Expérimenter avec l'histoire

Comprendre les savoirs passés
par la pratique et le terrain

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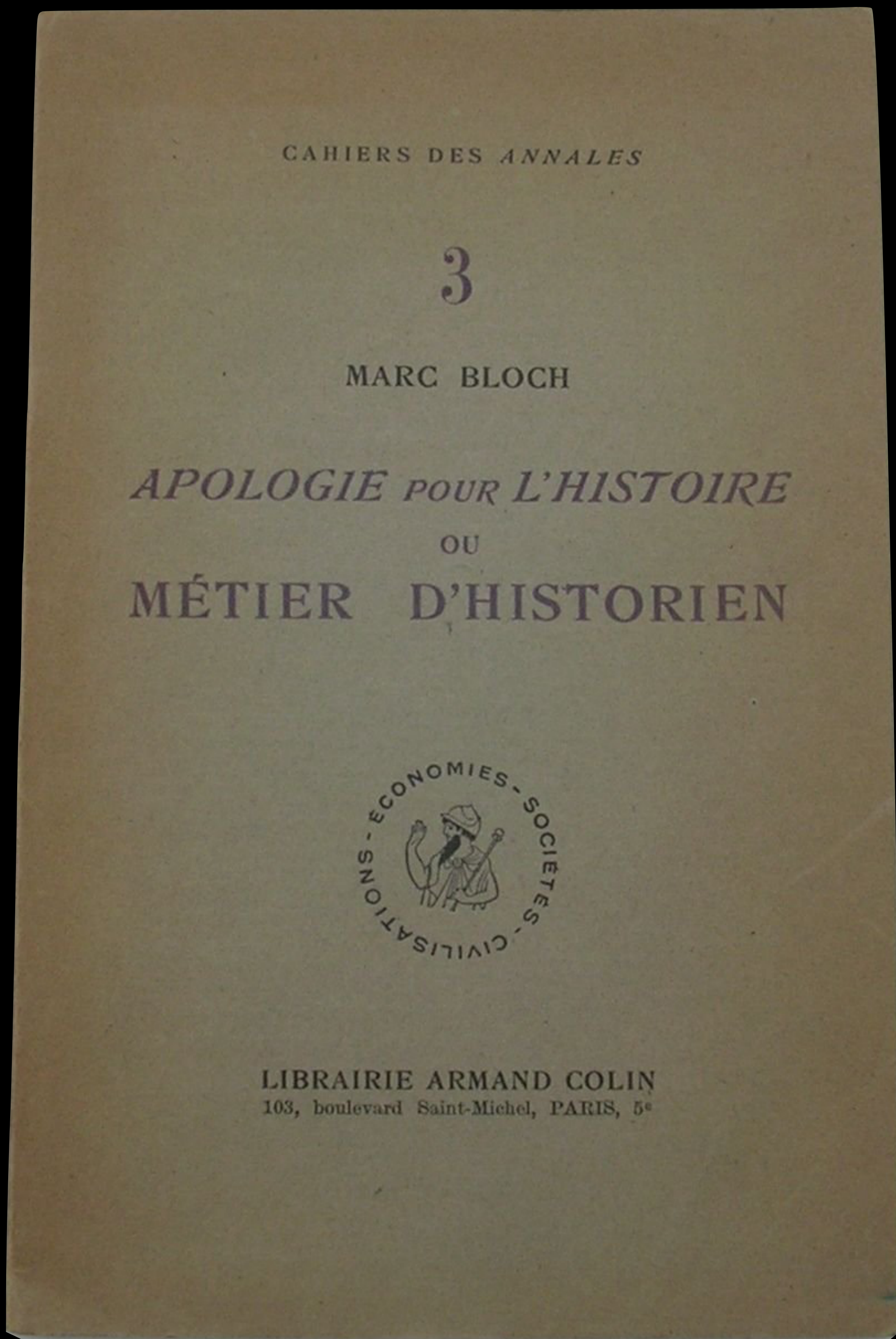
Conférence à la Société Vaudoise des Sciences Naturelles - 20 mai 2021

Introduction : le « métier d’historien »

1. Des archives à la pratique
2. Enseigner l’histoire expérimentale
3. Vers une histoire de plein vent ?

Conclusion

Introduction : le « métier d'historien »



Marc Bloch, *Apologie pour l'histoire ou Métier d'historien*, Paris : Armand Colin, 1949.

Introduction : le « métier d'historien »

Proposition pour une « histoire expérimentale [des sciences] » :

porter l'histoire *aussi* en-dehors des salles d'archives

et reproduire/répliquer/reconstituer/reconstruire

les pratiques/objets/expériences trouvées dans les sources

afin d'épaissir *par le travers* notre compréhension du passé

et, en conséquence, du présent

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≠ histoire des sciences expérimentales

≠ reconstitution historique

1. Des archives à la pratique

Chose courante en histoire ancienne et archéologie

En histoire des sciences :

- Années 60-70 : mécanique de Galilée, optique de Newton
- Années 70-80 : chimie/alchimie, pharmacie

Histoire expérimentale « vérificationniste »

1. Des archives à la pratique

H. Otto Sibum

1. Des archives à la pratique

H. Otto Sibum

Reworking the Mechanical Value of Heat: Instruments of Precision and Gestures of Accuracy in Early Victorian England

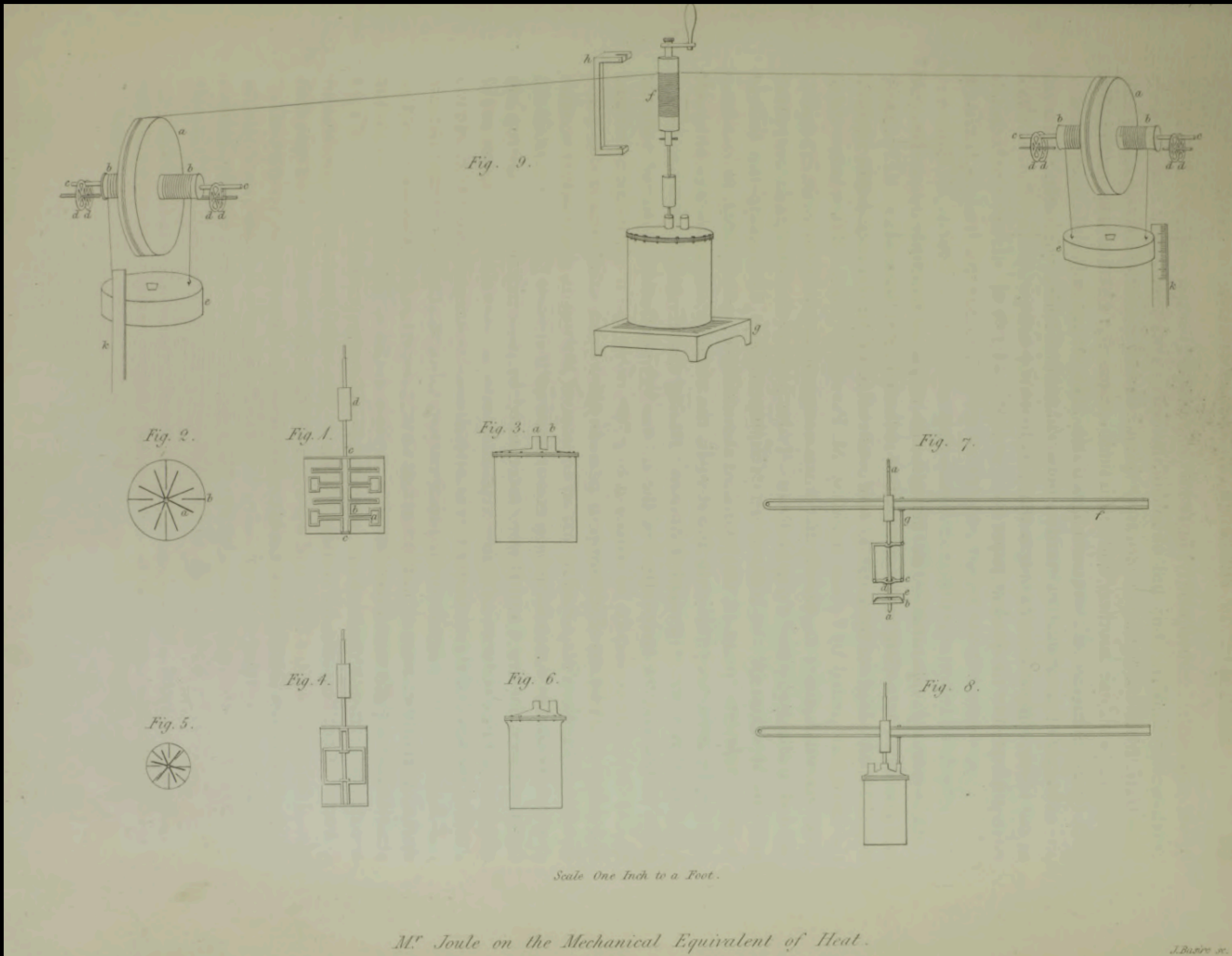
Heinz Otto Sibum*

Stud. Hist. Phil. Sci., Vol. 26, No. 1, pp. 73–106, 1995

Studies in History and Philosophy of Science

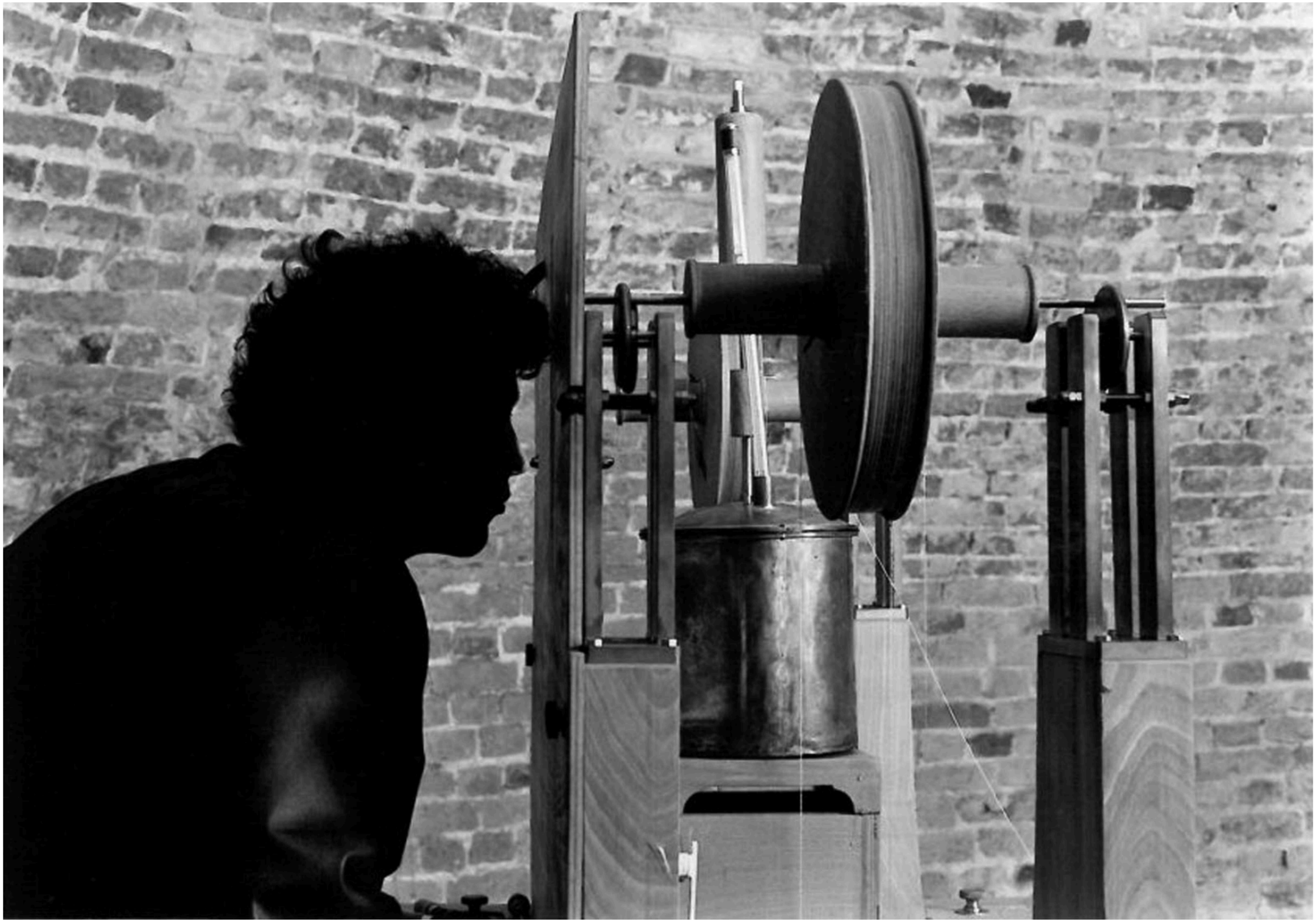
1. Source publiée :
   James Prescott Joule, « On the mechanical equivalent of heat », *Philosophical Transactions of the royal Society of London*, vol. 140, 1850, pp. 61-82.
2. Sources d'archive :
   - Cahiers d'expérience
   - Correspondance
3. Instruments et objets historiques

1. Des archives à la pratique



Joule
1850

1. Des archives à la pratique



1. Des archives à la pratique

SCIENCE MUSEUM GROUP

https://collection.sciencemuseumgroup.org.uk/

1. Des archives à la pratique

- Le **lieu physique** : le cellier
- L'**espace social et culturel** : la brasserie
- Les **sociabilités** : les « techniciens invisibles »
- Le **corps et les gestes** : savoirs tacites, savoir-faire
- Le **contexte politique et économique** : production de masse et standardisation

1. Des archives à la pratique

Pamela H. Smith

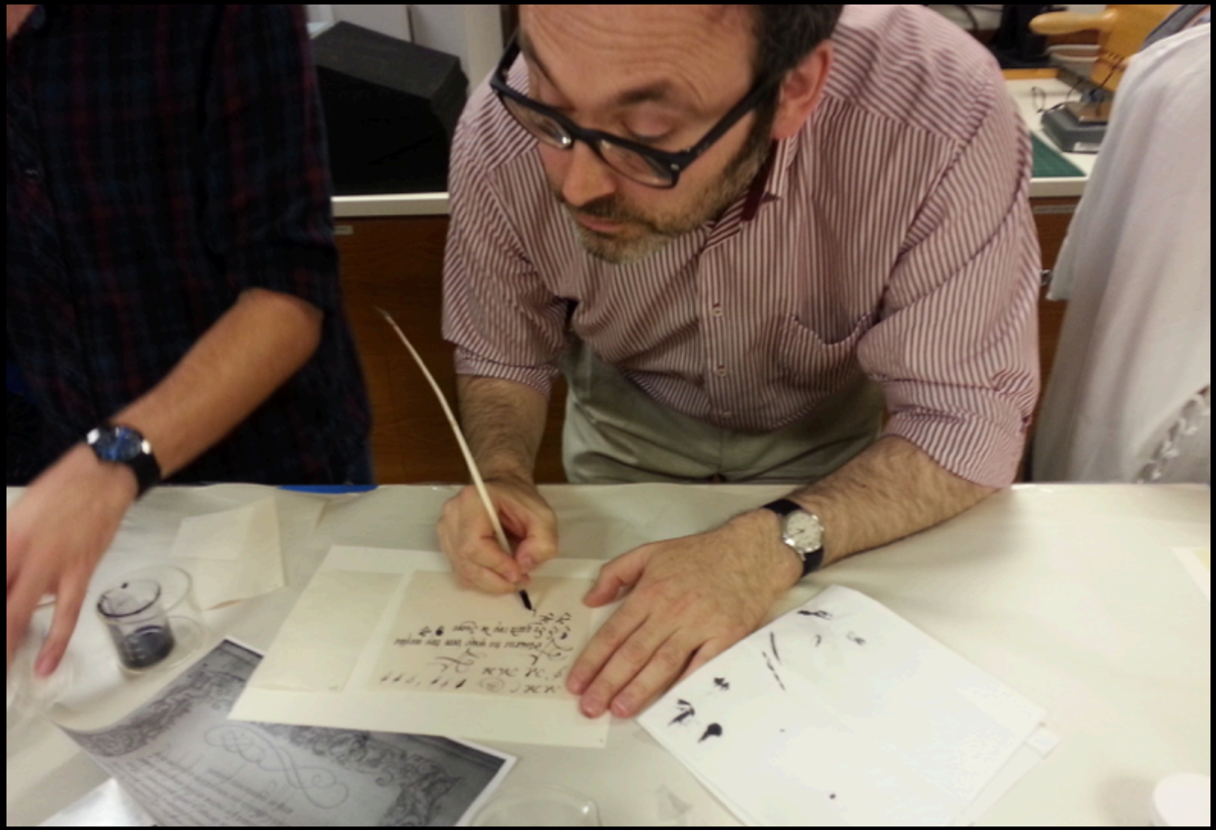
https://makingandknowing.org

1. Des archives à la pratique

BnF Ms. Fr. 640

1. Des archives à la pratique

1. Paléographie, traduction et encodage
2. Séminaires de laboratoire
3. Groupes de travail
4. Développement numérique



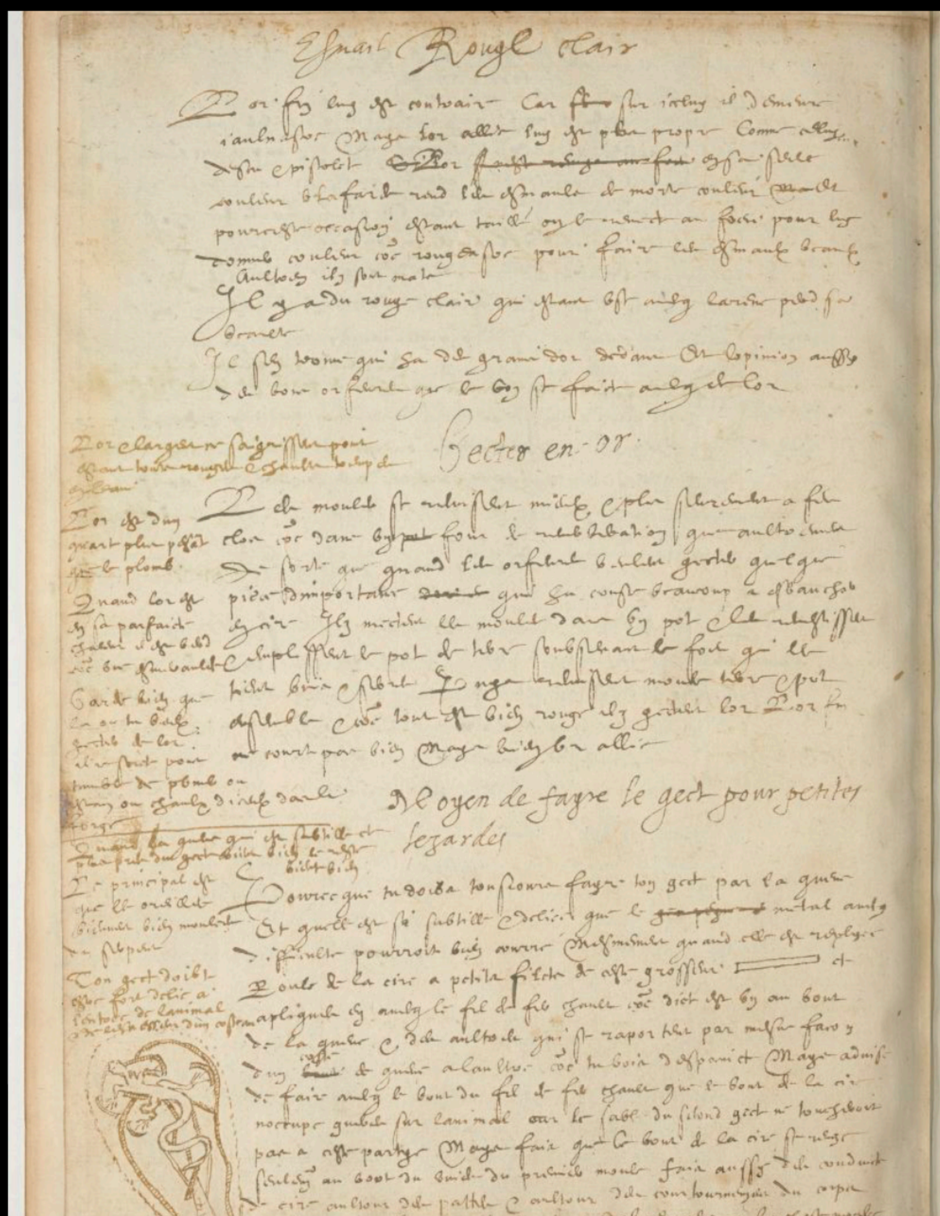
1. Des archives à la pratique

Secrets of Craft and Nature in Renaissance France

A Digital Critical Edition and English Translation of BnF Ms. Fr. 640

Read Fr. 640 | Essays | Resources | About | How to Use | Search the Edition

/ Folios / 124v — Facsimile



/ Folios / 124v — Diplomatic (FR)

Folio 124v

Esmail* **Rouge clair**

Lor fin luy est contraire Car ~~[illegible]~~ sur iceluy il demeure jaulnastre Mays lor allie luy est plus propre Comme celuy descu & pistolet ~~Si~~ Lor ~~f nest remys au foeu~~ en sa seule couleur blafarde rend les esmauls de morte couleur ~~Ma~~ Et pour ceste occasion estant taillé on le remect au foeu pour luy donner couleur co{mm}e rougeastre pour faire les esmaulx beaulx

Autrem{ent} ils sont mats

Il y a du rouge clair qui estant use avecq larene perd sa beaulte

Il sen trouve qui ha des grains dor dedans Et lopinion aussy des bons orfevres que le bon se faict avecq de lor

Lor & largent ne saigrissent point estant touts rouges et chaults trempes en leau

Lor est dun quart plus pesa{n}t que le plomb

Quand lor est en sa parfaicte

Gecter en or

Les moules se recuisent mieulx & plus seurement a feu clos co{mm}e dans un ~~pot~~ four de reverberation que aultrement De sorte que quand les orfevres veulent gecter quelque

2. Enseigner l’histoire expérimentale

- HUM-402: Experimental History of Science, I

  1e semestre : cours / ateliers

- HUM-466: Experimental History of Science, II

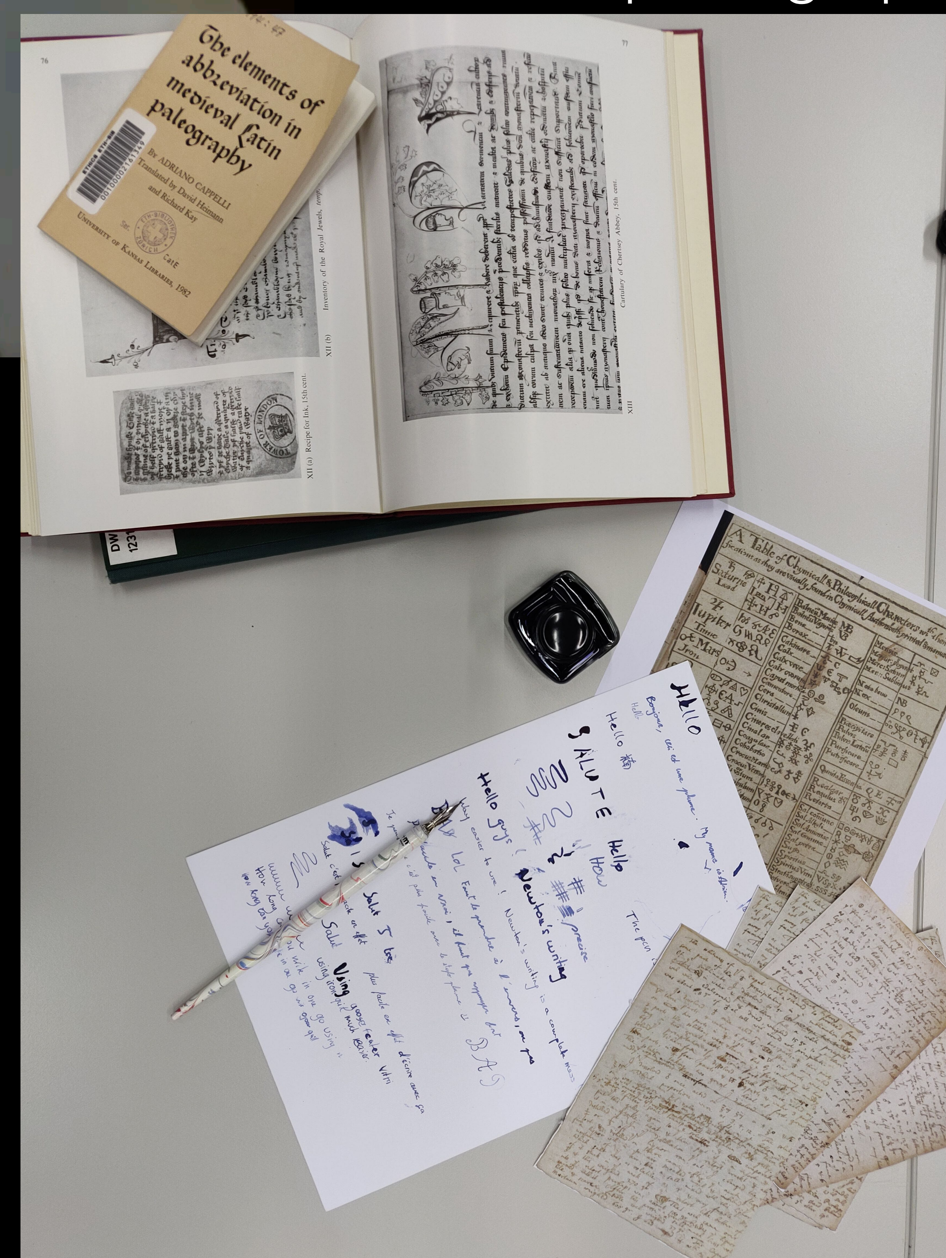
  2nd semestre : projets en groupes et en autonomie

Mot d’ordre = « *Learning by Doing* »

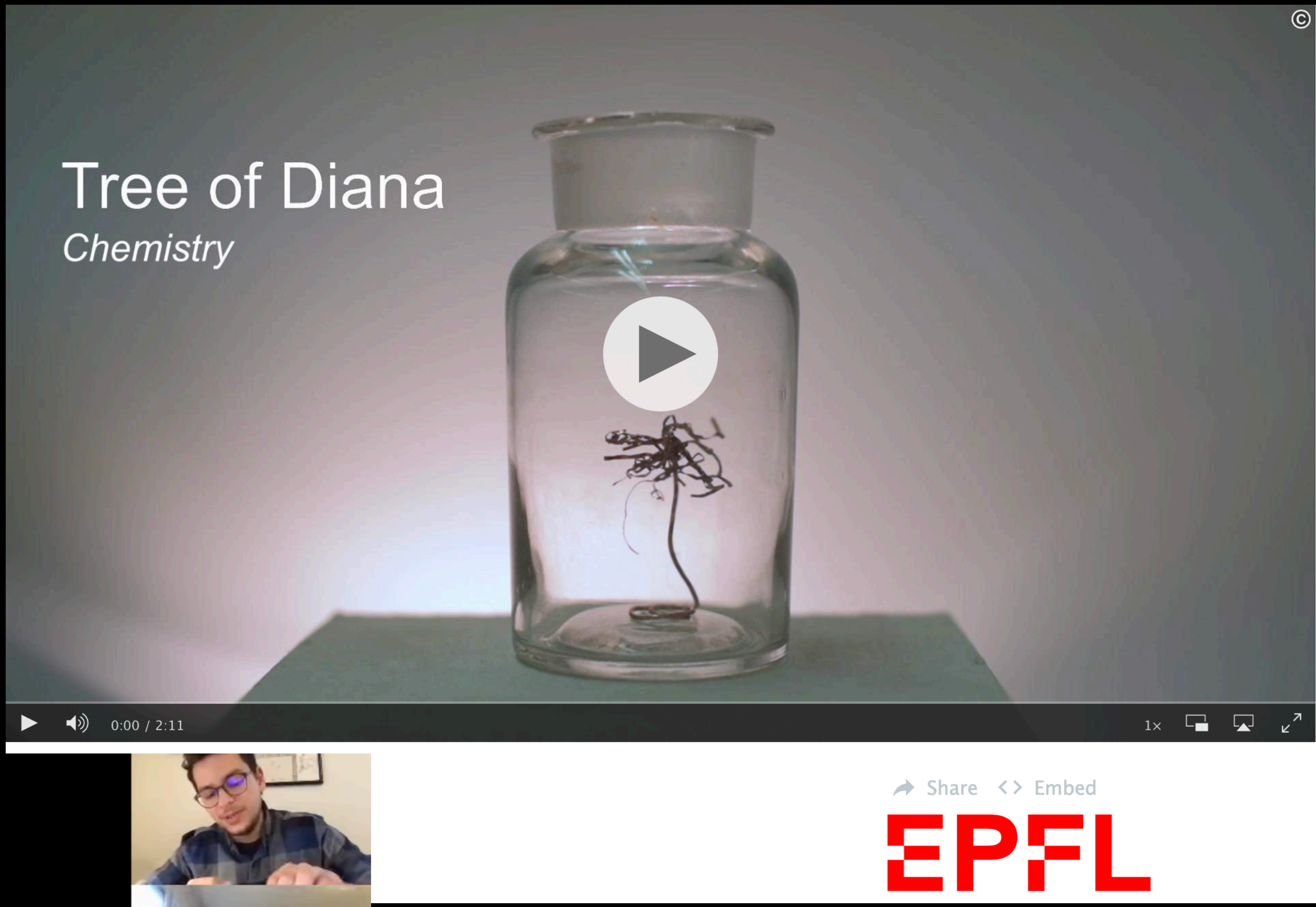
2. Enseigner l'histoire expérimentale

Visite aux archives de la SVSN

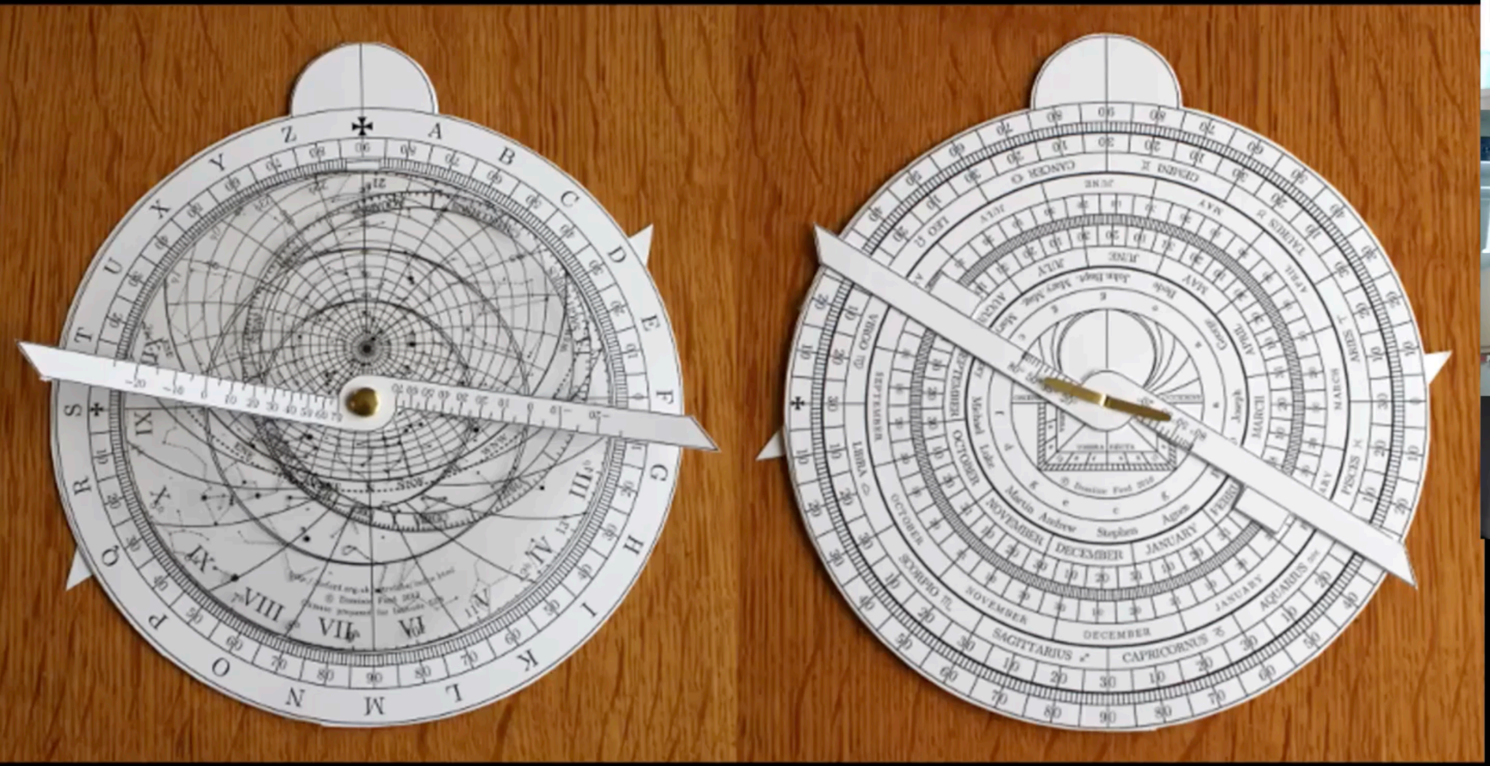
Atelier paléographie



2. Enseigner l'histoire expérimentale



Vidéos d'alchimie



Confection d'astrolabes de papier

2. Enseigner l'histoire expérimentale

Projets du second semestre :

- Horloges astronomiques
- Camera obscura
- Bouteilles de Leyde

2. Enseigner l'histoire expérimentale

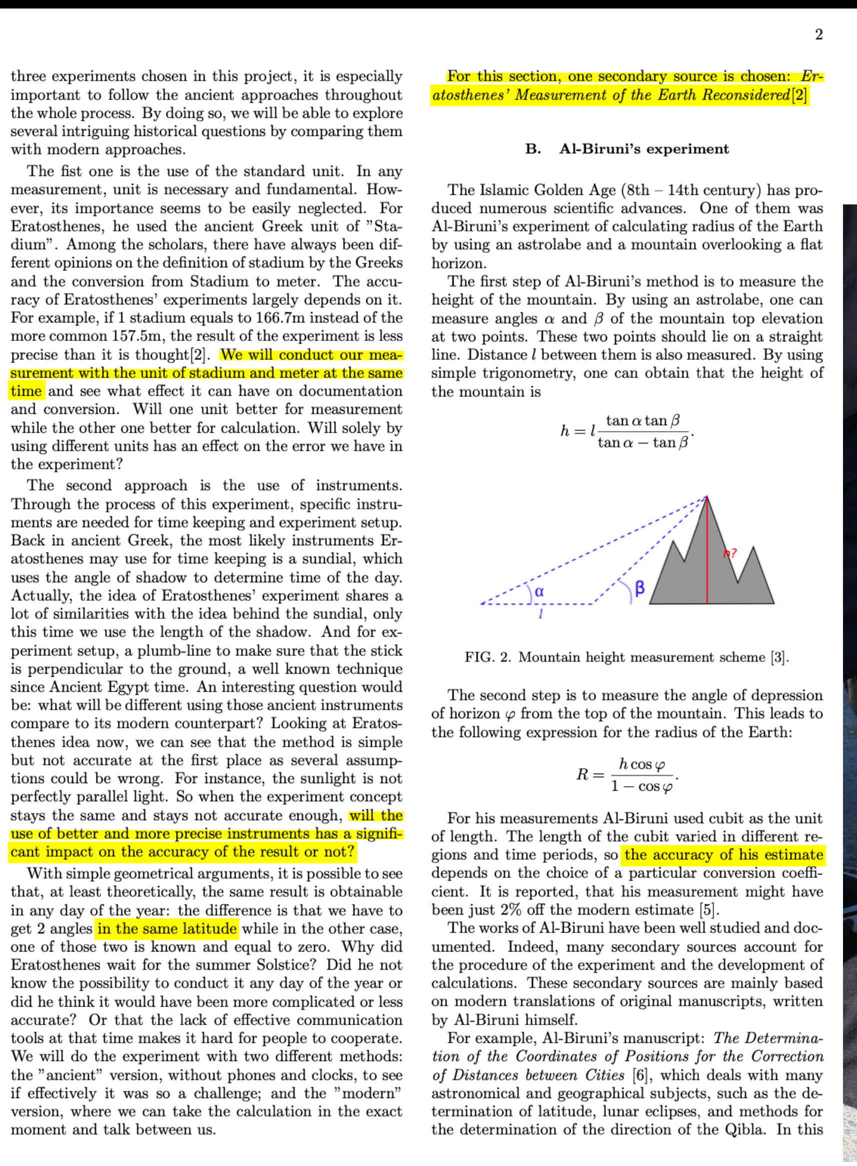
- Parfums de Jules César et Henry VIII

Coline Boulanger, Delphine Clauss, Maxence Coudurier, Yosua Hanria, Gianluca Quargnali, Sylvain Roch

2. Enseigner l’histoire expérimentale

- Géodésie : mesure du rayon de la Terre

Nikola Bebic, Mengbo Kang, Ferdinand Posva,
Giacomo Rubino, Fedor Sergeev



three experiments chosen in this project, it is especially important to follow the ancient approaches throughout the whole process. By doing so, we will be able to explore several intriguing historical questions by comparing them with modern approaches.

The fist one is the use of the standard unit. In any measurement, unit is necessary and fundamental. However, its importance seems to be easily neglected. For Eratosthenes, he used the ancient Greek unit of ”Stadium”. Among the scholars, there have always been different opinions on the definition of stadium by the Greeks and the conversion from Stadium to meter. The accuracy of Eratosthenes’ experiments largely depends on it. For example, if 1 stadium equals to 166.7m instead of the more common 157.5m, the result of the experiment is less precise than it is thought[2]. We will conduct our measurement with the unit of stadium and meter at the same time and see what effect it can have on documentation and conversion. Will one unit better for measurement while the other one better for calculation. Will solely by using different units has an effect on the error we have in the experiment?

The second approach is the use of instruments. Through the process of this experiment, specific instruments are needed for time keeping and experiment setup. Back in ancient Greek, the most likely instruments Eratosthenes may use for time keeping is a sundial, which uses the angle of shadow to determine time of the day. Actually, the idea of Eratosthenes’ experiment shares a lot of similarities with the idea behind the sundial, only this time we use the length of the shadow. And for experiment setup, a plumb-line to make sure that the stick is perpendicular to the ground, a well known technique since Ancient Egypt time. An interesting question would be: what will be different using those ancient instruments compare to its modern counterpart? Looking at Eratosthenes idea now, we can see that the method is simple but not accurate at the first place as several assumptions could be wrong. For instance, the sunlight is not perfectly parallel light. So when the experiment concept stays the same and stays not accurate enough, will the use of better and more precise instruments has a significant impact on the accuracy of the result or not?

With simple geometrical arguments, it is possible to see that, at least theoretically, the same result is obtainable in any day of the year: the difference is that we have to get 2 angles in the same latitude while in the other case, one of those two is known and equal to zero. Why did Eratosthenes wait for the summer Solstice? Did he not know the possibility to conduct it any day of the year or did he think it would have been more complicated or less accurate? Or that the lack of effective communication tools at that time makes it hard for people to cooperate. We will do the experiment with two different methods: the ”ancient” version, without phones and clocks, to see if effectively it was so a challenge; and the ”modern” version, where we can take the calculation in the exact moment and talk between us.

For this section, one secondary source is chosen: *Eratosthenes’ Measurement of the Earth Reconsidered*[2]

B. Al-Biruni’s experiment

The Islamic Golden Age (8th – 14th century) has produced numerous scientific advances. One of them was Al-Biruni’s experiment of calculating radius of the Earth by using an astrolabe and a mountain overlooking a flat horizon.

The first step of Al-Biruni’s method is to measure the height of the mountain. By using an astrolabe, one can measure angles α and β of the mountain top elevation at two points. These two points should lie on a straight line. Distance l between them is also measured. By using simple trigonometry, one can obtain that the height of the mountain is

$$h = l\frac{\tan\alpha\tan\beta}{\tan\alpha - \tan\beta}.$$

FIG. 2. Mountain height measurement scheme [3].

The second step is to measure the angle of depression of horizon φ from the top of the mountain. This leads to the following expression for the radius of the Earth:

$$R = \frac{h\cos\varphi}{1-\cos\varphi}.$$

For his measurements Al-Biruni used cubit as the unit of length. The length of the cubit varied in different regions and time periods, so the accuracy of his estimate depends on the choice of a particular conversion coefficient. It is reported, that his measurement might have been just 2% off the modern estimate [5].

The works of Al-Biruni have been well studied and documented. Indeed, many secondary sources account for the procedure of the experiment and the development of calculations. These secondary sources are mainly based on modern translations of original manuscripts, written by Al-Biruni himself.

For example, Al-Biruni’s manuscript: *The Determination of the Coordinates of Positions for the Correction of Distances between Cities* [6], which deals with many astronomical and geographical subjects, such as the determination of latitude, lunar eclipses, and methods for the determination of the direction of the Qibla. In this

2. Enseigner l'histoire expérimentale

- Géodésie : mesure du rayon de la Terre

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Visite virtuelle de la Collection d'instruments scientifiques UNIL-EPFL

2 POIDS & MESURES / 2.2 MESURE DES ANGLES, DES LONGUEURS, DES DISTANCES ET DES ÉLÉVATIONS

Inclinomètre (quadrant)

Inclinomètre (quadrant) portatif à usage principalement astronomique.

Mesure des angles d'élévation de –15° à +100°, lecture par vernier avec 30 divisions entre 0 et 60, donc avec une précision maximum de 2 minutes d'arc.

https://collection-lhst.epfl.ch

2. Enseigner l’histoire expérimentale

- Géodésie : mesure du rayon de la Terre

Nikola Bebic, Mengbo Kang, Ferdinand Posva,
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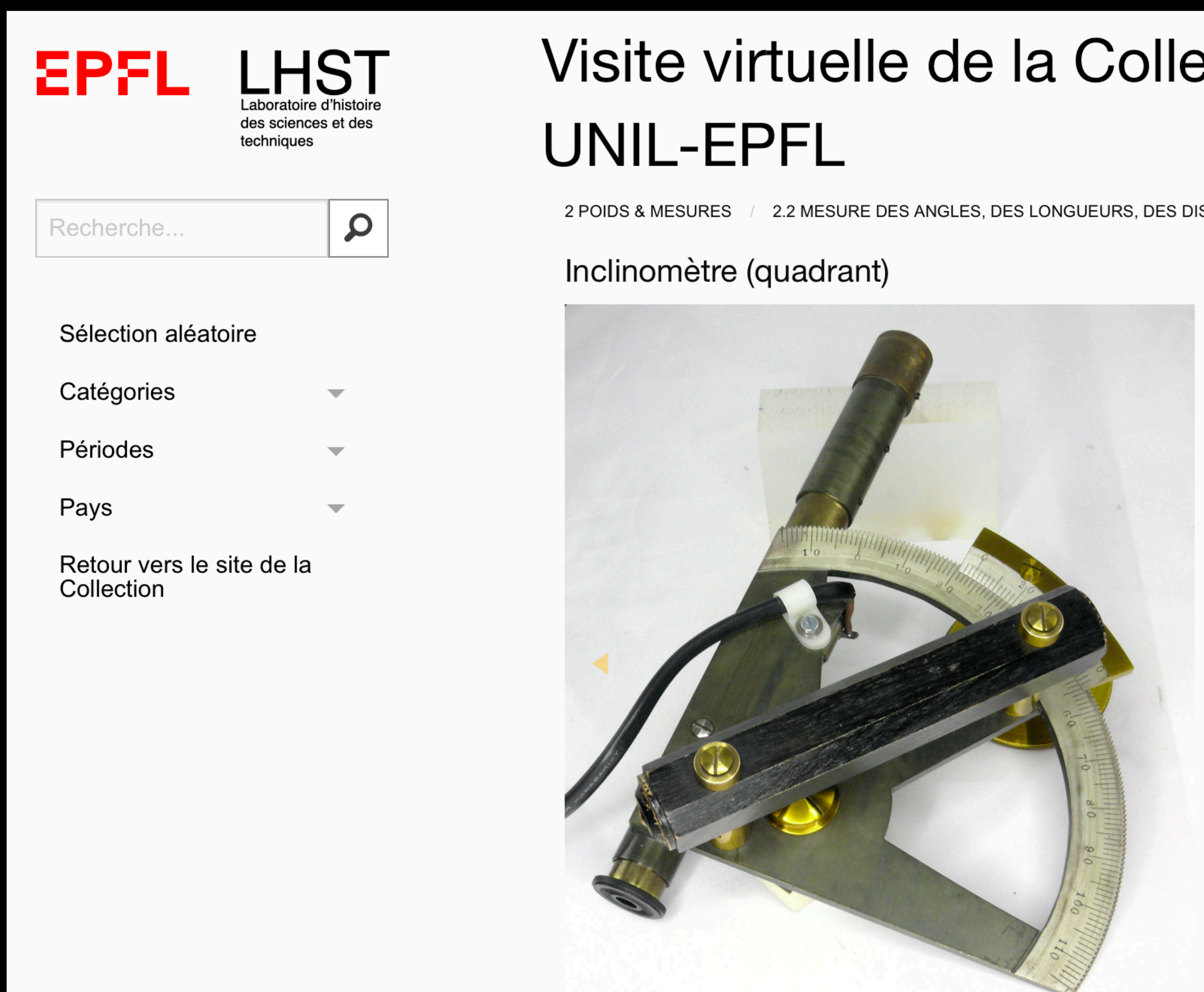


2. Enseigner l’histoire expérimentale

- Étudiant·e·s sensibles à la matérialité des sciences (passées et présentes)
- Aspect pratique et expérimental…
- …propice à la formulation de questionnements historiques sur leur propre pratique

3. Vers une histoire de plein vent ?

Géographes de cabinet

v.

« Géographes de plein vent »

Lucien Fèbvre

3. Vers une histoire de plein vent ?

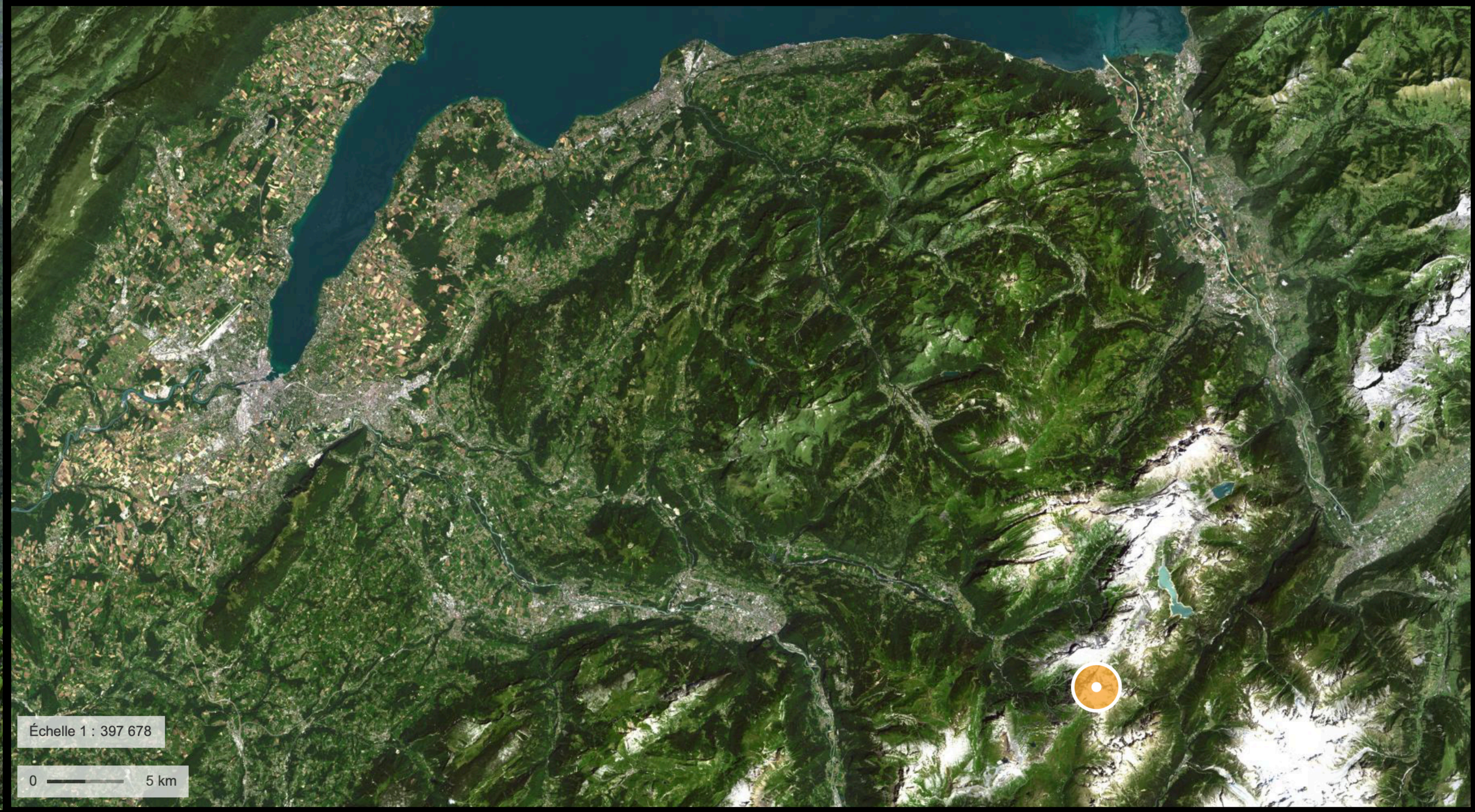
Géographe de cabinet v. « Géographe de plein vent »

Georges Cuvier (1769-1832)

Alexander von Humboldt (1769-1859)

3. Vers une histoire de plein vent ?

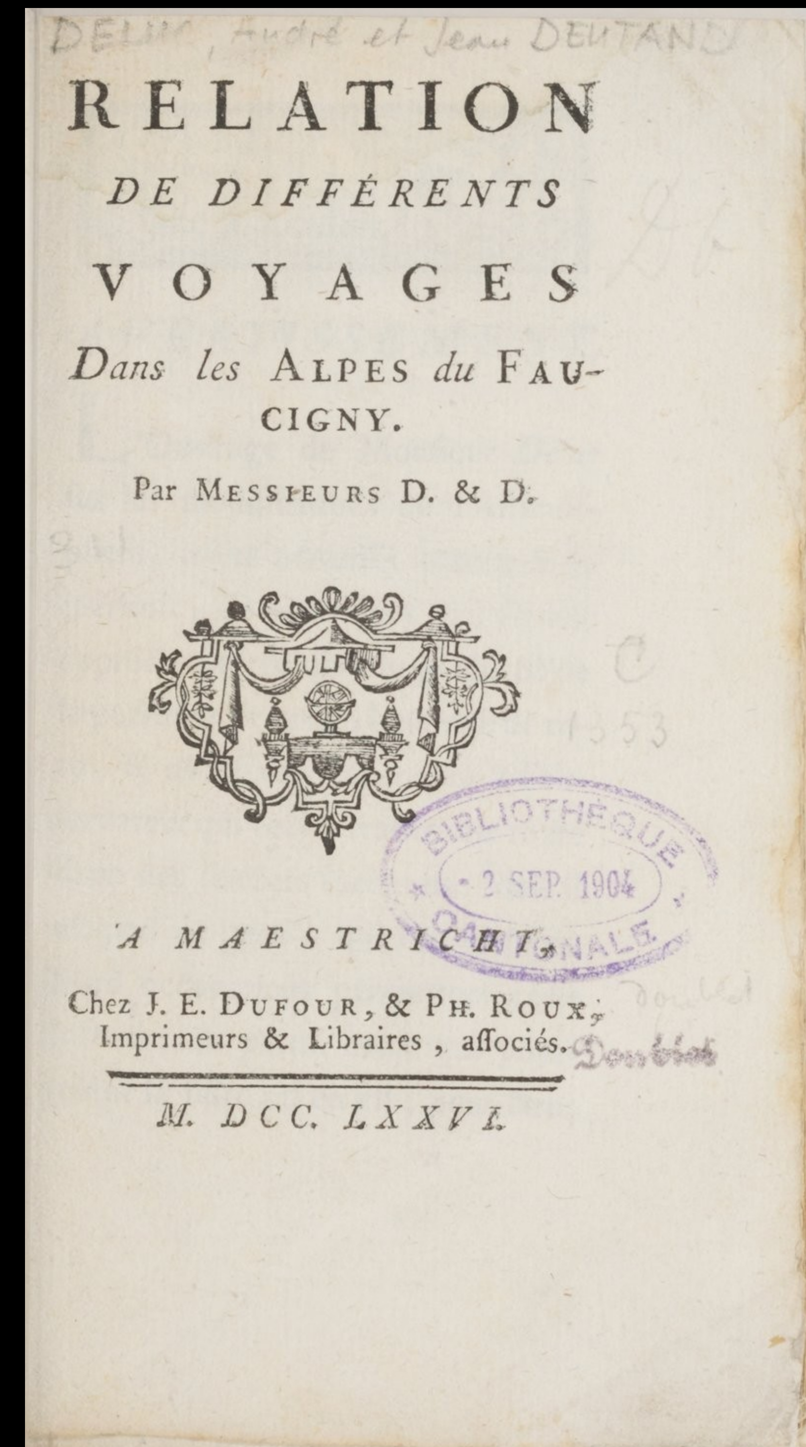
Mont Buet, 3098m



3. Vers une histoire de plein vent ?

Jean André Deluc
(1727, Genève – 1817, Windsor)

Première ascension du Mont Buet
le 20 Septembre 1770



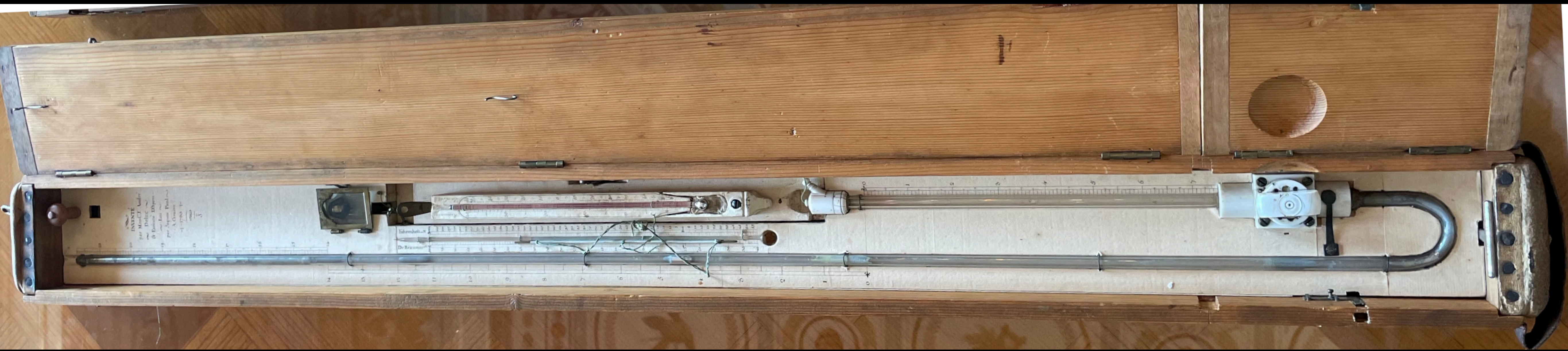
RELATION
DE DIFFÉRENTS
VOYAGES
Dans les ALPES du FAUCIGNY.

Par MESSIEURS D. & D.

A MAESTRICHT,
Chez J. E. DUFOUR, & PH. ROUX,
Imprimeurs & Libraires, associés.

M. DCC. LXXVI.

3. Vers une histoire de plein vent ?



« Celui qui veut être exact dans ses descriptions, quitte souvent le cabinet pour rentrer dans l'attélier. »

(Deluc 1772, §459)

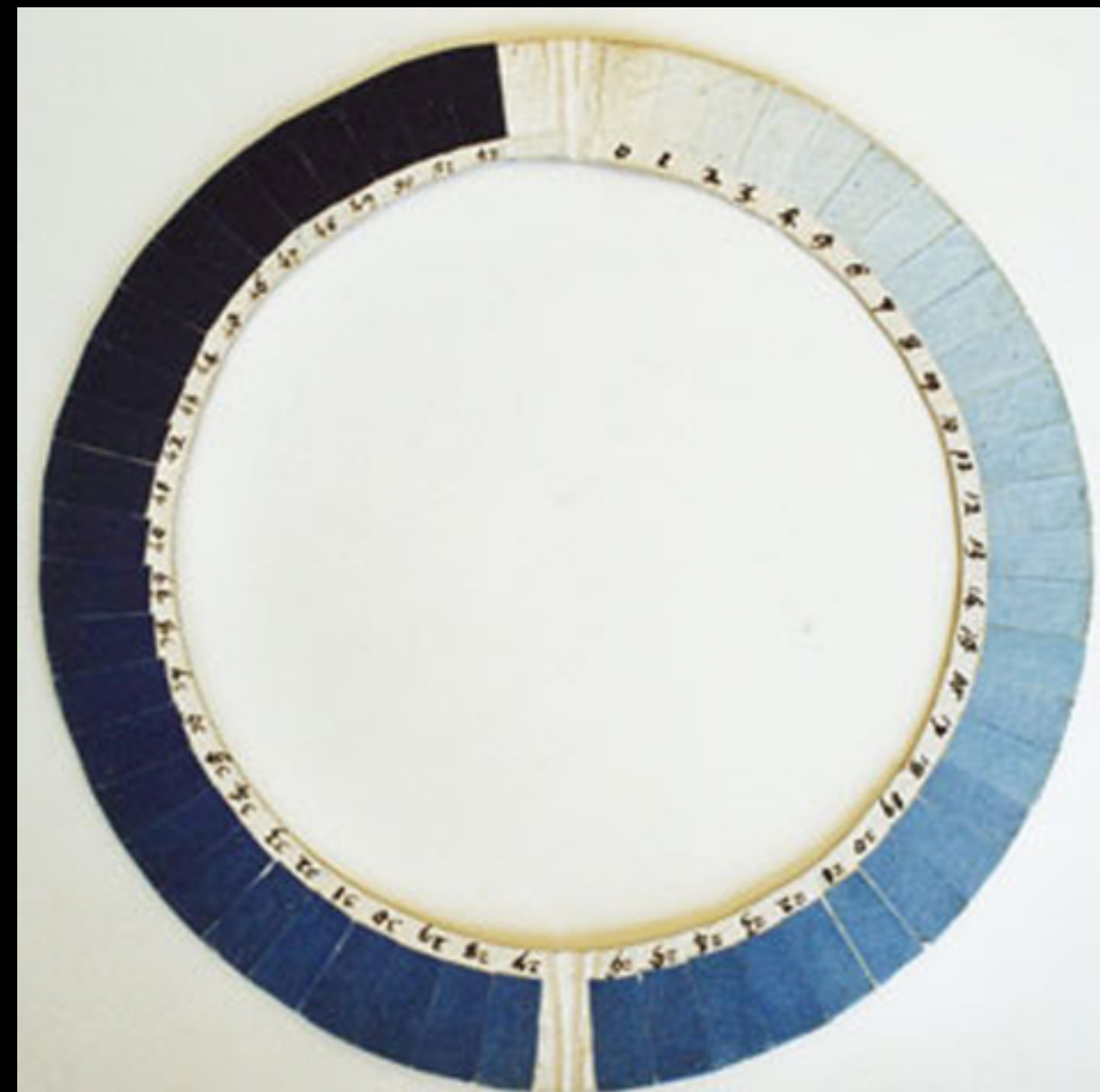
3. Vers une histoire de plein vent ?

Marc-Théodore Bourrit
(1739 – 1819)

Archives d'État de Genève,
Fonds Bourrit,
Archives privées 490.11

3. Vers une histoire de plein vent ?

Horace Bénédict de Saussure
(1740 – 1799)



Cyanomètre de Saussure

3. Vers une histoire de plein vent ?

Vue circulaire depuis le sommet du Buet

Dessinée par Bourrit

Gravée et publiée dans les *Voyages dans les Alpes* de Saussure

3. Vers une histoire de plein vent ?

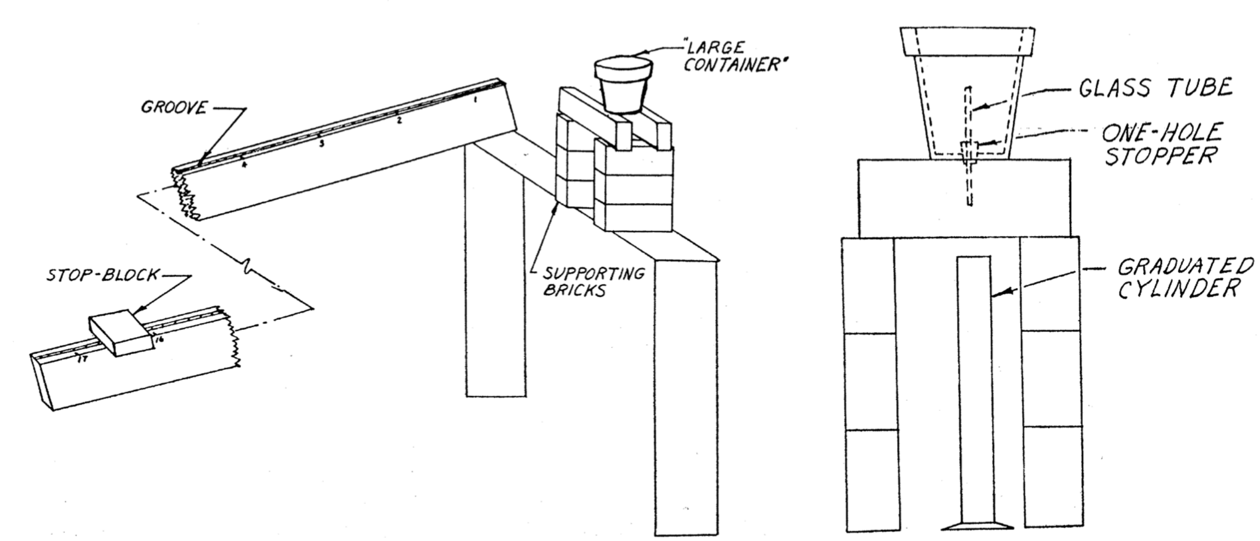
Une *histoire de plein vent* au croisement de l'histoire des sciences, de l'histoire environnementale, de l'histoire de l'art :

- Reproduire l'ascension
- Répliquer l'instrumentation
- Rejouer les sociabilités et le partage des compétences
- Retrouver une communication publique

Conclusion

Merci de votre attention !

1. Des archives à la pratique



(Left) General layout of the experimental apparatus. (Right) The timing apparatus.

Thomas B. Settle, « An Experiment in the History of Science », *Science*, vol. 133, no. 3445, 1961, pp. 19-23.

strike of the ball without anticipation or delay.

First, we must remember that the operator is an integral part of the apparatus. He must spend time getting the feel of the equipment, the rhythm of the experiment. He must consciously train his reactions. And each day, or at the end of each break, he must be allowed a few practice runs to get warmed up. Galileo accomplished all this by repeating the experiment "many, many times."

Table 1. Sample of experimental results and calculations which confirm Eq. 2.

Distance	Time (ml of water) (Exp.)	(Av.)	(Cal.)
15	88	90+	90+
	91		
	91		
	90		
	90		
	90		
	90		
	90		
	90		
	89		
	90		
13	84	84	84
	84	base	
	84		
	84		
	84		
	84		
	84		
10	72	72+	74−
	73		
	72		
	72		
	72		
	72		
7	62	62−	62−
	61		
	62		
	61		
	62		
	62		
	62		
5	53	52	52+
	53		
	53		
	53		
	53		
	52		
	53		
	51		
	51		
	52		
	53		
	51		
3	40	40	40+
	40		
	40		
	41		
	39		
	41		
	40		
1	26		
	17		
	25		
	24		
	23		
	25		
	23	23.5	23+
	24		
	23		
	23		
	24		
	24		
	24		
	23		
	23		

Then we must remember that this is not a water clock; it is what it is and no more—a container for water with a pipe of small diameter in its bottom and with no dials, falling weights, or gear trains. All we are interested in, we find, is maintenance of a constant flow in the pipe for a maximum of 8 seconds. How can we test this? Galileo mentions a "pulse beat." Is it possible that he checked his own flow rate against a beating pendulum, a *pulsilogia?* On this hunch I made a simple pendulum out of a piece of thin wire and the billiard ball. Since a 1-meter pendulum has a beat of about 1 second, I made this pendulum somewhat less than a meter long so that it would beat at about pulse rate. By watching the shadow of the bob against vertically lined paper I could accurately lift and reset my finger in the timer at the end of a beat. I found, after collecting water at intervals of 2, 4, 6, 8, and 10 beats, that the flow was indeed constant within the limits of precision discussed below (*9*).

As a matter of interest, using the second-hand on my watch and timing for 5- and 10-second intervals, I made a rough determination of the rate of flow and found it to be 19.5 milliliters per second. It followed that, if I could measure a definite interval to within 2 milliliters, my apparatus would be precise to almost 1/10 second. In fact, it was very common to get sets of points well within this limit, to 1 milliliter or about 1/20 second. Is this better than Galileo could have done? My flowerpot was probably smaller than his "large vessel," giving me a greater fall of head for each reading. If my flow was "constant," his certainly was. Then the only thing in doubt is the "weighing." From Agricola we learn that early 16th century assayers could weigh with precision to the equivalent of 0.2 grams (*10*). My cylinder was graduated to 2 milliliters, and I read to 1 milliliter—a measurement five times as crude as the one that Galileo could have commanded.

We note further that Galileo, though presenting his results as valid for all slopes, only claimed to have successfully tested relatively shallow ones.

Table 2. Experimental data obtained with the billiard ball for the bases of three slopes, and times computed from one of the other slopes. *L*, slope length; *a*, vertical height; *T*, time.

Slope	Experimental data L	*a*	T	Calculated data T
a	12	2.92	117	118− (from b)
b	13	6.25	84	85− (from c)
c	9	11.47	52	51+ (from a)

Whether this was the result of experimental insight alone or of poor results obtained at steeper inclinations we do not know. But the reasons are obvious. The theoretical results are only valid if there is no slippage between the ball and the plane and since the errors in the time readings are fixed, the accuracy decreases with the shorter intervals. So I followed Galileo's example, nor did I think it particularly worthwhile to try to find a maximum practicable slope.

Experimental Results

As I have intimated, all this turned out quite well. Table 1 gives a representative sample of some experimental results and calculations which confirm Eq. 1 above. This particular run involved the billiard ball on a slope;

$$a/c = 6.25/(8\times12) \text{ inches},$$

or about 3°44′. The distances are given in Table 1, column 1.

Column 2 gives, for each distance, the several observed times in milliliters of water. In this case all except the last set were recorded one evening, this last being recorded the following morning. Here we see the process of warming up; only after the first six readings did I begin to take the results seriously.

Column 3 merely gives the sight-averages of the good readings of column 2. They serve as specific times for the distances where these are needed in further calculations or comparisons.

Column 4 shows calculated times. Whereas Galileo struggled simultaneously with two unknowns, the validity of the laws and the worth of the equipment, I was really using known and accepted laws to determine the latter. As a result I have chosen to focus on the most ticklish part of the

1. Des archives à la pratique

ALCHEMY REVISITED

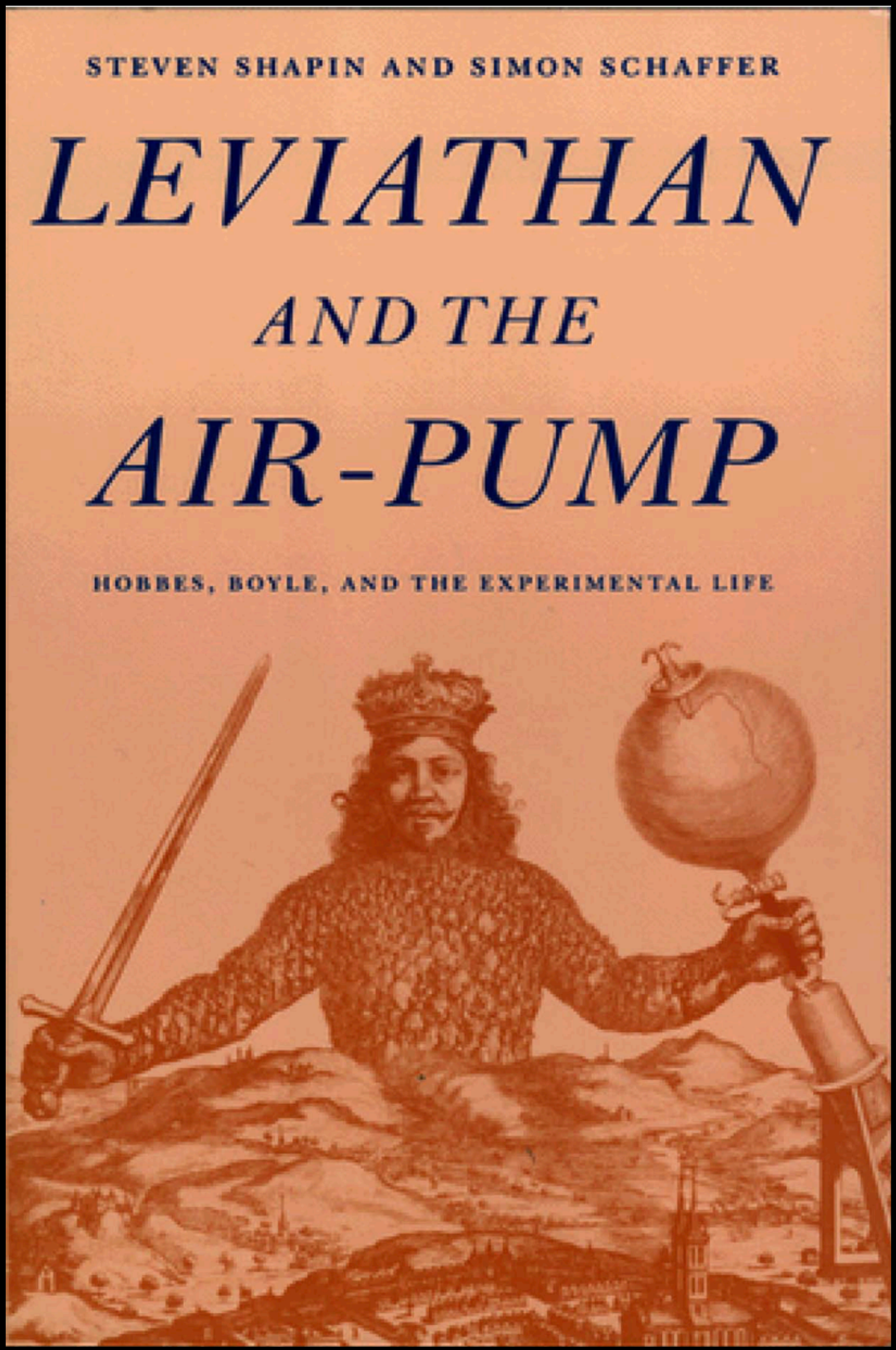
PROCEEDINGS OF THE INTERNATIONAL CONFERENCE
ON THE HISTORY OF ALCHEMY
AT THE UNIVERSITY OF GRONINGEN
17-19 APRIL 1989

EDITED BY

Z.R.W.M. von MARTELS

Lawrence M. Principe, « The Gold Process: Directions in the Study of Robert Boyle's Alchemy », *in* Z.R.W.M. von Martels (dir.), *Alchemy Revisited*, Leiden : Brill, 1989, pp. 200-205.

1. Des archives à la pratique



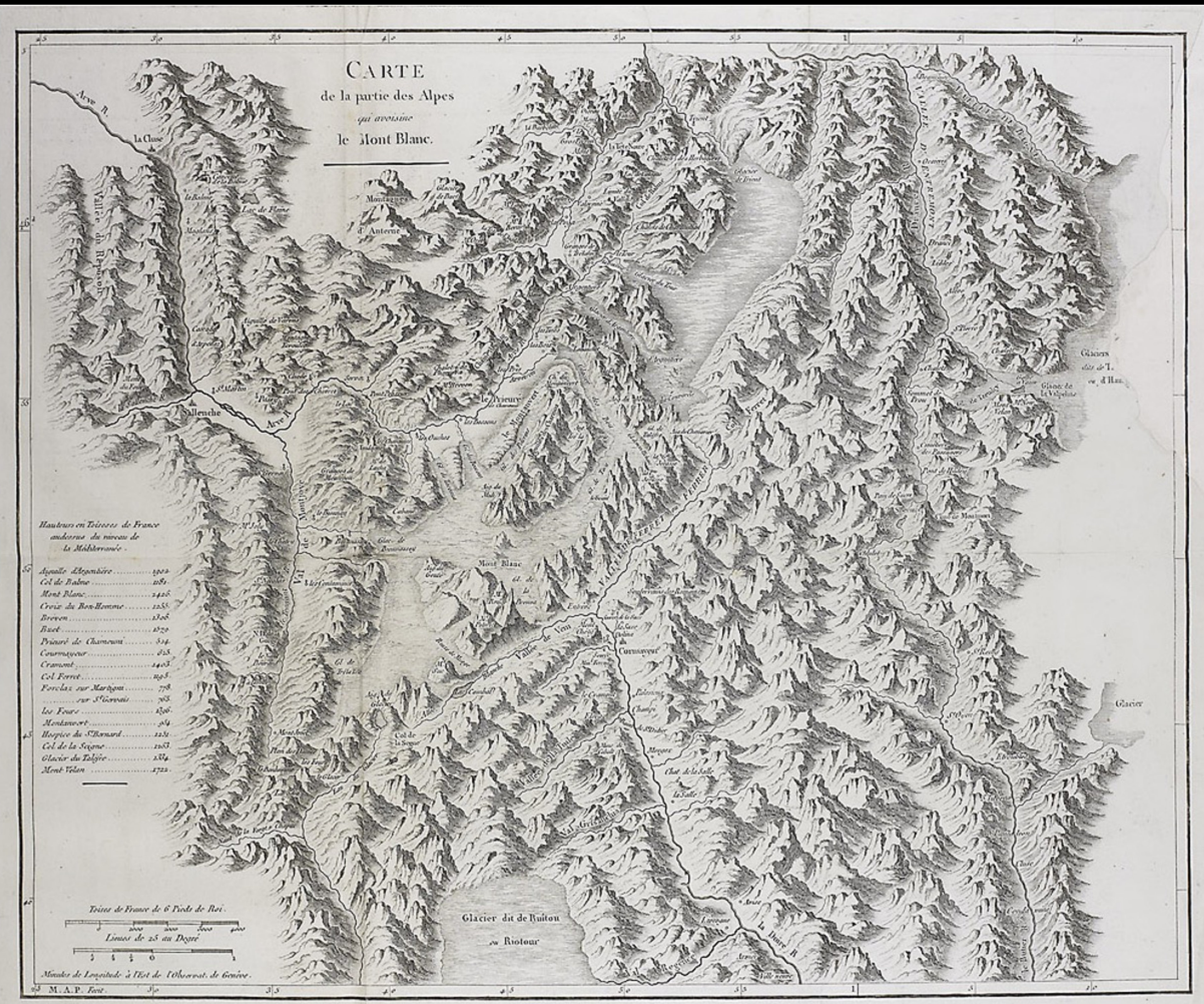
Steven Shapin et Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton : Princeton University Press, 1985.

3. Vers une histoire de plein vent ?

Borgonio, 1683

Borgonio, 1772

3. Vers une histoire de plein vent ?



Carte de
Marc-Auguste
Pictet