Some Philosophical Aspects of Measurement

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“If you cannot measure, your knowledge is meager and unsatisfactory.”

Quotation from William Thompson (Lord Kelvin) inscribed on the façade of the Social Science Research Building at the University of Chicago

(After Kuhn: "The Function of Measurement in Modern Physical Science" (1961))

Galileo's maxim:

"To measure everything measurable and to make what is unmeasurable, measurable.”

Justification:

The book of nature is written in the language of geometry.

Kuhn's “traditional sciences”

- Astronomy
- Opticks
- Mechanics

Kuhn's “Baconian sciences”

The study of

- Heat
- Electricity
- Magnetism
- Chemistry

“...measurement is the assignment of numerals to events or objects according to rule...”

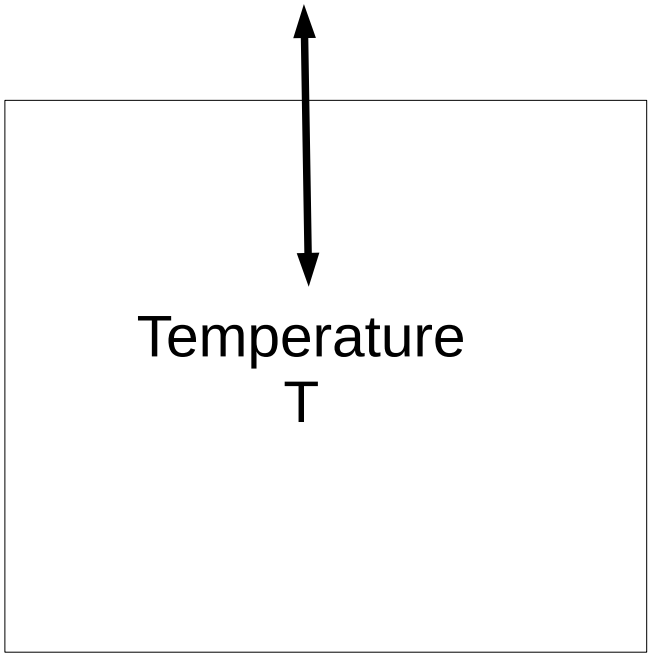
S. S. Stevens: Mathematics, measurement and psychophysics (1951)

Different kinds of scales:

- nominal
- ordinal
- interval
- ratio

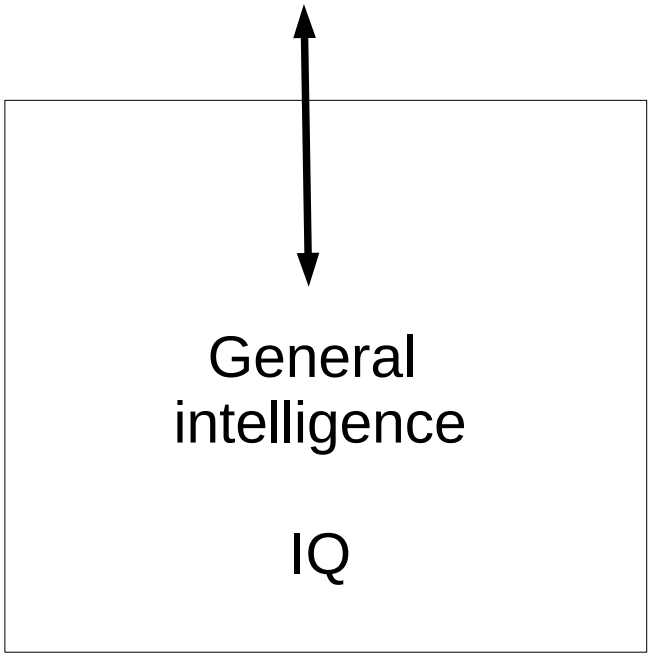
1. We carry out the operations that constitute the measurement procedure

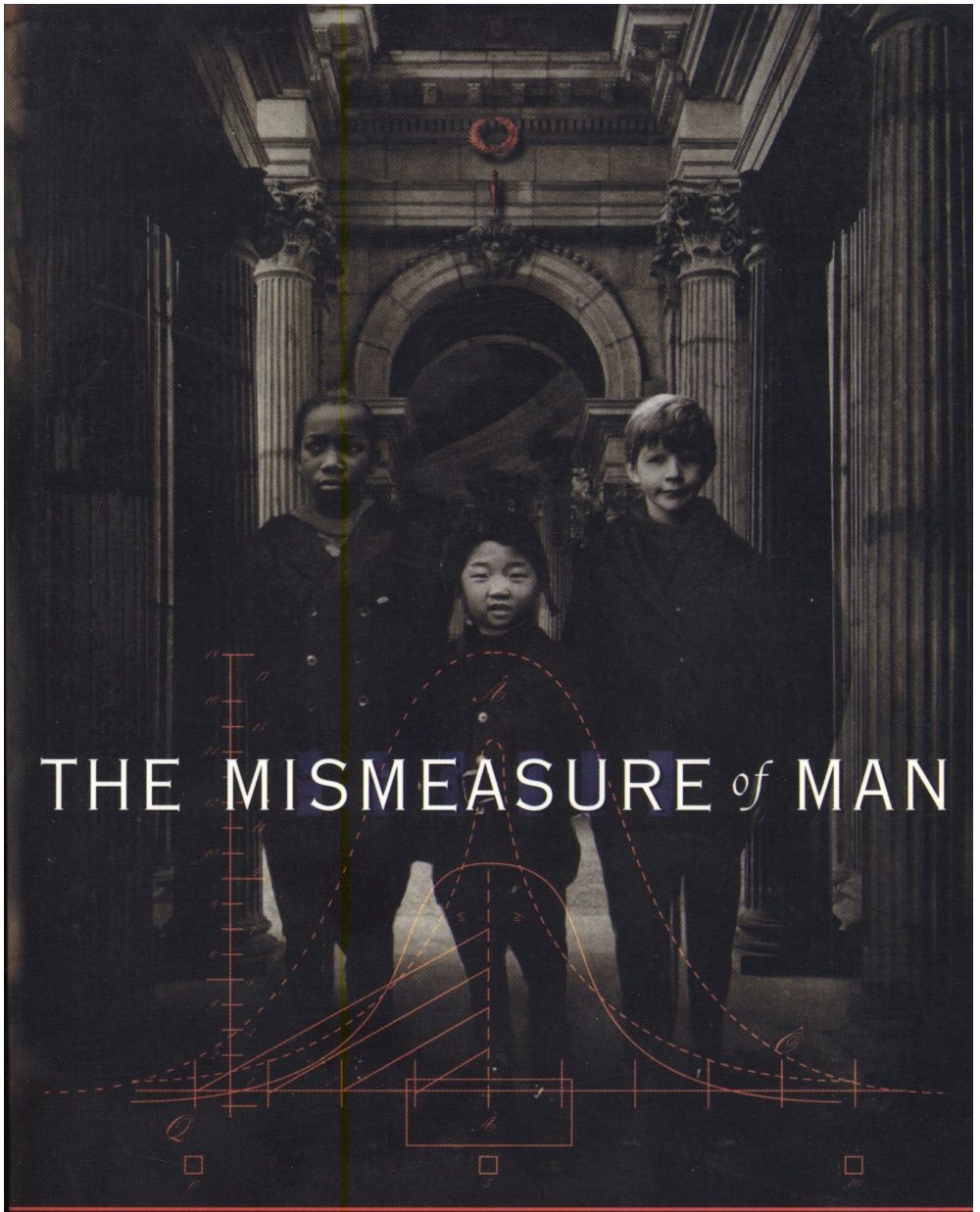
2. The result is assigned to the event, object or property



1. We carry out the operations that constitute the measurement procedure: intelligence tests

2. The result is assigned to the event, object or property





THE MISMEASURE of MAN

STEPHEN JAY GOULD

The definitive refutation to the argument of *The Bell Curve*

REVISED AND EXPANDED, WITH A NEW INTRODUCTION

“The error of reification”: To award physical meaning to a measured magnitude

Example: decathlon

Day 1

* 100 metres
* Long jump
* Shot put
* High jump
* 400 metres

Day 2

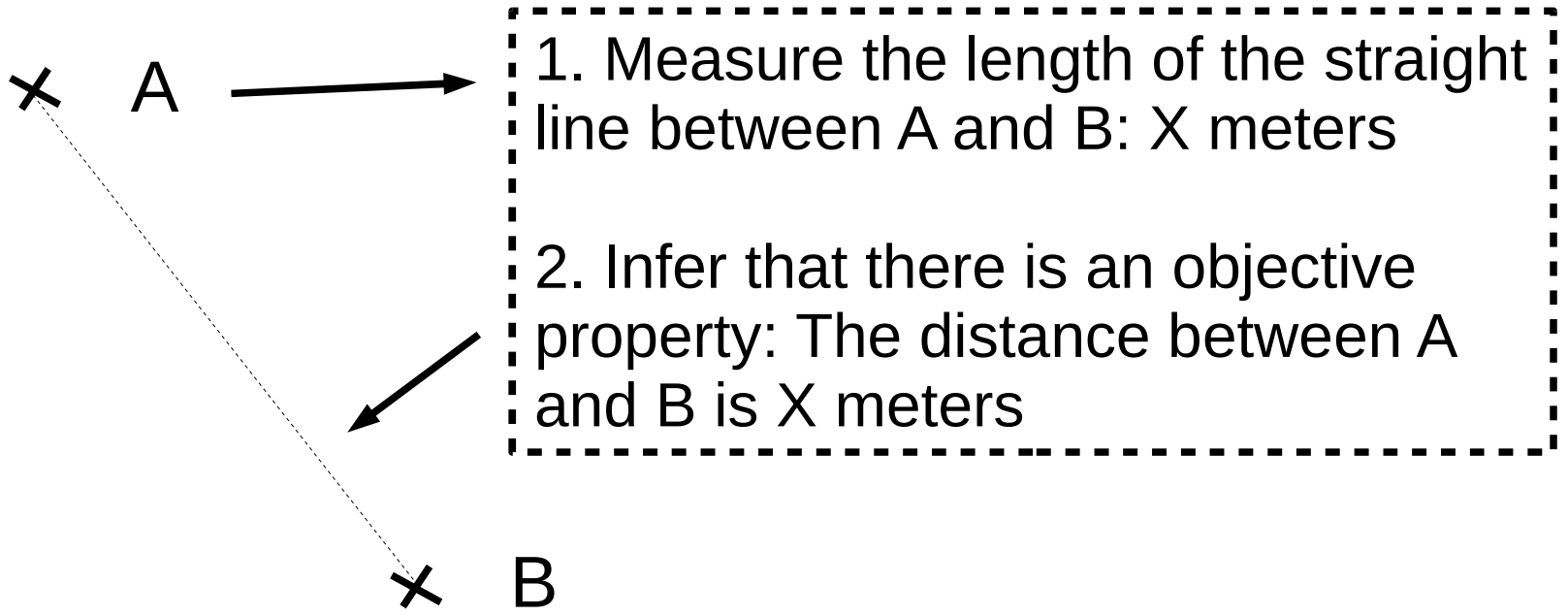
* 110 metres
* hurdles
* Discus throw
* Pole vault
* Javelin throw
* 1500 metres

Question: Is there a physical property corresponding to the ability to perform well in a decathlon competition?

Answer: Of course not

What about IQ?

Example: distance



Operationalism

Percey William Bridgman (1882 – 1961, Nobel Prize in physics 1946)

“Operationalism is based on the intuition that we do not know the meaning of a concept unless we have a method of measurement for it.”

“His writings were primarily “reflections of a physicist” rooted in experimental practice and aimed at articulating the scientific method from a first-person point of view. However, as Bridgman's ideas gained currency they were shaped into a general philosophical doctrine of “operationalism” or “operationism”, and in that form became very influential in many areas, especially in methodological debates in psychology.” (Stanford Encyclopedia of Philosophy, http://plato.stanford.edu/entries/operationalism/)

From Bridgman: *The Logic of Modern Physics*

- [W]hat do we mean by the length of an object?
- To find the length of an object, we have to perform certain physical operations.
- [T]he concept of length involves as much as and nothing more than the set of operations by which length is determined.

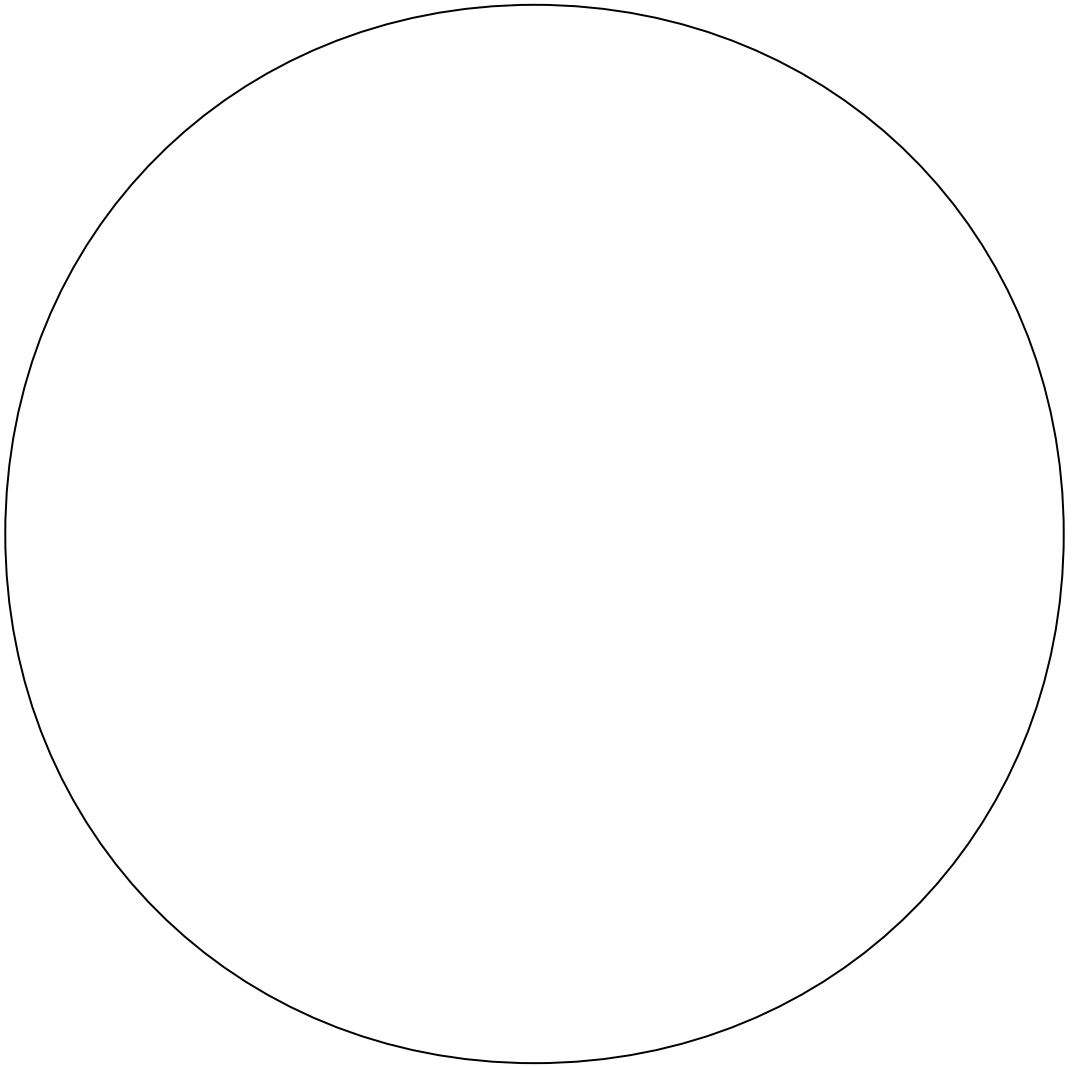
Edmund Husserl: Die Krisis der europäischen Wissenschaften und die transzendentale Phänomenologie (1954), Engl. transl. The Crisis of European Sciences and Transcendental Phenomenology (1970).

This purpose [of procuring objectivity] is obviously served by the *art of measuring*. This art involves a great deal, of which the actual measuring is only the concluding part; on the one hand, for the bodily shapes of rivers, mountains, buildings, etc., which as a rule lack strictly determining concepts and names, it must create such concepts – first for their "forms".... (§ 9a)

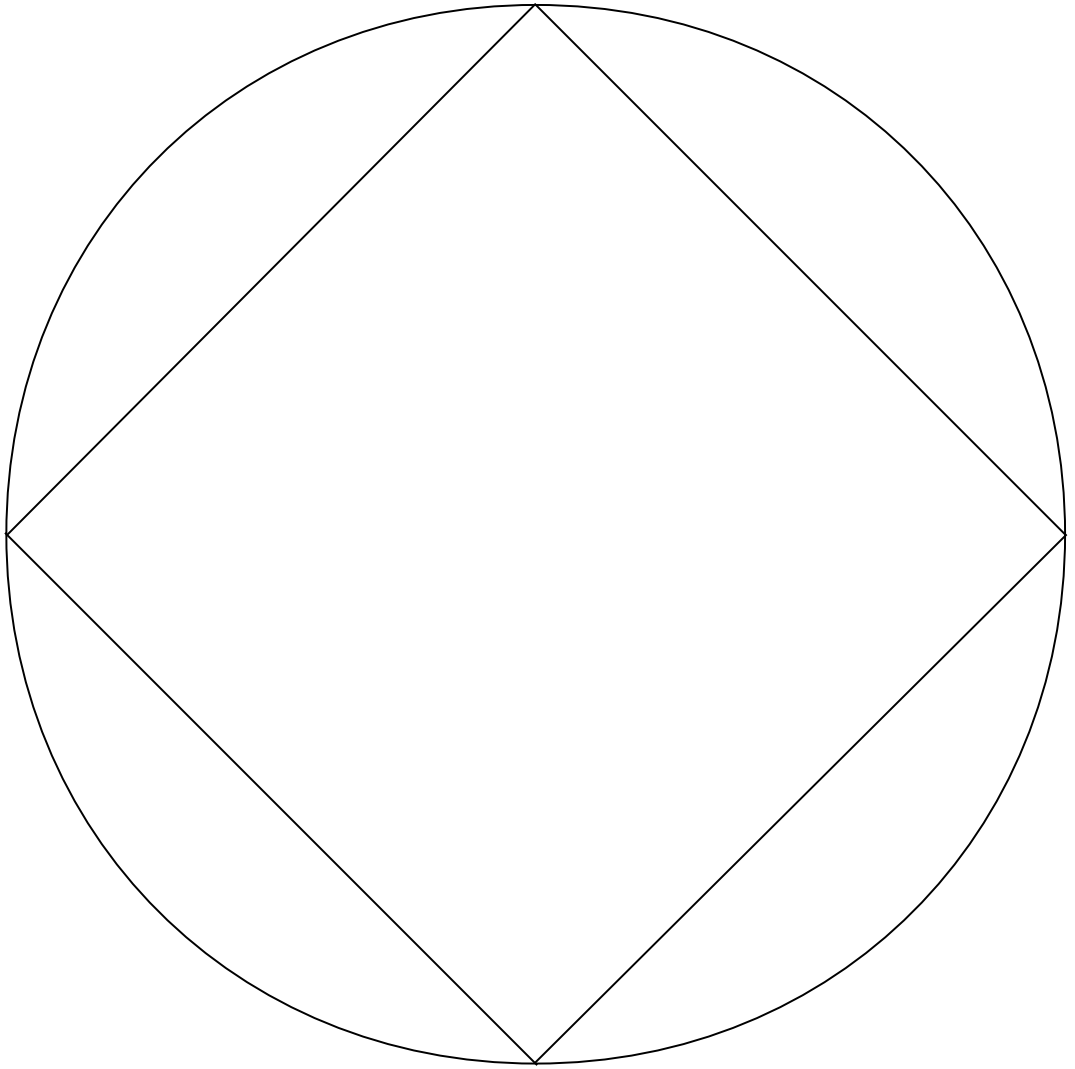
Benoit Mandelbrot: How Long is the Coast of Britain?, Science 155/1967

Contrast between natural and artificial borders

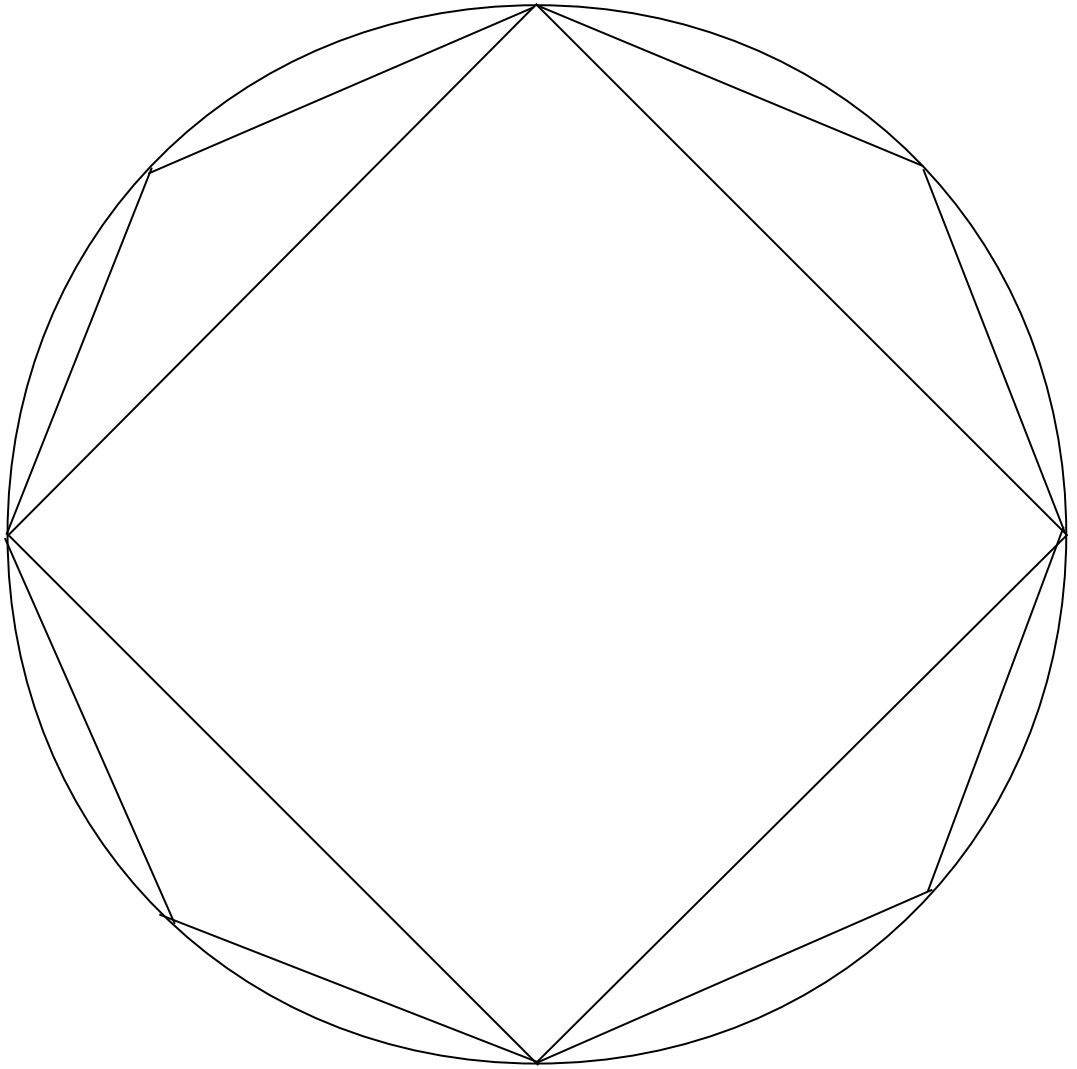
How to measure the circumference of a circle

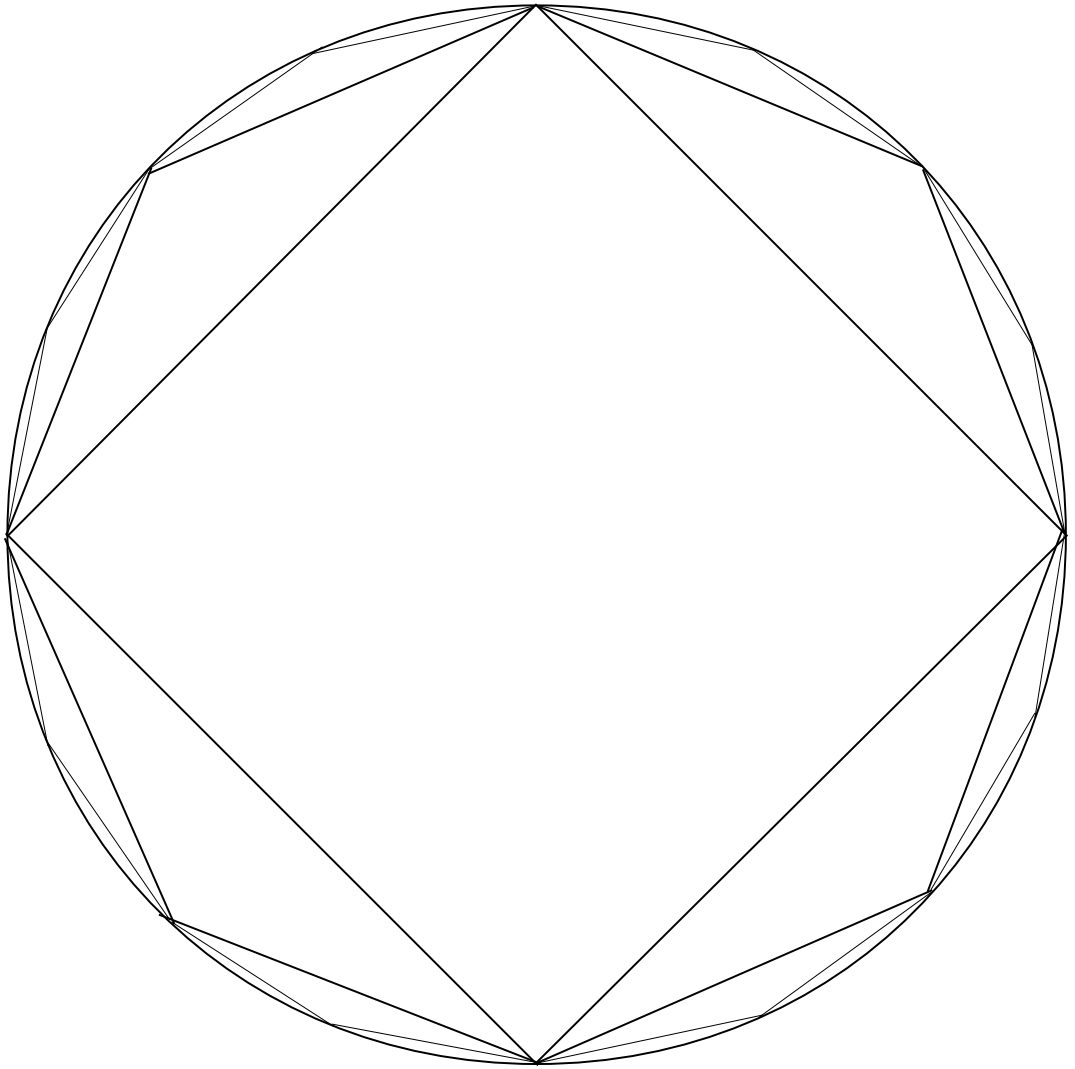


You inscribe a polygon and measure the length of the sides



Then you increase the number of sides

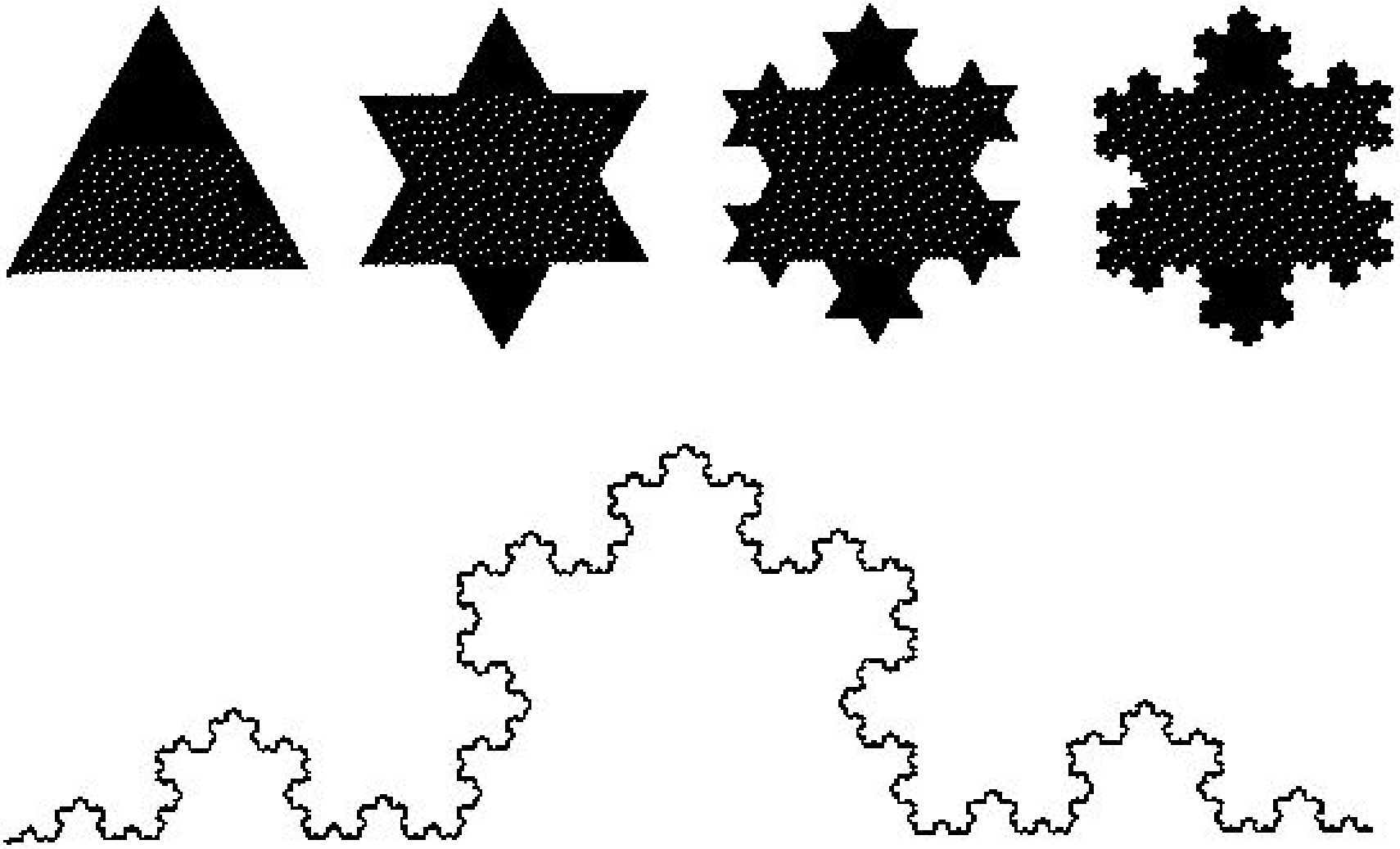


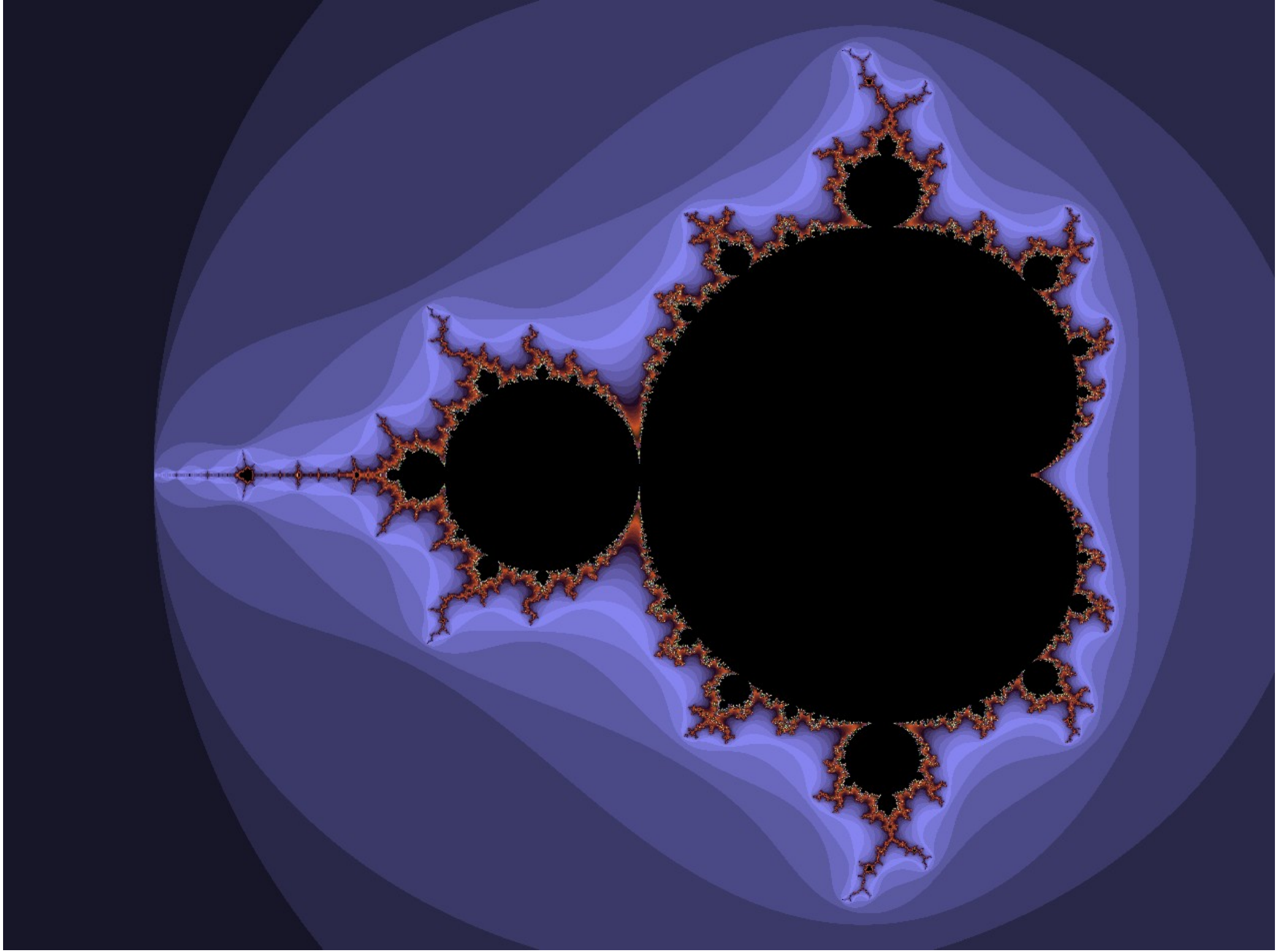


The coast of Britain

Measuring rod:	Length:
500 km	2600 km
100 km	3800 km
54 km	5770 km
17 km	8640 km

“Koch island”





"Why is [Euclidean] geometry often described as "cold" and "dry"? One reason lies in its inability to describe the shape of a cloud, a mountain, a coastline, or a tree. Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line."

Benoit Mandelbrot: *The Fractal Geometry of Nature* (1977)

If a lion is stalking at you, or a shark is out to kill you, you are of course in mortal danger. We have lived with these dangers for millions of years. The straight line is a man-made danger. There are so many lines, millions of lines, but only one is deadly, and that is the straight line drawn with a ruler. The danger of the straight line cannot be compared with the danger of organic lines described by snakes, for instance. The straigh line is completely alien to mankind, to life, to all creation. (Friedensreich Hundertwasser)

“The book of nature” is not written in the language of (Euclidean) geometry.

Euclidean geometry is intimately related to technology.

When we make technological devices, we impose Euclidean geometry on nature.

When we measure distances, we impose a Euclidean grid on nature.

The same applies to measurements more generally.

Cf Theodore M. Porter: Trust in Numbers. The Pursuit of Objectivity in Science and Public Life (1995)

Chapter One: A World of Artifice