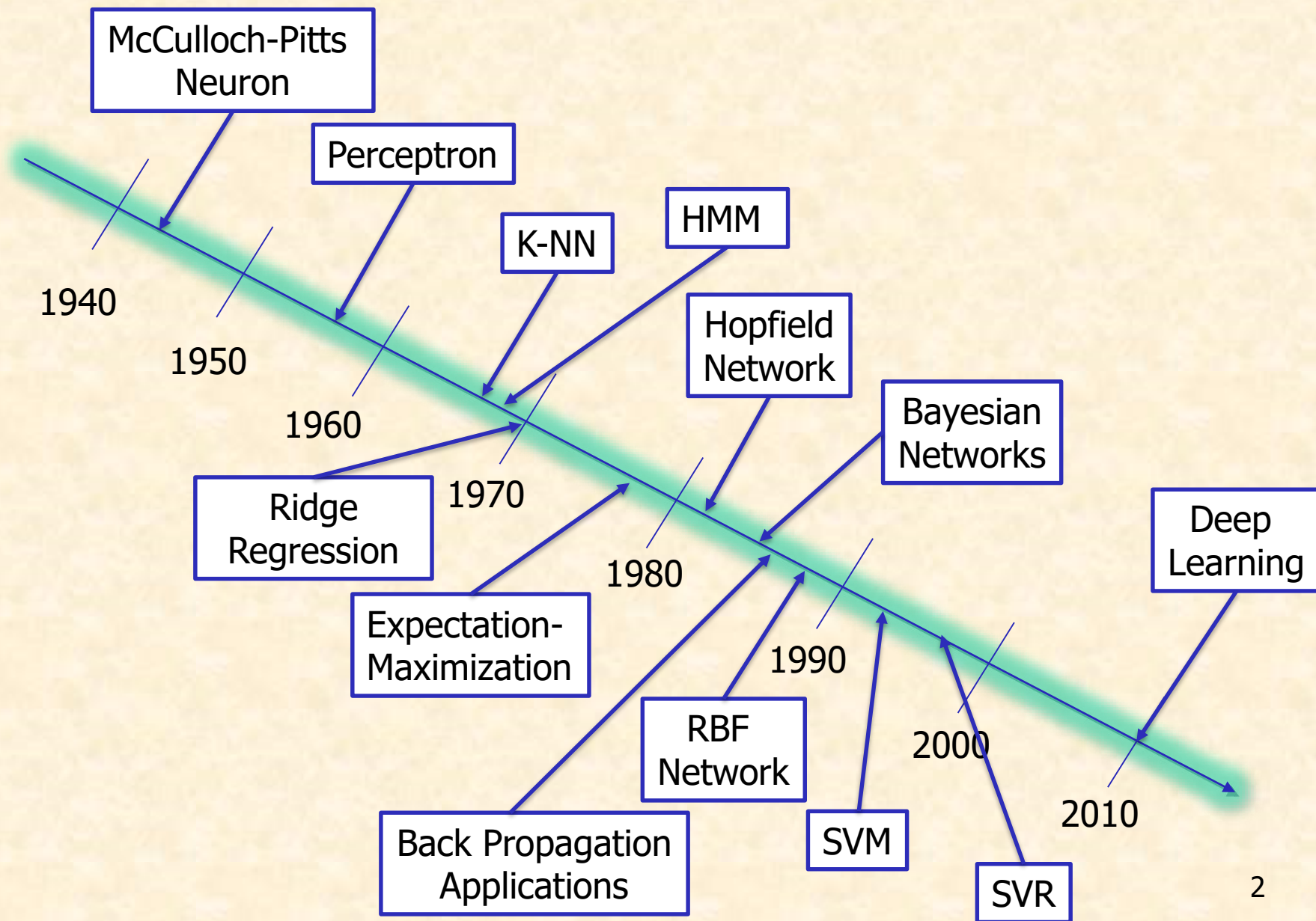
(Monty Python)



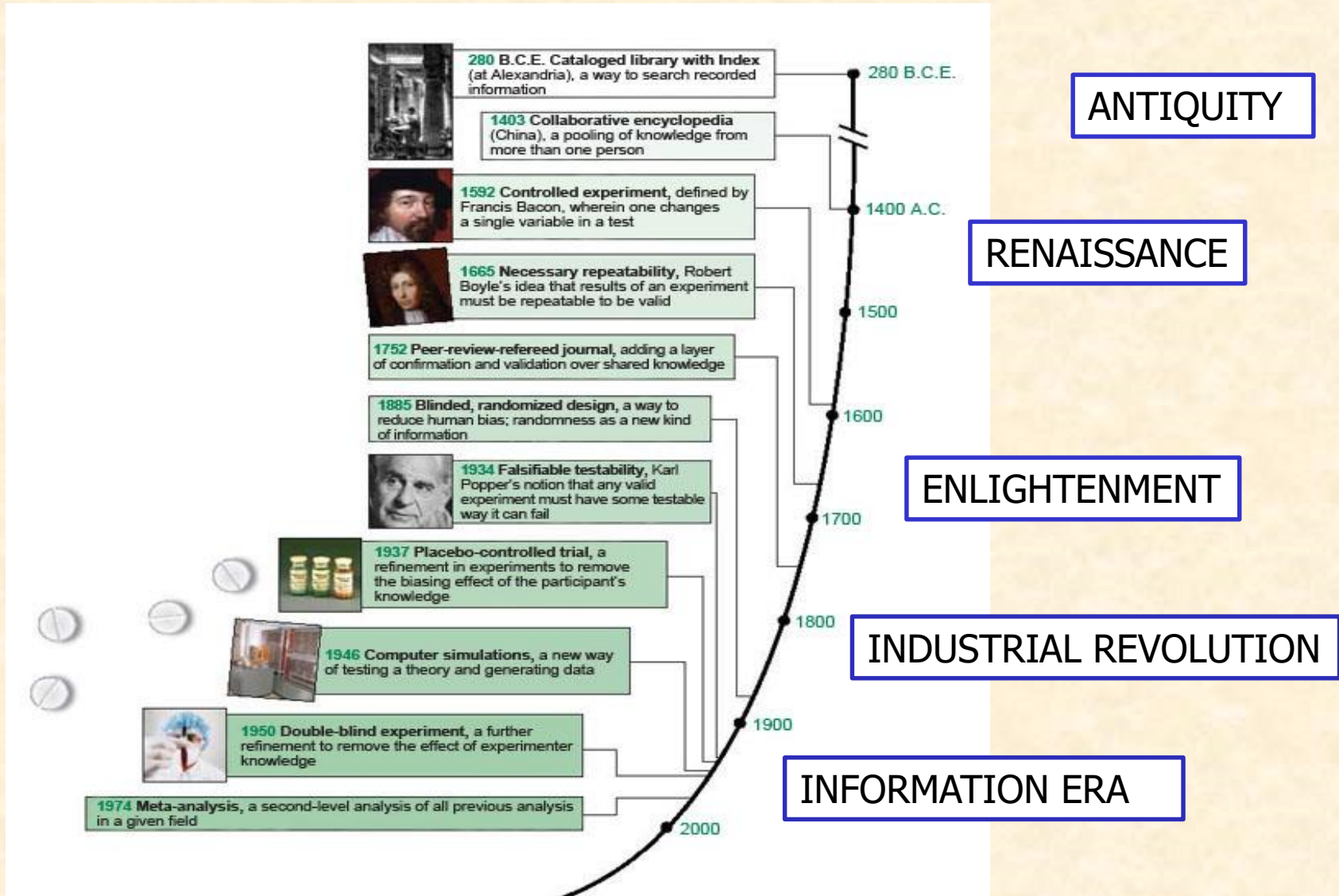
OR

Some inspiration for young scientists

Machine Learning Timeline

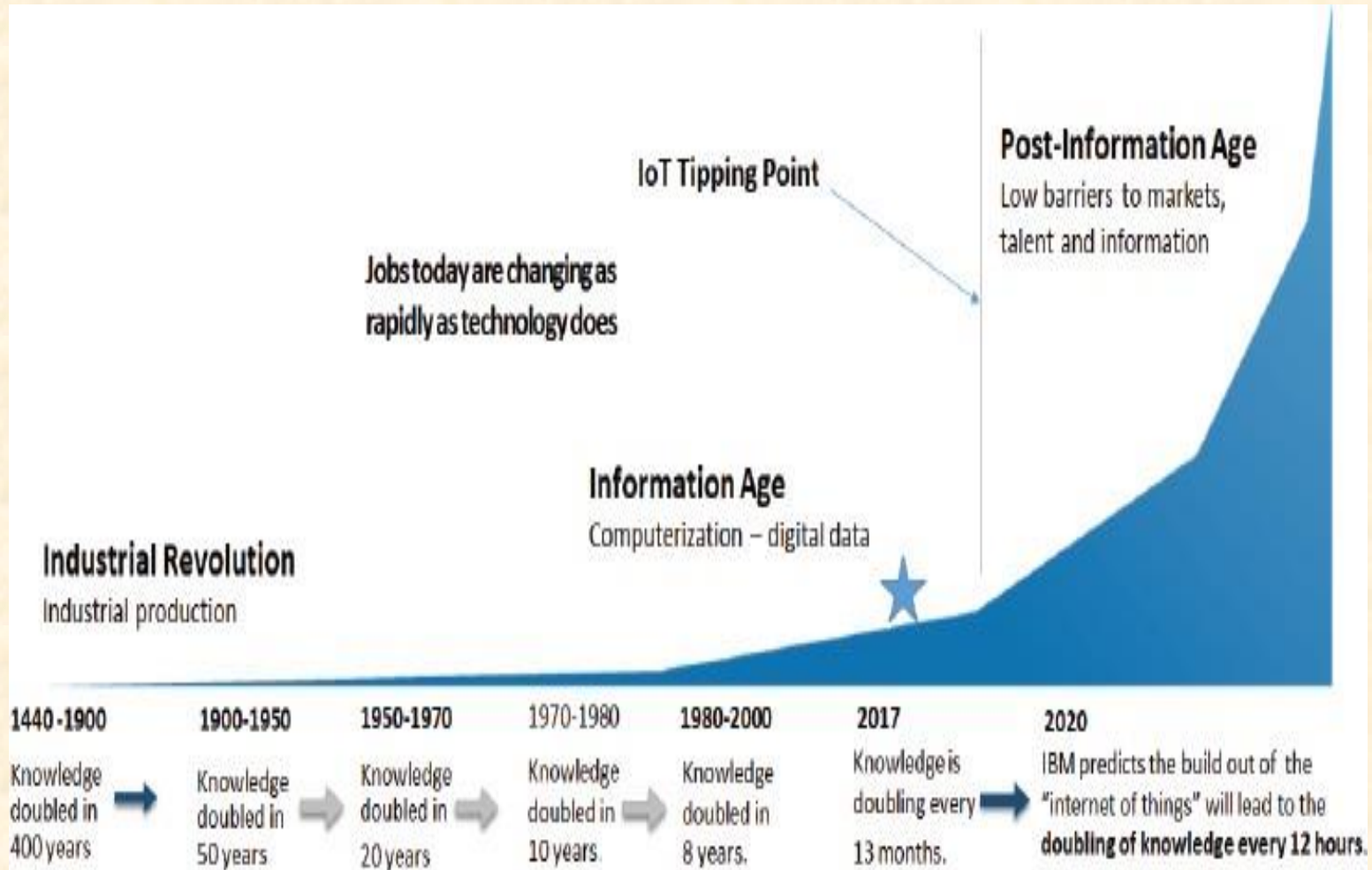


Evolution of the Scientific Method



Source: *The Science Magazine*

“Knowledge” doubling curve



The “Socratic” motto: A modern perspective

I KNOW THAT I KNOW
NOTHING

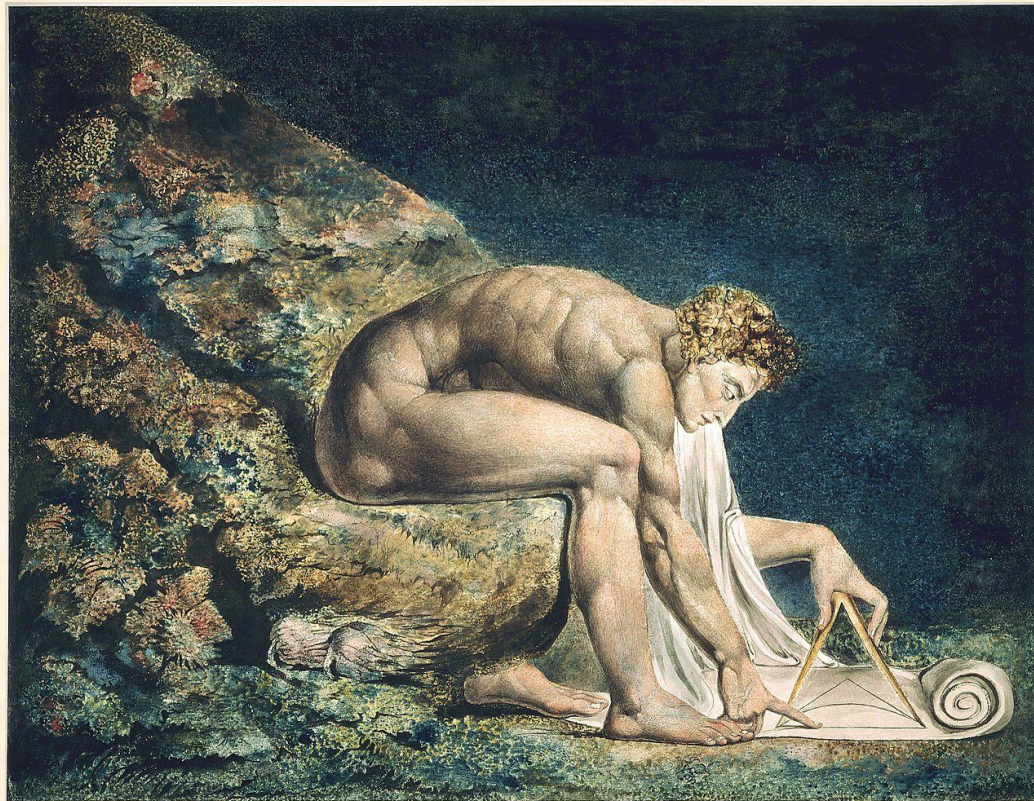


Your relation with the past

On the shoulders of giants

- ❖ If I have seen further it is by standing on the shoulders of Giants.

Isaac Newton, 1675



Newton by William Blake, 1805

Maxwell on the speed of electromagnetic waves

The velocity of light in air, by M. FIZEAU's † experiments, is

$$V=314,858,000;$$

according to the more accurate experiments of M. FOUCAULT ‡,

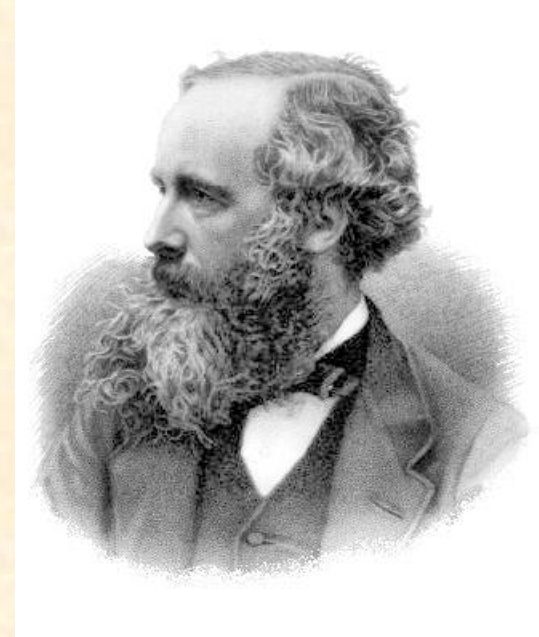
$$V=298,000,000.$$

The velocity of light in the space surrounding the earth, deduced from the coefficient of aberration and the received value of the radius of the earth's orbit, is

$$V=308,000,000.$$

(97) Hence the velocity of light deduced from experiment agrees sufficiently well with the value of v deduced from the only set of experiments we as yet possess. The value of v was determined by measuring the electromotive force with which a condenser of known capacity was charged, and then discharging the condenser through a galvanometer, so as to measure the quantity of electricity in it in electromagnetic measure. The only use made of light in the experiment was to see the instruments. The value of V found by M. FOUCAULT was obtained by determining the angle through which a revolving mirror turned, while the light reflected from it went and returned along a measured course. ~~No use whatever was made of electricity or magnetism.~~

The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws.



James Clerk Maxwell
(1831-1879)

Herschel on the sun

FAMILIAR LECTURES ON SCIENTIFIC SUBJECTS

By SIR JOHN F. W. HERSCHEL, BART., K. H.;

M.A.; D.C.L.; F.R.S. L. AND E.; HON. M.R.I.A.; F.R.A.S.; M.C.U.P.S.
MEMBER OF THE INSTITUTE OF FRANCE; AND
CORRESPONDENT, ASSOCIATE, HONORARY OR ORDINARY MEMBER OF VARIOUS OTHER
ACADEMIES AND INSTITUTIONS



ALEXANDER STRAHAN, PUBLISHER
LONDON AND NEW YORK
1866

the chemical products have to be disposed of. In the case of gun cotton, it has been calculated that, if the sun were made of it so condensed as only to burn on the surface, it would burn out, at the rate of the sun's expenditure of light and heat, in eight thousand years. Anyhow—fire, kept up by fuel and air, is out of the question. There remain only three possible sources of them, so far as we can perceive—electricity, friction, and vital action. The first of these was suggested by the late Sir William Herschel in 1801; the second, at least as a possibility, though without indicating any mode by which the necessary friction could arise, by myself, in a work* published in 1833. The theory at present current of it is founded on what may not unfairly be considered a further development of this idea, the friction being supposed to arise from meteoric matter circulating round the sun, and gradually subsiding into it, and either tearing up its surface, or ploughing into its atmosphere. But on this we cannot dilate, as nothing has been hitherto said about the appearance of the sun in telescopes, and the strange phenomena its surface, so examined, exhibits.

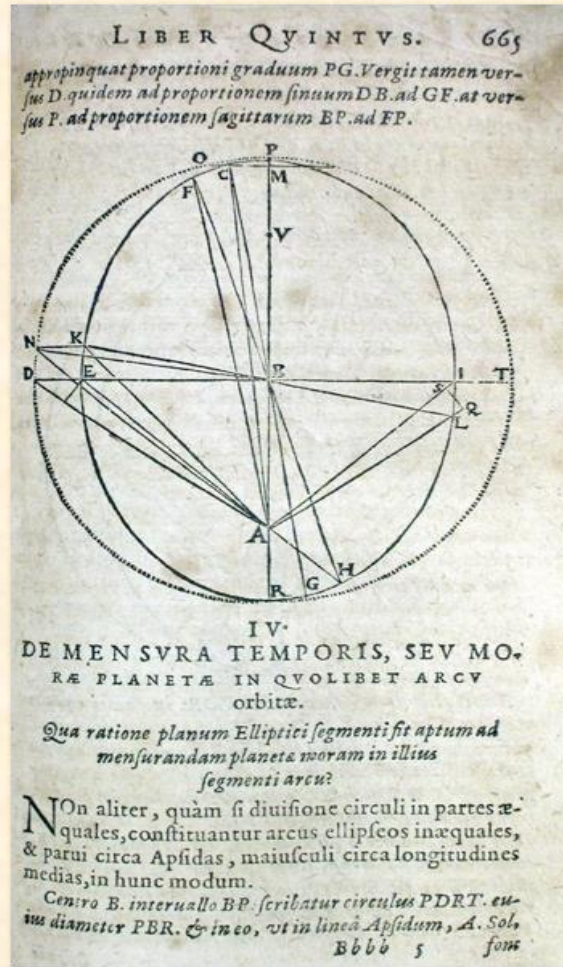
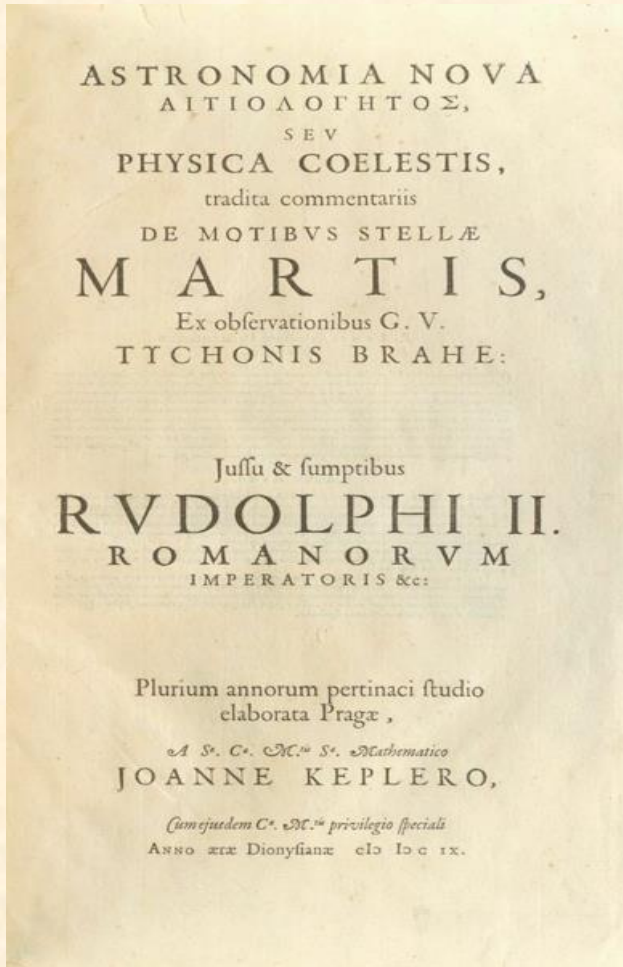
(33.) One of the earliest applications of the telescope was to turn it on the sun. And the first fruits of this application (which originated about the same time in the year 1611, with Harriot in England, Galileo in Italy, and Fabricius and Scheiner in Germany), was the dis-

* "Lardner's Cabinet Cyclopaedia," Astronomy, s. 337, p. 212. Aristotle was earlier in making this suggestion: but such random guesses as those of the ancients can hardly merit the name of scientific suggestions.



John Herschel (1792-1846)

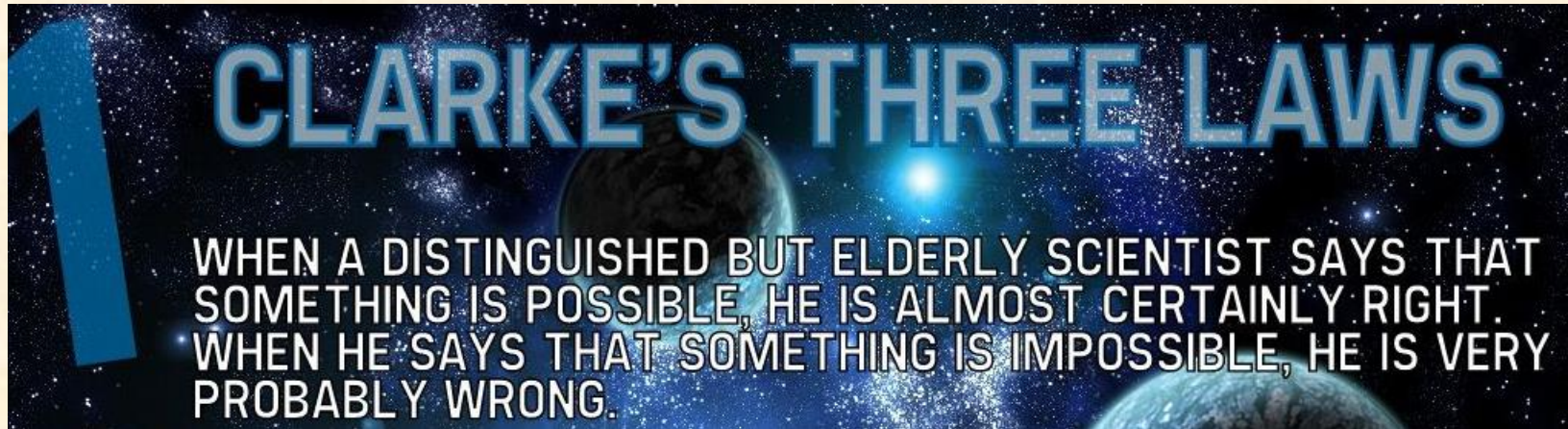
Kepler on the orbit of Mars



Johannes Kepler
(1571-1630)

**Your relation with the present:
Work and research**

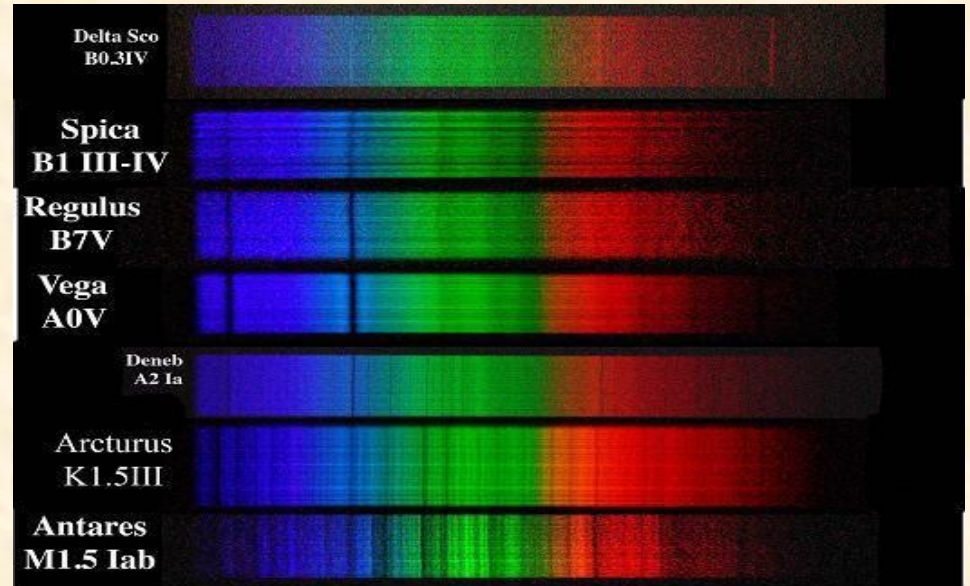
Arthur Clarke's Three Laws



I solemnly predict ... but don't listen to me

- ❖ On the subject of stars, all investigations which are not ultimately reducible to simple visual observations are ... necessarily denied to us. While we can conceive of the possibility of determining their shapes, their sizes, and their motions, we shall never be able by any means to study their chemical composition or their mineralogical structure ... I regard any notion concerning the true mean temperature of the various stars as forever denied to us.

August Comte, 1835



I solemnly predict ... but don't listen to me

- ❖ It is apparent to me that the possibilities of the aeroplane, which two or three years ago were thought to hold the solution to the [flying machine] problem, have been exhausted, and that we must turn elsewhere.

Thomas Edison, 1895

- ❖ I can state flatly that heavier than air flying machines are impossible.

Lord Kelvin, 1895



I solemnly predict ... but don't listen to me

- ❖ I think there is a world market for maybe five computers.

Thomas Watson, president of IBM, 1943



2

THE ONLY WAY TO DISCOVER THE LIMITS
OF THE POSSIBLE IS TO VENTURE A LITTLE
FURTHER INTO THE IMPOSSIBLE.



- ❖ Thomas S. Kuhn, *The Structure of Scientific Revolutions*, Chicago and London, The University of Chicago Press (1996)

Your prime years as a scientist



Sir Ronald Aylmer Fisher (1890-1962)



Ada Lovelace, *née* Byron (1815-1852)¹⁸

❖ Hidden Figures (2017)

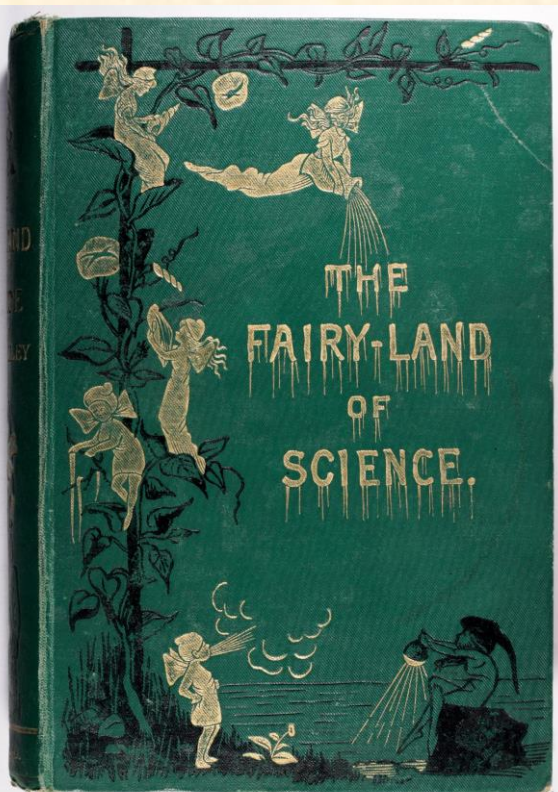


❖ Bombshell: The Hedy Lamarr Story (2017)

**Your relation with the future:
Education of the younger generations**



The marvel of science and technology

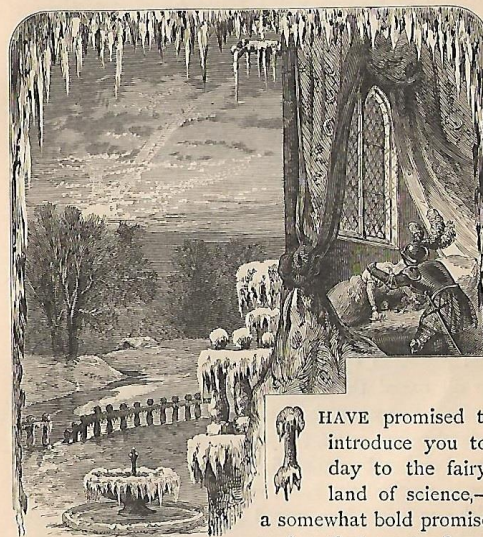


Arabella Buckley, The Fairy Land of Science, London, 1878

THE FAIRY-LAND OF SCIENCE.

LECTURE I.

HOW TO ENTER IT; HOW TO USE IT; AND HOW
TO ENJOY IT.



HAVE promised to introduce you to-day to the fairy-land of science,— a somewhat bold promise, seeing that most of you probably look upon science as a bundle of dry facts, while fairy-land is all that is beautiful, and full of

2

THE FAIRY-LAND OF SCIENCE.

poetry and imagination. But I thoroughly believe myself, and hope to prove to you, that science is full of beautiful pictures, of real poetry, and of wonder-working fairies; and what is more, I promise you they shall be true fairies, whom you will love just as much when you are old and greyheaded as when you are young; for you will be able to call them up wherever you wander by land or by sea, through meadow or through wood, through water or through air; and though they themselves will always remain invisible, yet you will see their wonderful power at work everywhere around you.

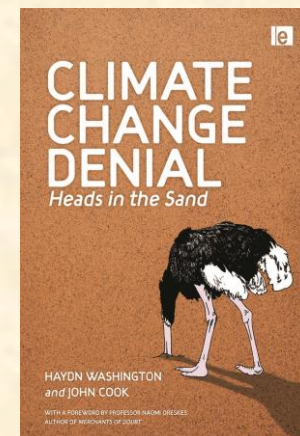
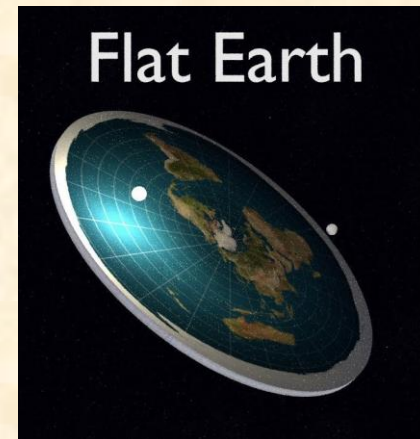
Let us first see for a moment what kind of tales science has to tell, and how far they are equal to the old fairy tales we all know so well. Who does not remember the tale of the "Sleeping Beauty in the Wood," and how under the spell of the angry fairy the maiden pricked herself with the spindle and slept a hundred years? How the horses in the stall, the dogs in the court-yard, the doves on the roof, the cook who was boxing the scullery boy's ears in the kitchen, and the king and queen with all their courtiers in the hall remained spell-bound, while a thick hedge grew up all round the castle and all within was still as death. But when the hundred years had passed the valiant prince came, the thorny hedge opened before him bearing beautiful flowers; and he, entering the castle, reached the room where the princess lay, and with one sweet kiss raised her and all around her to life again.

Can science bring any tale to match this?

Tell me, is there anything in this world more busy

Science and Technology Denial

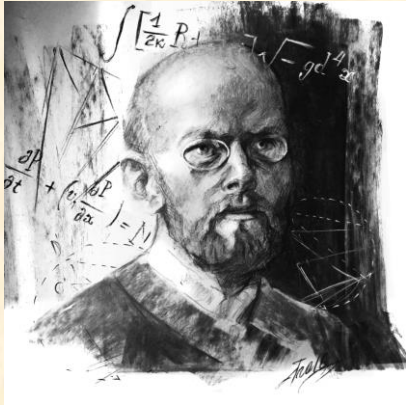
- ❖ Science and technology is effective
 - not because it is **infallible**, but because it is **falsifiable**
 - Not because scientists are robots, but because they are humans
 - Not only because of its successes, but also because of its failures
- ❖ Science and technology is not common sense. The truth is hidden and a lot of effort and imagination is required to uncover it
- ❖ There is some inherent uncertainty in science and technology. Every experiment has its margin of error
- ❖ Poor understanding of science and the sense of being left out of it leads to science denial, which is becoming more and more apparent nowadays
- ❖ People tend to revert to myths and conspiracy theories that make them temporarily happy
- ❖ These make them feel at home, that they have a grip on what is going on in the world
- ❖ They provide them with a false feeling of certainty



Upholding science and technology in a world of uncertainty and misinformation

- ❖ William Clifford, *The Ethics of Belief*, In Brian Davies (ed.), *Philosophy of Religion: A Guide and Anthology*, Oxford University Press (1879)
- ❖ Karl Popper, *In Search of a Better World: Lectures and Essays from Thirty years*, London-New York, Routledge (1992)
- ❖ Carl Sagan and Ann Druyan, *The Demon Haunted World: Science as a Candle in the Dark* (1997). Especially chapter 12, *The Fine Art of Baloney Detection*
- ❖ Steven Pinker, *Enlightenment Now. The Case for Reason, Science, Humanism and Progress*, London, Allen Lane (2018)

Defending the freedom of expression



How one German city developed – and then lost – generations of math geniuses

Hilbert was asked in 1934 by the minister of science under the Nazi regime whether mathematics in Göttingen had suffered from the departure of the Jews and friends of the Jews. He replied: "Suffered? It hasn't suffered, Mr. Minister. It doesn't exist anymore!" Hilbert was right. Only one of the pre-Nazi full professors stayed past 1934. The center of mathematics shifted quickly during the Nazi era and in the wake of World War II. Courant, Weyl and others helped move it to the U.K. and the U.S., where most of the top-ranked mathematics programs are located today. These countries' mathematical heritage is in Göttingen. Its story is their story.

<https://theconversation.com/how-one-german-city-developed-and-then-lost-generations-of-math-geniuses-106750>

Brilliant teaching



The sense of "I was there when he said it"

<https://www.youtube.com/watch?v=-OhweQWrltQ>