“The Great Tide Experiment”

and its role for the XIXth century scientific communication

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RFBR project № 17-03-00812-ОГН ОГН-А ”The rise of the philosophy of science. William Whewell, his communication circle and consequences for the XX century"

Introduction

Not into consideration:

1) How accurate Whewell's theory was;
2) The impact for tide studies;

Into consideration:

1) Professionalization of science;
2) Communication network.

Summary

I. Preliminary Theoretical Hypothesis
II. The Experiment: Structure, Participants, Results
III. Conclusions

a) Social Studies of Science
b) Philosophy of Science

William Whewell (1794-1866)

- 1820 elected member of Royal Society
- 1831 British Association for the Advancement of Science (David Brewster, Charles Babbage, J.F.W. Johnston)
- **1835 The Great Tide Experiment**
- 1837 ***History of the Inductive Sciences, from the Earliest to the Present Times*** *& Royal Medal*
- 1840 ***The Philosophy of the Inductive Sciences, founded upon their history***
- 1841 – Master of Trinity College
- 1858 ***The history of scientific ideas***
- 1858 ***Novum Organon renovatum***
- 1860 ***On the philosophy of discovery: chapters historical and critical***
- 1866 ***Comte and Positivism***

Theoretical Issues

“Our philosophers assert, without hesitation, that this phenomenon is the result of the law of universe gravitation of matter; yet no one has hitherto deduced, from this law, the laws by which this phenomena are actually regulated with regards to time and place”. (Whewell, 1834, p. 15).

Before the experiment 1

Problems in tides investigations:

- Lack of theory;
- Absence of unified and interpreted data;
- Tide tables = private property of tide tables makers (business matter);
- No methodology for gathering the data.

Before the Experiment 2

"To provide a systematic and broad-ranged empirical study of the tides and to establish a general scientific theory of tidal phenomena" (Ducheyne, 2010, p. 27)

"His early work to tidology also taught him a valuable lessons concerning the discovery process, including the difficulty of connecting facts with theory, the disparate ways of testing those theories, and the proper methods of data analysis and representation" (Reids, 2008, p. 14, 155).

“Working Hypothesis”

Lubbock’s “On the tides of London” (1831)

Equilibrium theory:

- Cotidal lines;
- Lubbock’s formula & calculations.

Part of astronomy – requires **observation** as methodology (Whewell, 1838, p. 232)

And its Limits

Troubles with equilibrium-theory:

- Hydrostatics VS hydrodynamics;
- Lack of mathematical models;
- Insufficient and contradicting data.

“could be useful to suggest a better one” (Ducheyne)

Claims

”On an empirical level, Whewell attempted to systematize and unify tidal data by means of tide tables and visual modes of representation. On a theoretical level, he made serious attempts to test how well the equilibrium-theory, of which he became well aware of its limits, could be reconciled with extant data”. (Ducheyne, 2010, p. 39)

Why study tides?

Government interests:

- Military navigation;
- Merchant shipping;
- Urban planning;
- Public safety.

The Experiment

2 weeks – June (July) 1835

- Every 15 minutes measurements;
- Thousands of people;
- More than 650 tidal stations:
  - 319 England;
  - 219 Ireland;
  - 29 US;
- 9 nations & colonies;
- Both sides of Atlantic.

Arrangements:

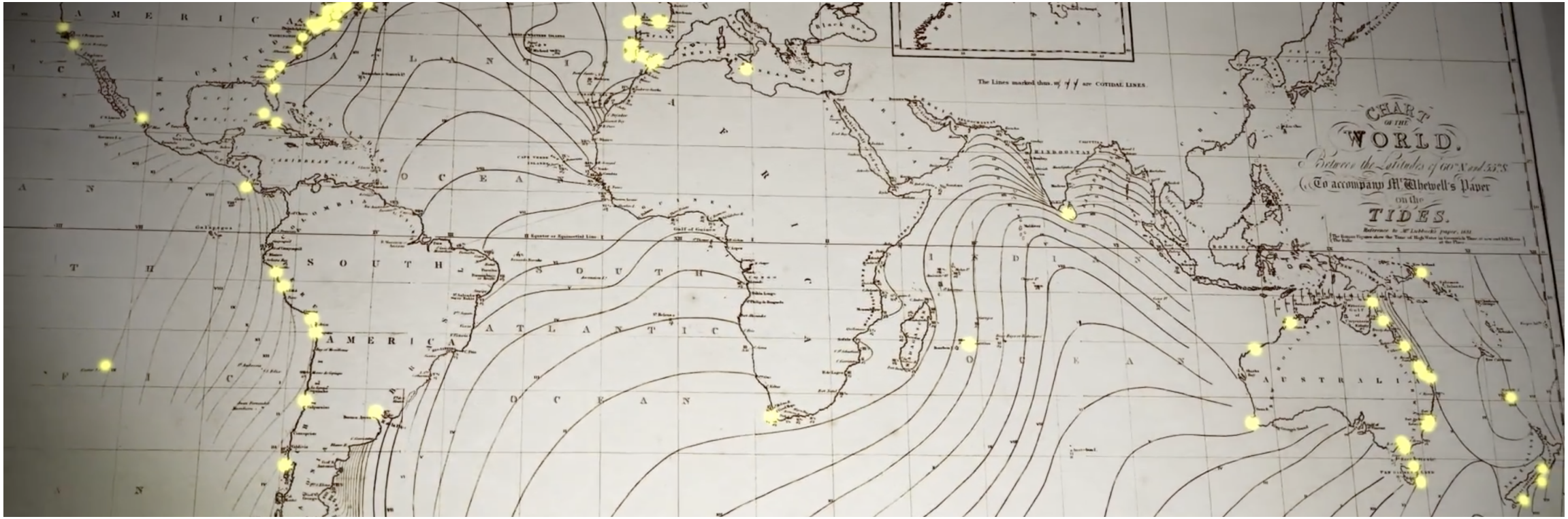
Whewell (1834) Memoranda and directions for tide observations

Whewell & F. Beaufort (hydrographer and officer in the Royal Navy) – the initial plan;

Foreign Secretary duke of Wellington – arrangements with foreign governments.

Map 1

England & Ireland stations

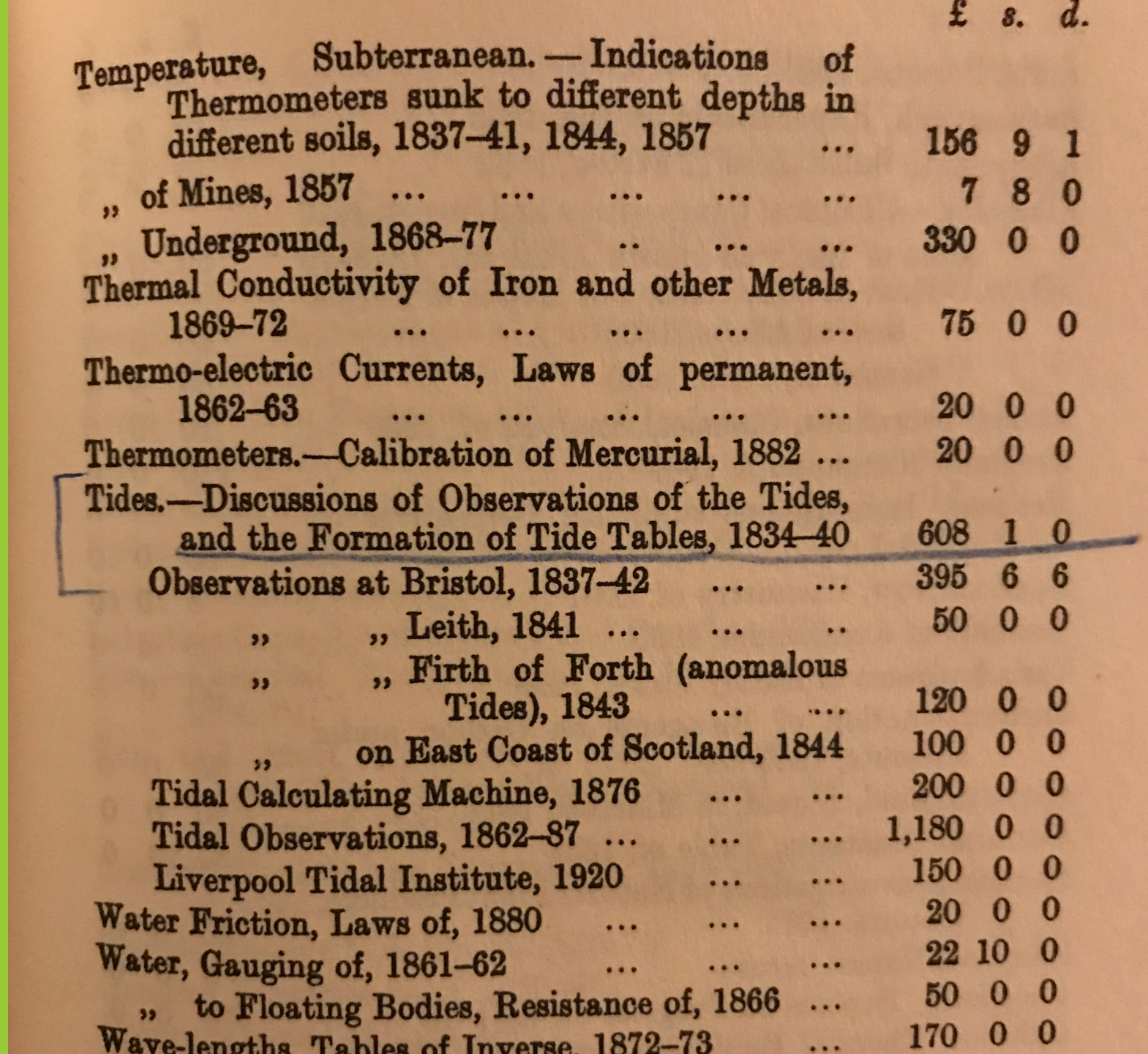

The Lines marked thus are COTIDAL LINES.
CHART OF THE WORLD.
Between the Latitudes of 60° N and 55° S
To accompany Mr Whewell's Paper on the
TIDES.
Reference to Mr Lubbock's paper, 1831
NORTH AMERICA
SOUTH AMERICA
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
AUSTRALIA

Map 2

Funding

Howarth (1931)
The British Association for the Advancement of Science: A Retrospect 1831-1931

≈£ 78 000,00 in 2019

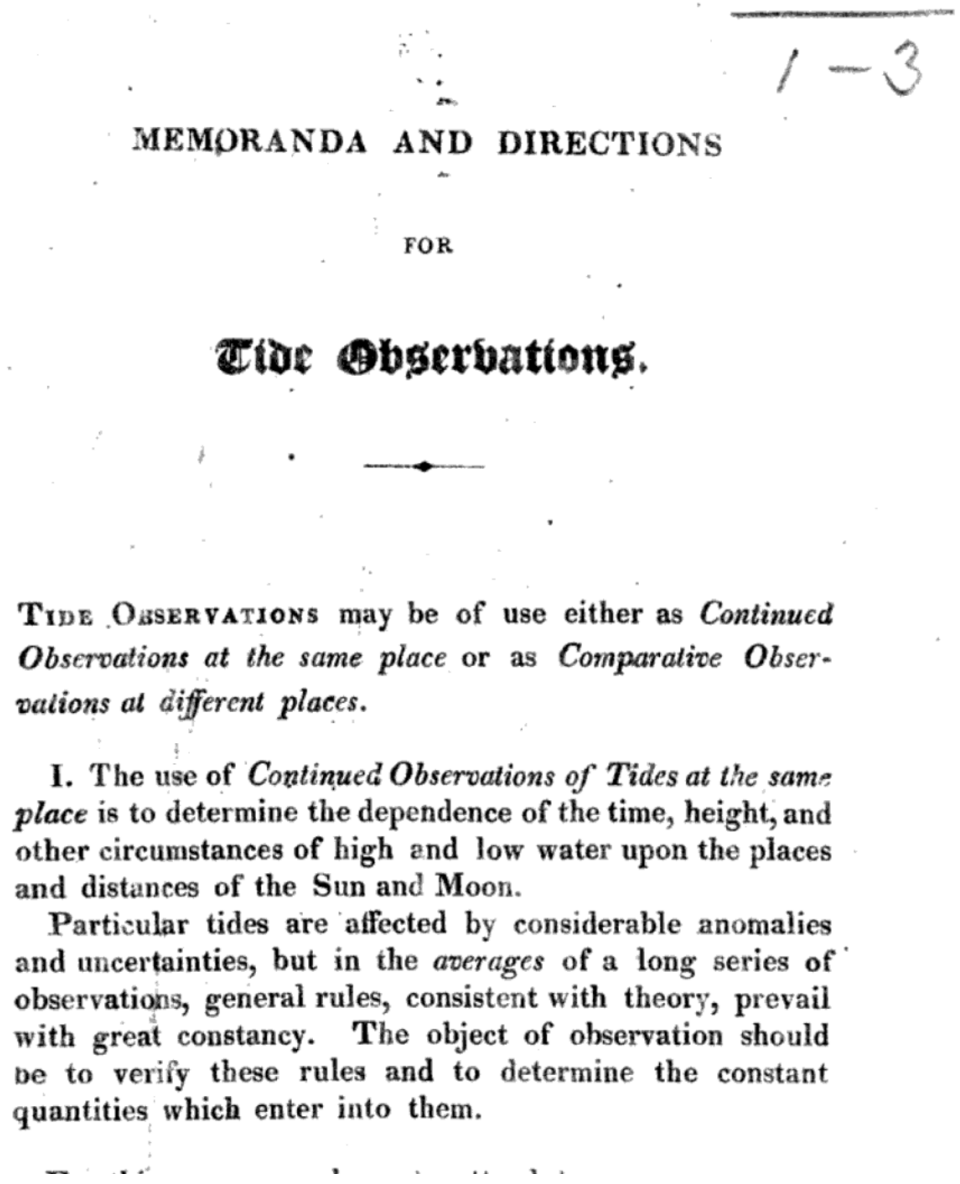


	£	s.	d.
Temperature, Subterranean.—Indications of Thermometers sunk to different depths in different soils, 1837–41, 1844, 1857 ...	156	9	1
„ of Mines, 1857	7	8	0
„ Underground, 1868–77	330	0	0
Thermal Conductivity of Iron and other Metals, 1869–72	75	0	0
Thermo-electric Currents, Laws of permanent, 1862–63	20	0	0
Thermometers.—Calibration of Mercurial, 1882 ...	20	0	0
Tides.—Discussions of Observations of the Tides, and the Formation of Tide Tables, 1834–40	608	1	0
Observations at Bristol, 1837–42	395	6	6
„ „ Leith, 1841	50	0	0
„ „ Firth of Forth (anomalous Tides), 1843	120	0	0
„ on East Coast of Scotland, 1844	100	0	0
Tidal Calculating Machine, 1876	200	0	0
Tidal Observations, 1862–87	1,180	0	0
Liverpool Tidal Institute, 1920	150	0	0
Water Friction, Laws of, 1880	20	0	0
Water, Gauging of, 1861–62	22	10	0
„ to Floating Bodies, Resistance of, 1866 ...	50	0	0
Wave-lengths, Tables of Inverse, 1872–73 ...	170	0	0

Participants

"Subordinate Labourers":

- dockyard officials;
- sailors;
- harbormasters;
- local tide table makers;
- costal surveyors;
- professional military men;
- amateur observers.



1-3

MEMORANDA AND DIRECTIONS

FOR

Tide Observations.

TIDE OBSERVATIONS may be of use either as *Continued Observations at the same place* or as *Comparative Observations at different places.*

I. The use of *Continued Observations of Tides at the same place* is to determine the dependence of the time, height, and other circumstances of high and low water upon the places and distances of the Sun and Moon.

Particular tides are affected by considerable anomalies and uncertainties, but in the *averages* of a long series of observations, general rules, consistent with theory, prevail with great constancy. The object of observation should be to verify these rules and to determine the constant quantities which enter into them.

Further Development

"I inclose a Memorandum respecting Tide Observations to which subject I am desirous of drawing the attention of the Russian government. Nobody knows better than you do how much remains to be done respecting the Tides, and what important results any advance in that subject would have. I hope through your Russian friends you may have the means of bringing this Memorandum to the notice of the administration of their Navy, so as to lead to some steps being taken, in the way of directing observations to be made. The Russian government has shown so much zeal in promoting science, that I hope it will not be difficult to engage them in a kind of research *so easy, so useful practically, and so interesting in its theoretical bearing*".

(Whewell to M. Sommerville, 1838, (In: Deacon, 2016)).

Whewell's further works on Tides 1

1835

- On the results of tide observations made in June 1834 at the coast guard stations in Great Britain and Ireland (N 125, p. 83-90)

1836

- Researches on the tides. Fourth series: On the empirical laws of the tides in the port of Liverpool (N 126, p. 1-15)
- Researches on the tides. Fifth series: On the solar inequality and on the diurnal inequality of the tides at Liverpool (N 126, p. 131-137)
- Researches on the tides Sixth series: On the results of an extensive system of tide observations made on the coasts of Europe and America in June 1835 (N 126, p. 238-336)

1837

- Researches on the tides. Seventh series: On the diurnal inequality of the height of the tide, especially at Plymouth and at Singapore; and on the mean level of the sea (N 127, p. 75-85)
- Researches on the tides. Eighth series: On the progress of the diurnal equality wave along the coasts of Europe (N 127, p. 227-266)

Whewell's further works on Tides 2

1838

- Description of a new tide-gauge, constructed by Mr. T. G. Bunt, and erected on the eastern bank of the River Avon, in front of the Hotwell House, Bristol (N128, p. 249-251)
- Researches on the Tides. Ninth series: On the determination of the laws of the tides from short series of observations (N 128, p. 231-247)

1839

- Researches on the tides. Tenth series: On the laws of low water at the port of Plymouth, and on the permanency of mean water (N 129, p. 151-161)
- Research on the tides. Eleventh series: On certain tide observations made in the Indian seas (N 129, p. 163-166)

1840

- Additional note to the eleventh series of researches on the tides (N 130, p. 161-174)
- Researches on the tides. Twelfth series: On the laws of the rise and fall of the sea's surface during each tide (N 130, p. 255-272)

Whewell's further works on Tides 3

1848

- The Bakerian lecture. Researches on the tides. Thirteenth series: On the tides of the Pacific, and on the diurnal inequality (N 138, p. 1-29)

1850

- Researches on the tides. Fourteenth series: On the results of continued tide observations at several places on the British coasts (N 140, p. 227-233)

1851

- On our ignorance of the tides // British Association Report 1850, p. 27–28.

Citizen Science explanation

“Elite hobby” vs “professional science”:

“Necessity of using free human resources to contribute to scientific innovation, due to lack of funds in science” (Cooper, 2016)

“like a conductor of a global orchestra, he coordinated thousands of people in nine nations and continents on both sides of the Atlantic in the synchronized measurement of tides” (Cooper, 2016)

“Whewell, the person who relied on citizen science to achieve his highest honor, helped delineate science as an exclusive profession with specific norms and procedures for valid discovery” (Cooper, 2016)

Citizen Science Model

‘Real’ scientist	’Citizen’ scientist
Provides theoretical knowledge	Ignorant of the theory
Elaborates standards	Follows instructions
Interprets data	Provides data
Claims reward	No reward provided
Keeps elite position (status quo) as a professional	Stays non-professional (but still useful)

Critique 1: the role of power

For the experiment arrangements:

- State interest;
- British Navy & the government (Arthur Wellesley, 1st Duke of Wellington);
- Foreign governments.

Demand of state paternalism:

- Babbage Ch. (1830) Reflexions on the Decline of Science in England, and on some of its Causes.
- Brewster D. (1830) Review on: Reflexions on the Decline of Science in England, and on some of its Causes. By Charles Babbage.

Critique 2: Hierarchy Case 1

Man of science VS engineer case: Stevenson-Davy debate on the safety lamp

“The one was yet but a colliery engine-wright, scarce raised above the manual labour class, without chemical knowledge or literary culture, pursuing his experiments in obscurity, with a view only to usefulness; the other was the scientific prodigy of his day, the pet of the Royal Society, the favourite of princes, the most brilliant of lecturers, and the most popular of philosophers. […] And though the theory on which Stephenson constructed his lamp was erroneous, he had proved it to be a safety lamp to all intents and purposes. He had discovered the lamp, though not its rationale”. (Smiles, 1857, p. 101)

1835 – Committee of the House of Commons

Critique 2: Hierarchy Case 1

"Thus the two components of the scientific method were separated by a social barrier: logical training was reserved for upper class scholars, experimentation, causal interest, and quantitative method were left to more or less plebian artisans. Science was born, when, with the progress of technology, the experimental method eventually overcame the social prejudice against manual labor and was adopted by rationally trained scholars" (Kronick, 1962, p. 40)

Professionalization of science

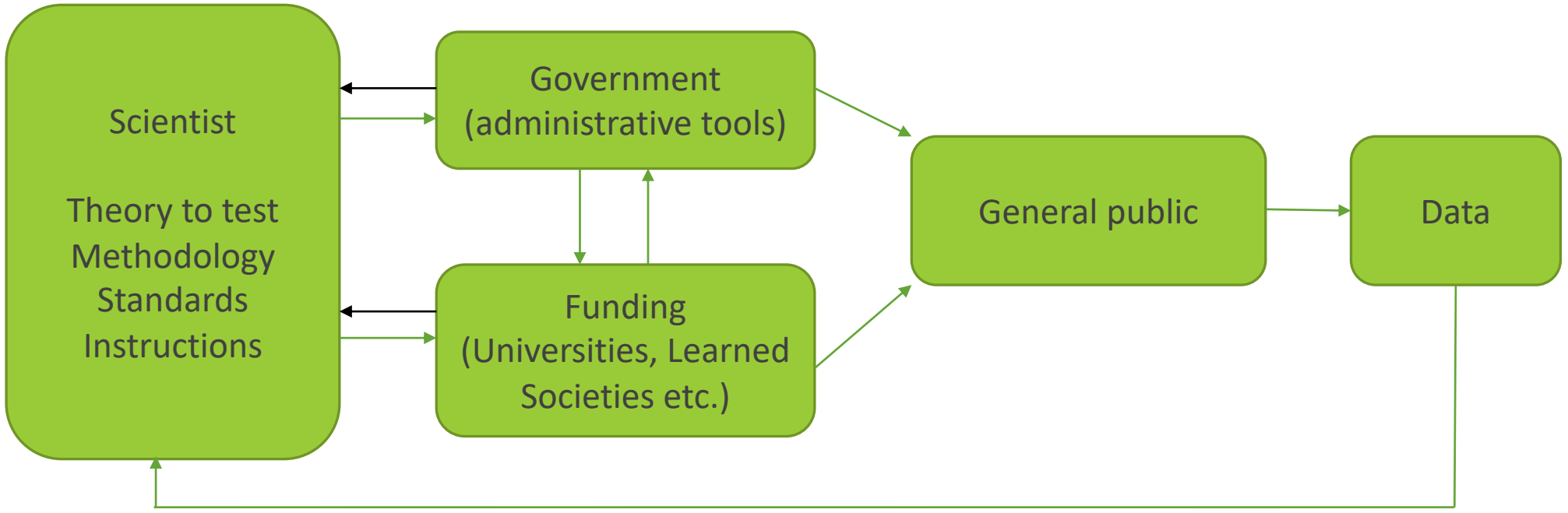
Disciplinary point of view:

- Educational requirements;
- Specialization.

Institutional point of view:

- Official positions;
- Research as the main source of income;
- Evaluation procedures.

More complicated model



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