



2022 CER Lunchtime Lectures - Humboldt, Science, and The Geography of Nature

Western Culture and the Study of Nature

January – Natural Philosophy and the Study of Nature

February – Natural History and the Taxonomy of Nature

March – Ecological Imperialism and the Geography of Nature

April – Physical Geography and the Science of Nature

Humboldt and the Science of Nature

May – The Science of Nature: Humboldt and the Empirical Earth

June – The Romance of Nature: Science, Imagination, and the Poets of Nature

July – The Invention of Modern Nature: The Earth as a “Natural Whole”

August – The Evolution of Nature: Humboldt, Darwin, and Biogeography

September – The Economy of Nature: Ecology, Culture, and Cosmos

Humboldt and the Geography of Nature

October – The Great Disruptors: Physical Geography as Modified by Human Action

November – The Earth Managers: New Science and Environmental Change

December – The Anthropocene: Gaia and the Geography of Nature





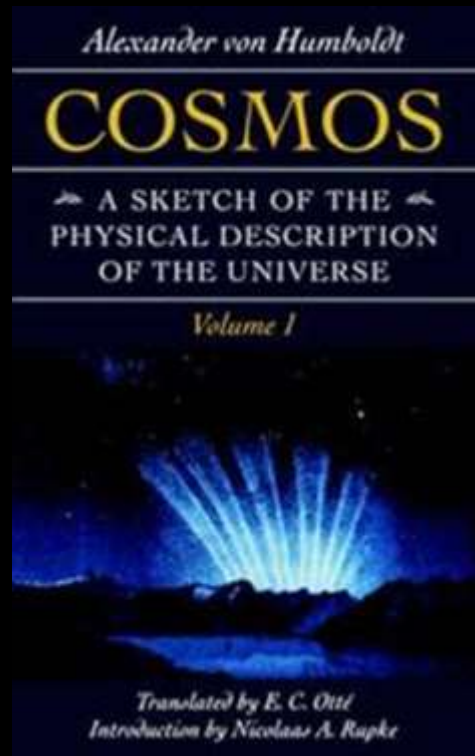
**Center for
Environmental
Research** at Hornsby Bend



The Science of Nature: Humboldt and the Empirical Earth

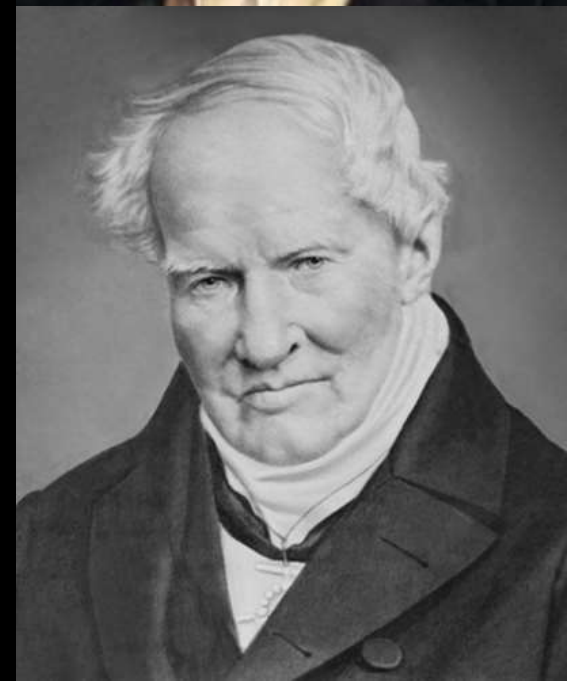
Kevin M. Anderson, Ph.D.

Austin Water Center for Environmental Research





Alexander von Humboldt
1769-1859

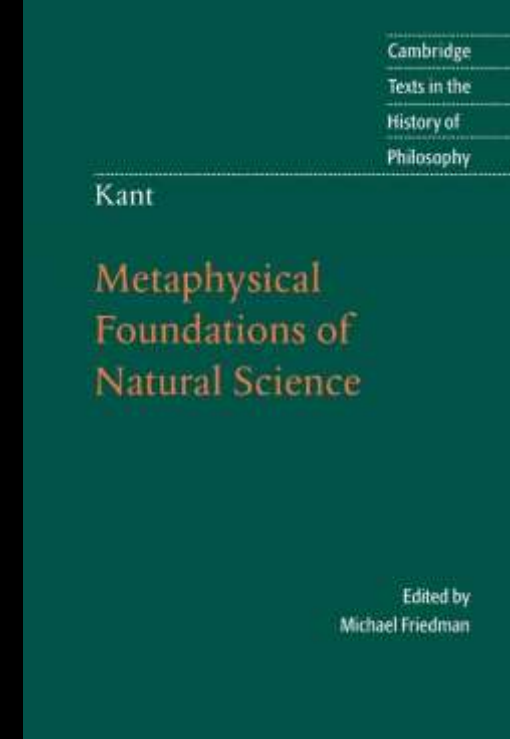


Description and the Science of Nature

Natural History – purely descriptive “Earth sciences”

- Biology
- Botany
- Mineralogy
- Geognosy (Geology)
- Physical Geography

“History” with no history - no temporal explanation



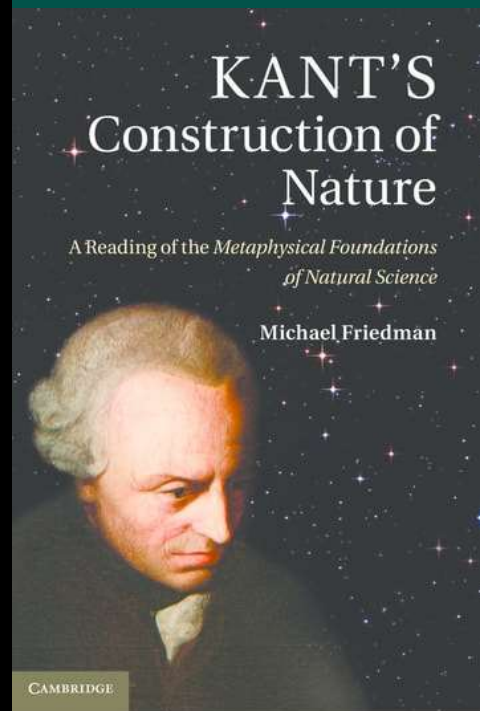
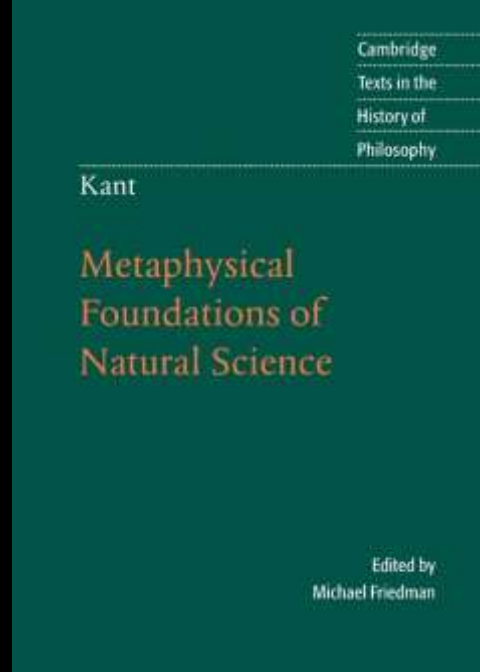
Explanation and the Science of Nature

Natural Philosophy – The Explanative Science

- The causal science
- Temporal explanation – Earth history

Earth Physics (Earth science)

- The Earth is an interconnected whole
- The richness and complexity of natural phenomena
- Integrative and unifying processes that were not directly visible.
- A full description of phenomena as they actually occurred and coexisted in the world.
- “Regularities amongst the phenomena of the descriptive Earth sciences with a view to determine their causes”
- Time/History – origins of valleys
- The Earth must have a history (either biblical or not) and so a theory of the Earth about origins and development is needed to explain the present



The Science of Nature - Newton

Reconciling Mathematics and Natural Philosophy

- “This momentous occurrence broadened the previous all-too-narrow scope of the ancient and medieval exact sciences which now, by virtue of natural philosophy, would seek physical causes for all sorts of natural phenomena, rather than being confined to mere calculation and quantification...” Grant (2007)
- Philosophers - But what is the epistemological and ontological status of mathematical ideas?
- Rational or Empirical?

A HISTORY OF NATURAL PHILOSOPHY

*From the Ancient World to
the Nineteenth Century*



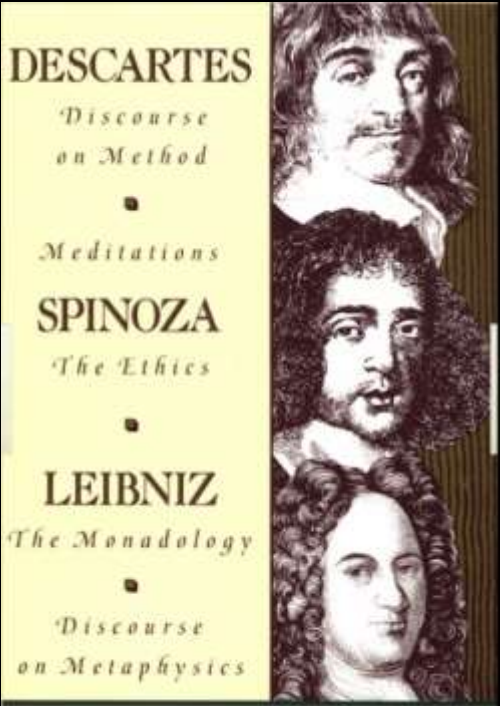
EDWARD GRANT

CAMBRIDGE

Rationalism

- Innate knowledge
- Knowledge is based on reason and logic
- Mathematics and logic is the paradigm of knowledge
- Genuine knowledge is certain
- Experience (sense perception) does not produce certainty

1596-1650



1632-1677

1646-1715

THE RATIONALISTS

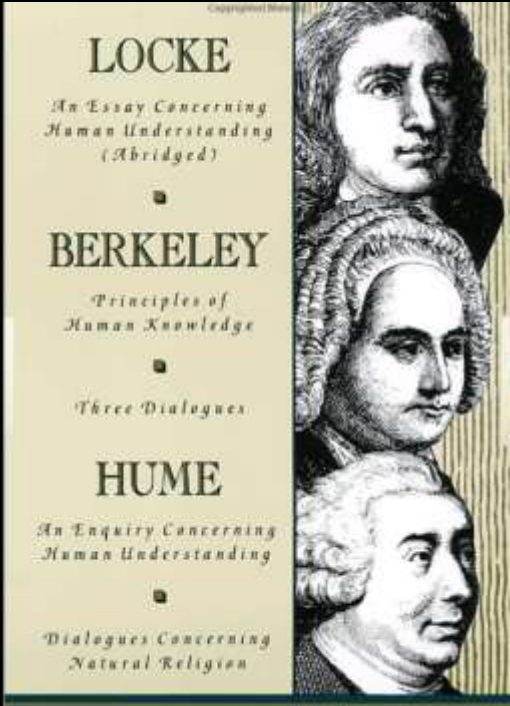
Empiricism

- No innate knowledge (tabula rasa)
- Knowledge is based on experience and experimentation
- Experimental science is the paradigm of knowledge
- Experience and experiment rarely, if ever, produce certainty
- Problem of mathematics and certainty

1632-1704

1685-1753

1711-1776



THE EMPIRICISTS

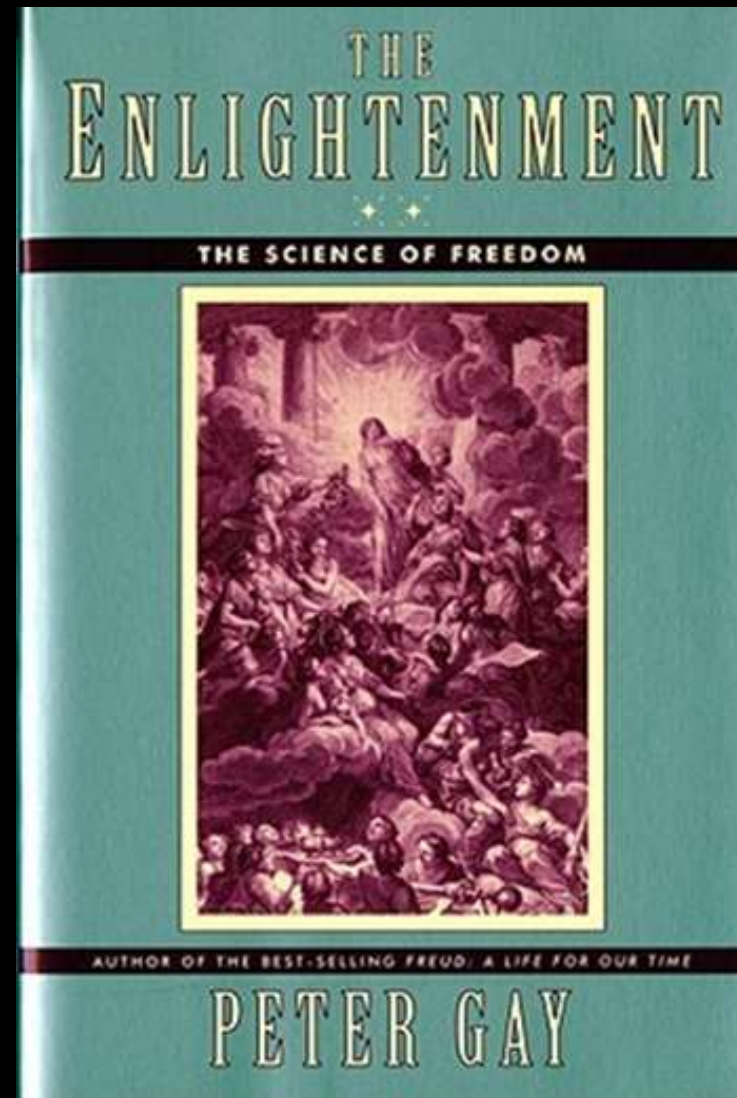
The Enlightenment and the Republic of Letters

1637-1799



The Age of Enlightenment – The Science of Freedom 1637-1799

- Descartes' 1637 philosophy of *Cogito, ergo sum* ("I think, therefore I Am")
- The sovereignty of reason and the evidence of the senses as the primary sources of knowledge
- Ideals such as liberty, progress, toleration, fraternity
- Constitutional government
- Separation of church and state
- Scientific method, empiricism, and reductionism
- An attitude captured by Immanuel Kant's essay *Answering the Question: What is Enlightenment*, where the phrase *Sapere aude* (Dare to know)
- Ends with the French Revolution 1789-1799



Fraternity - The Republic of Letters Talent and Thought

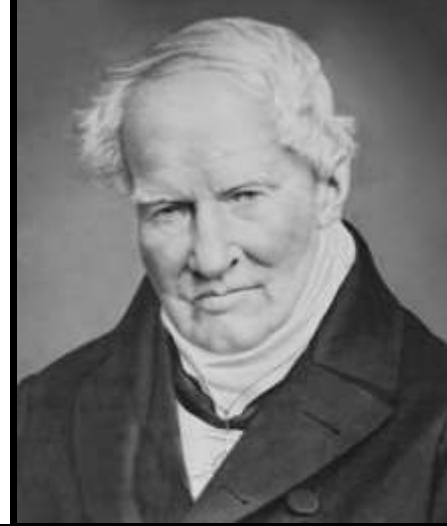
- The term "Republic of Letters" was coined in 1664 by Pierre Bayle in his journal *Nouvelles de la Republique des Lettres*.
- “In the midst of all the governments that decide the fate of men; in the bosom of so many states, the majority of them despotic ... there exists a certain realm which holds sway only over the mind ... that we honor with the name *Republic*, because it preserves a measure of independence, and because it is almost its essence to be free. It is the realm of talent and of thought.”



Pierre Bayle
(1647 – 1706)

A Life of Political and Social Turmoil

- The Enlightenment
- Revolution
- Reaction



1769 Alexander Born in Berlin

– Napoleon Bonaparte (1769-1821)

1740-1786 Fredrick the Great rules Prussia

1760-1860 Industrial Revolution

1776-1783 American Revolution

1789-1799 French Revolution

1800-1815 Napoleonic Era, Four Powers (Austria, Russia, Prussia, Britain)

1808-1830 Simón Bolívar and War for Latin American Independence

1815-1840 Return of French Monarchy – Ultra-Royalist Revenge

1848 Revolutions (Crushed or Compromised), Publication of *Communist Manifesto*

1852 Second French Empire

1859 Dies in Berlin the most famous “scientist” but marginalized politically in Europe

Prussia and Fredrick the Great

- Frederick II (1712 – 1786) ruled the Kingdom of Prussia from 1740 until 1786, the longest reign of any Hohenzollern king at 46 years.
- Prussia was just one of many different German states and principalities
- During his reign, Prussia greatly increased its territories and became a leading military power in Europe under his rule. He became known as Frederick the Great



Frederick Wilhelm II

Reign 1786 – 1797

- Pleasure-loving and indolent, he is seen as the antithesis to his predecessor, Frederick the Great.
- Under his reign, Prussia was weakened internally and externally, and he failed to deal adequately with the challenges to the existing order posed by the French Revolution.
- His religious policies were directed against the Enlightenment and aimed at restoring a traditional Protestantism.
- Alexander von Humboldt's godfather



Frederick Wilhelm II

1744 – 1797

Humboldt's Father

Alexander Georg von Humboldt (1720-79)

- Although not one of the titled gentry, he was a major in the army and was deployed during the War of Austrian Succession (1740–1748) and the Seven Years' War (1756–1763)
- He was given a title for this service and appointed chamberlain to the crown princess.
- He was a confidant of Friedrich Wilhelm II and set eventually to be a minister...



Humboldt's Mother

Marie Elisabeth Colomb (1741-96)

- in 1766 at the age of 46, Alexander Georg married the widow of Baron Hollwede - 25-year-old Marie Elisabeth Colomb.
- She brought real wealth into the family. Her contributions included a country estate and the lease on the Tegel manor house — not to mention a son, Heinrich von Hollwede (1762-1817), from her first marriage.
- The new couple soon had two sons of their own, first came Wilhelm, and two years later, Alexander.
- After Heinrich left to pursue a military career, she planned brilliant careers for Wilhelm and Alexander in the Prussian civil service.



Wilhelm von Humboldt (1767–1835)

- Wilhelm was studious. in his early teens Wilhelm learned German, Greek, Latin and French. Later he would become a linguist and study Chinese, Tartar, Arabic and Coptic among a dozen other languages.
- Prussian Diplomat, Linguist, Education Reformer – founder Berlin University October 1810 (Renamed Humboldt University in 1949)

Wilhelm 1784



Alexander

September 14, 1769



Alexander 1784

The Schloss Tegel or Humboldt-Schloss

The Humboldts enjoyed entertaining guests at Tegel. The brothers spent much of their childhood on the estate and were taught by tutors.



Goethe visits 1778 meets the boys. Later in *Faust* -
“The pack of devils by no rules is daunted:
We are clever, and yet is Tegel haunted.”



Then in 1779, Alexander Georg dies at 59.

Alexander was 9 and Wilhelm was 11.



Leaving the brothers in the care of their now twice widowed mother.

Humboldt as a boy with his mother, 1780



"Until I reached the age of 16, I showed little inclination for scientific pursuits. I was of a restless disposition and wished to be a soldier."

The “Little Apothecary”

Humboldt's Scientific Education



Humboldt and Botany - Karl Ludwig Willdenow (1765 – 1812)

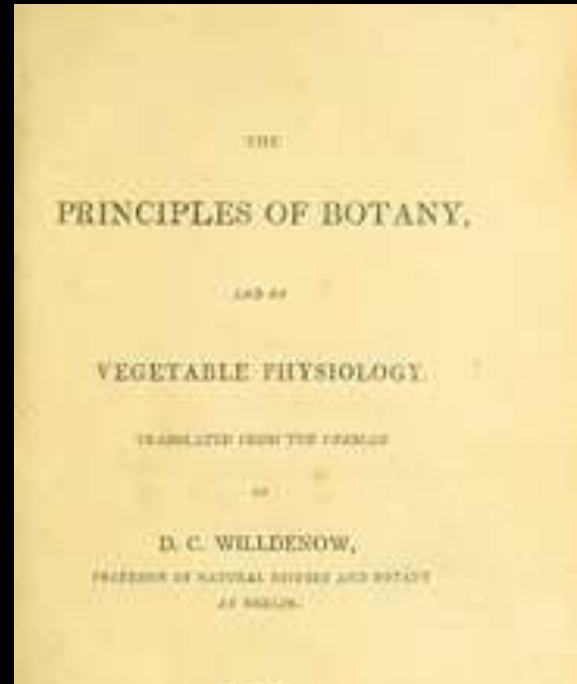
- 1787-8 tutored by Willdenow in botany and collects plants
- Willdenow is a major figure in the field of botany, considered to be one of the founders of phytogeography (the geographical distribution of plants)
- *Flora of Berlin* 1787
- 1801 named director of the Berlin Botanical Garden; named principal botanist of the Berlin Academy of Sciences.
- 1810 Professor of botany at the University of Berlin (founded by Wilhelm in 1810)



Karl Ludwig Willdenow - Nature is Dynamic

Principles of Botany 1792

- Willdenow came up with an idea to explain restricted plant distributions.
- It was based on past history with mountains surrounded by seas with different sets of plants initially restricted to the peaks which then spread downward and out with receding sea levels.
- The climate was the most important factor determining the type and number of plant species in a particular region.
- Plant communities changed over time.
- Plants could cross geographic barriers such as mountains and oceans, thereby expanding their range from one region to another.
- New species could appear and that others could become extinct.



Scientific Education - Center of Scientific Scholarship

He joins Wilhelm at the University of Göttingen 1789

A distinctive school of natural philosophy developed at Göttingen embracing Kant's ideas of physical geography –

- The Earth is an interconnected whole
- The richness and complexity of natural phenomena
- Integrative and unifying processes that were not directly visible.
- A full description of phenomena as they actually occurred and coexisted in the world.

“Regularities amongst the phenomena of the descriptive Earth sciences with a view to determine their causes”



Der Große Bibliotheks Saal zu Göttingen



Das Göttinger Universitätsgebäude, erbauet von 1737 bis 1741, nach dem Entwurfe des berühmten Baumeisters Johann Carl Friedrich Scharoun, in der Göttinger Straße, im Jahre 1741.

University of Göttingen

1789-90

"I learned so much (there) that I began to feel better about myself; and at Göttingen, I was a very serious, hard-working student. But that only heightened my awareness of the fact that there was still so much to learn...

At times, the feeling of constant restlessness that plagues me makes me believe that I am losing my mind. Yet, I absolutely need that sense of agitation to work ceaselessly towards my goals."

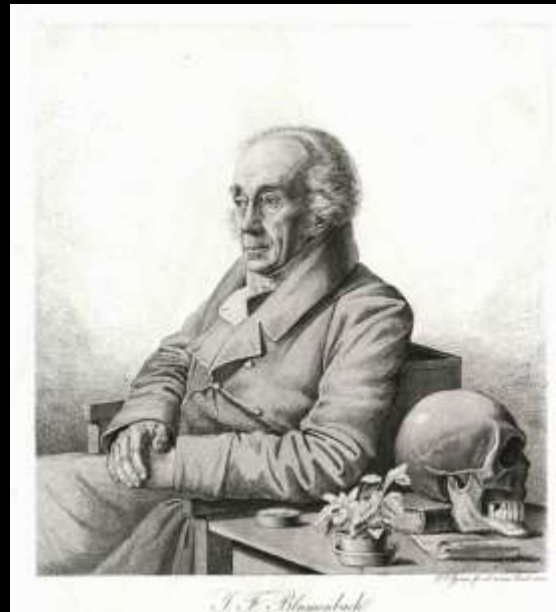
Alexander writing to Wilhelm Gabriel Wegener
23 September 23rd 1790



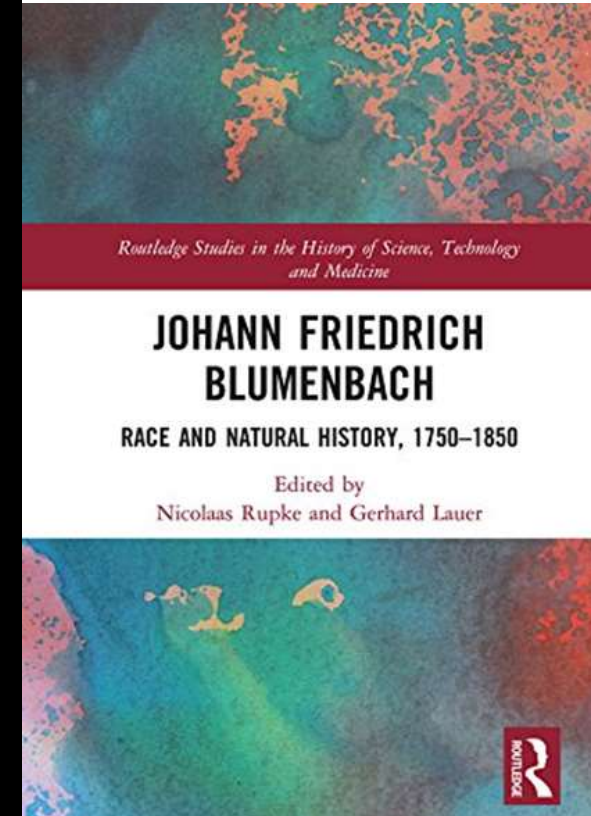
Humboldt and Biology

Johann Friedrich Blumenbach (1752 - 1840)

- Kant and Friedrich Schelling both called him "one of the most profound biological theorists of the modern era"
- Critic of Linnaeus taxonomy – species based on single characteristic
- Defining species based on a series of morphological characters
- Recognized the potential for species to change through time or to become extinct.



BLUMENBACH.



Explaining Order – The Science of Biology

Bildungstrieb – The Formative Drive

- Studied how individuals within a species vary, and to explain such variations, he proposed that a force operates on organisms as they develop (or evolve).
- *Bildungstrieb* – a formative drive responsible for biological "procreation, nourishment, and reproduction"
- All living organisms "from man down to maggots, and from the cedar to common mould or mucor," possess an inherent "effort or tendency which, while life continues, is active and operative; in the first instance to attain the definite form of the species, then to preserve it entire, and, when it is infringed upon, so far as this is possible, to restore it."
- *Bildungstrieb* was central to the creation of new species.
- The concept was adopted by Goethe and Kant



Racial Equality and Monogenism

- Blumenbach used *Bildungstrieb* to explain the degeneration of an original type of human into the five varieties—which he later classified as Caucasian, Mongolian, Malayan, Ethiopian, and American—found around the world.
- The concept was adopted by Kant and Goethe.
- Proponent of racial equality [contra Kant] Blumenbach strongly upheld the unity of the human species
- "No doubt can any longer remain but that we are with great probability right in referring all . . . varieties of man . . . to one and the same species."



1

Tungusae.

2

Caribaei.

3

Feminae Georgianae.

4

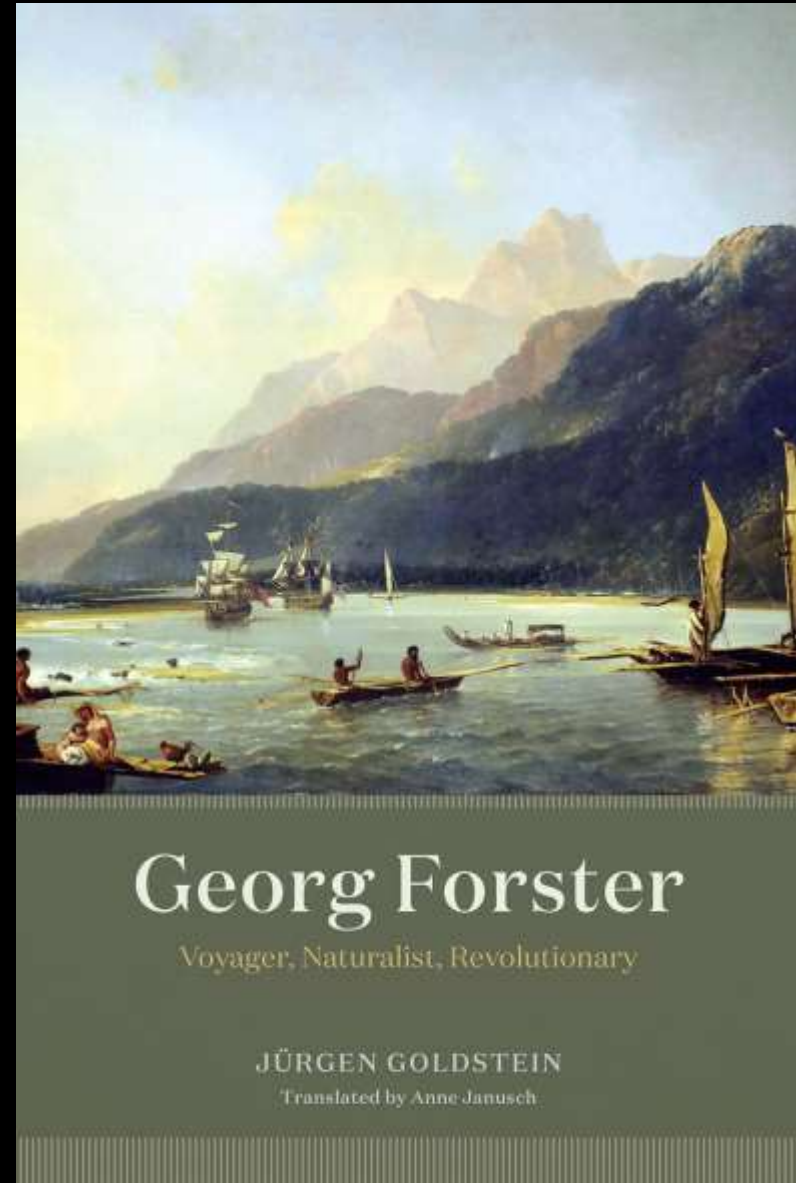
O. tahitiae.

5

Aethiopsae.

Humboldt and Scientific Travel

Humboldt goes to Mainz and meets Georg Forster in 1789

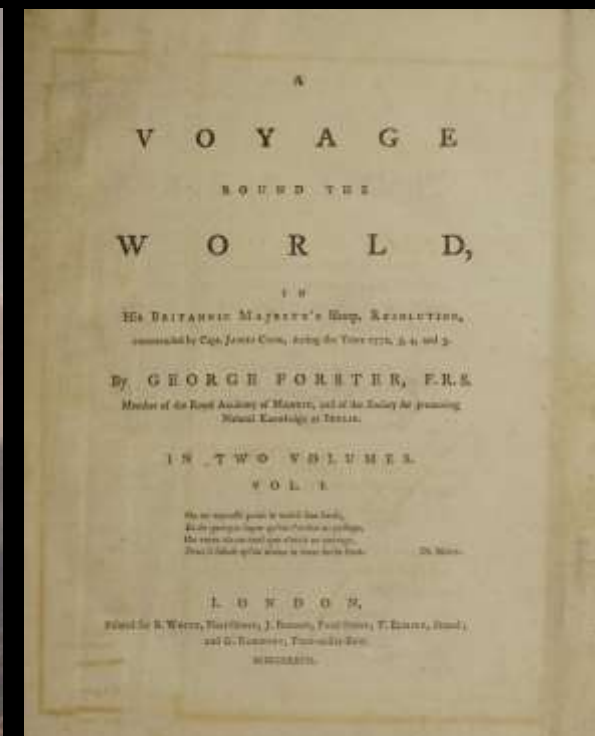
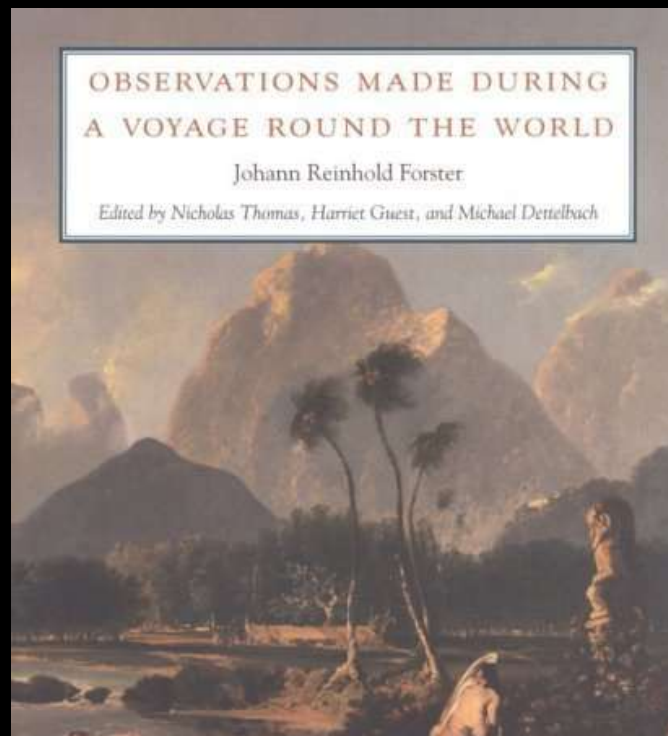


The Age of Discovery

Johann Reinhold Forster (1729-98)

Georg Forster (1754-1794)

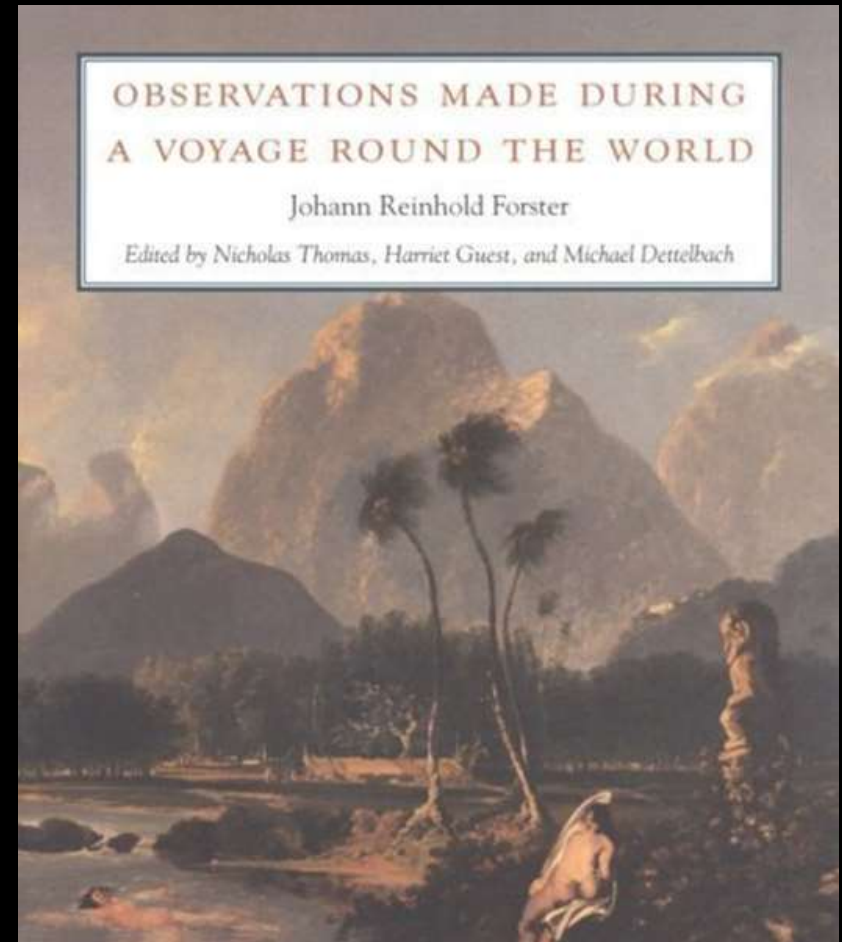
- They emigrated to England in 1766. Both were invited to accompany Capt. James Cook on his second voyage around the world (1772–75).
- J. Reinhold Forster *Observations Made during a Voyage round the World* (1778)
- Georg Forster *A Voyage Towards the South Pole and Round the World* (1777)
- Georg admitted to the Royal Society at the age of 22



Johann Reinhold Forster - Biogeography

Observations Made during a Voyage round the World (1778)

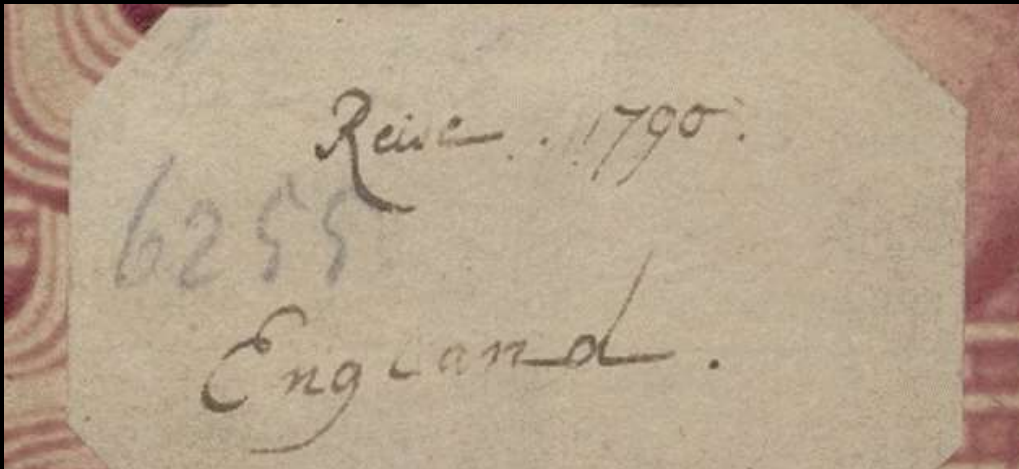
- Distinct regions of the world defined by temperature – plants and animals
- Regions are biological units
- Similarities and differences between continental and island species



Georg Forster (1754-1794)

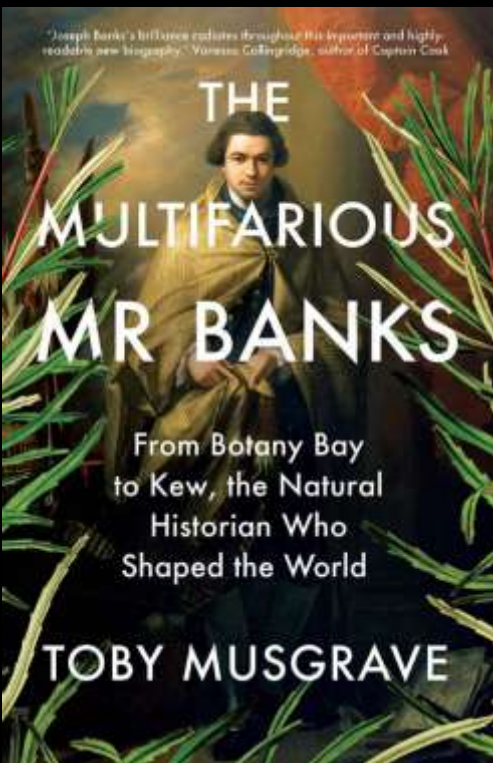
Humboldt's Mentor and Role Model

- Scientific Travel and International Collaboration
- The Republic of Letters - liberty, progress, toleration, fraternity
- Takes Humboldt for a journey March – July 1790 to the Netherlands, France, England – introduces him to Joseph Banks president of the Royal Society.
- “A quite congenial, well-behaved, spirited, knowledgeable young man”
- There is a profound political aspect to contemplating Nature.



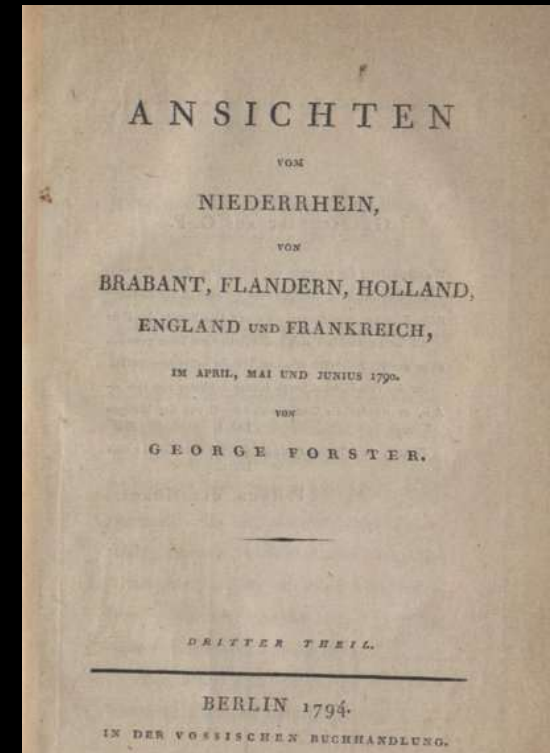
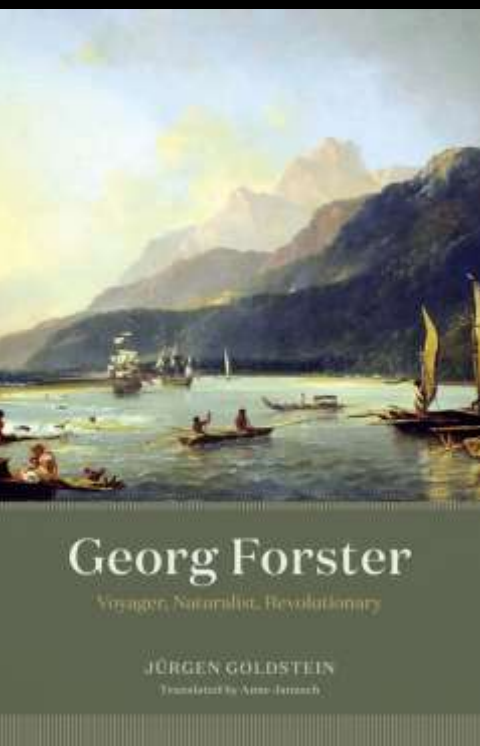
Republic of Letters - Joseph Banks 1743-1820

- Finds the Royal Botanic Gardens at Kew and leads the Royal Society
- Major patron of further collecting
- On his American expedition, Humboldt arranged for specimens be sent to Banks, should they be seized by the British.
- Banks and Humboldt remained in touch until Banks's death, aiding Humboldt by mobilizing his wide network of scientific contacts to forward information to Humboldt.



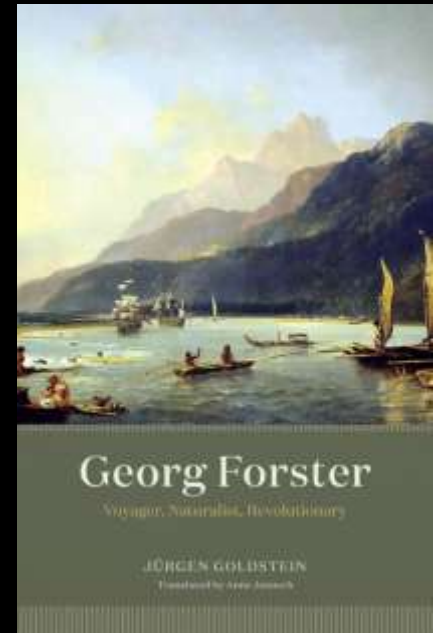
Scientific Travel – Forster and Humboldt

- Forster publishes an account of their journey *Views of the Lower Rhine, Brabant, Flanders* (three volumes, 1791–94)
- Humboldt dedicates his book “*Views of Nature*” (*Ansichten der Natur*) to Forster
- Goethe said about the book: “One wants, after one has finished reading, to start it over, and wishes to travel with such a good and knowledgeable observer.”
- “The book does not incite revolution, nor does it demand republicanism. But it does generate a historical plausibility for one as much as for the other.” Goldstein



Georg Forster - Nature, Liberty, and Revolution

- Supports the French Revolution and helps lead the short-lived Mainz Republic. He dies in exile in Paris 1794.
- He claimed a deep connection between nature, reason, politics, and revolution. “The revolution is truly to be viewed as a work of nature’s justice.”
- Revolution as a natural phenomenon like a volcano. Rhine basalts with Humboldt.
- Schlegel on Forster “unwavering necessity of the laws of nature and the indestructible capacity for human perfectibility”
- “All peoples of the earth have equal claims to my good will ... and my praise and blame are independent of national prejudice.”



Humboldt and Forster – Nature is the Domain of Liberty

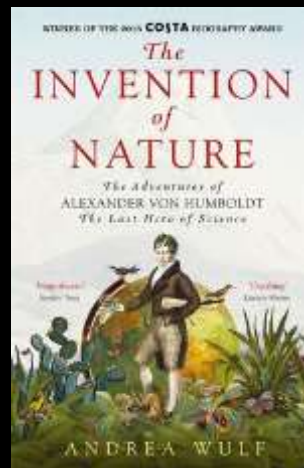
Humboldtian Science = Cosmopolitan science

International collaboration, Friendship, Mutual Support, Mentorship

“Nature is the domain of liberty,’
Humboldt said, because nature’s balance
was created by diversity which might in
turn be taken as a blueprint for political
and moral truth.

Everything, from the most unassuming
moss or insect to elephants or towering
oak trees, had its role, and together they
made the whole. Humankind was just
one small part.”

Wulf Invention of Nature



Humboldt and Geology 1791-96



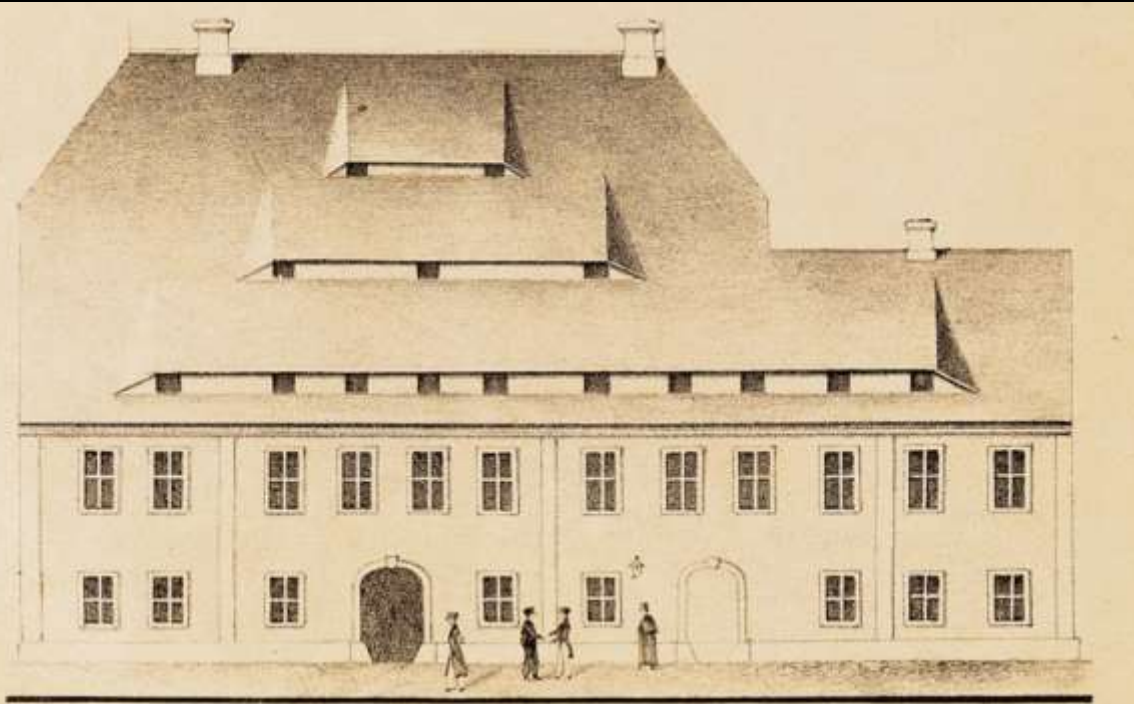
Humboldt the Geologist

- Humboldt published his first book in late 1790.
- "Mineralogical Observations on Some Basalts in the Rhine Basin."
- a 126-page volume dedicated to Forster.
- Humboldt had just turned 21.



Mineralogy and Geognosy (Geology)

In 1791, with the book as an application, Humboldt enrolled at the Freiberg Mining Academy, famous throughout Europe for a curriculum combining theory and practice.



Königl. Sächsisches Berg-Academiegebäude in
FREIBERG IN SACHSEN.

1831

Humboldt, A. v.
Mineralogische
BEOBACHTUNGEN
über
einige Basalte am Rhein

MIT
vorangeschickten, zerstreuten Bemerkungen
über den Basalt der ältern und neuern
Schriftsteller.

Braunschweig
in der Schulbuchhandlung 1792.

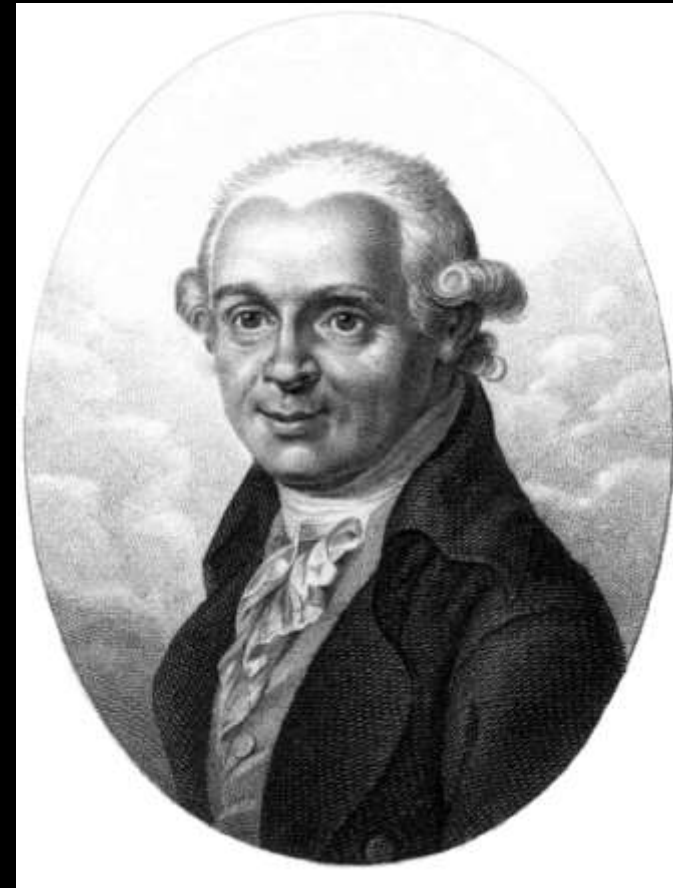
Explaining Order - The Science of Geology

“Father of German Geology”

Abraham Gottlob Werner

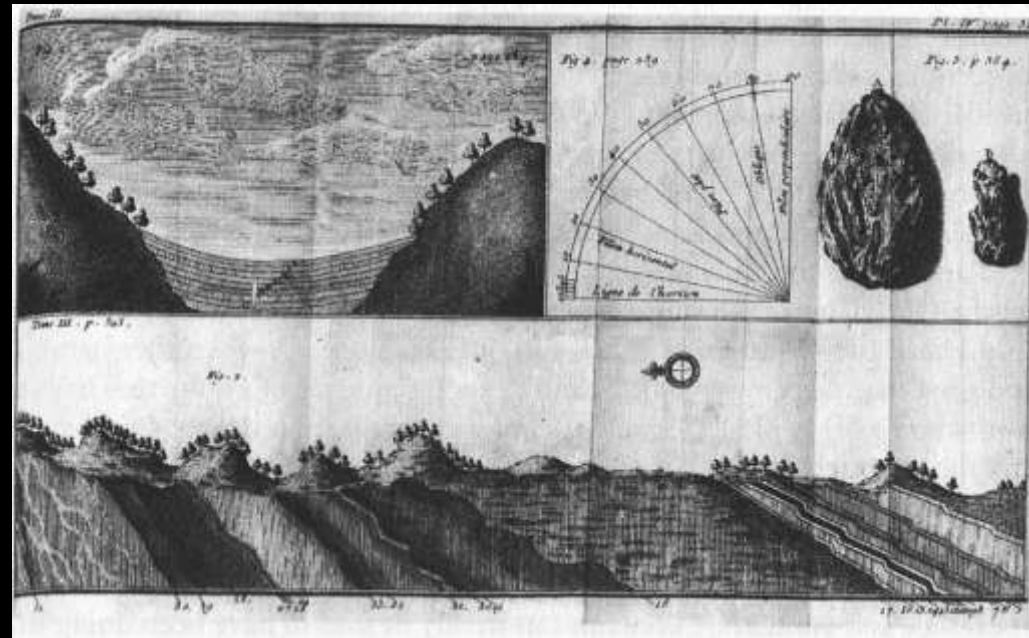
(1750-1817)

- In 1773 Werner wrote a mineralogy book entitled “On the External Characteristics of Fossils”
- This book described minerals based on their diagnostic physical characteristics.
- The book was a huge success because it helped geologists identify rocks in the field.
- The Science of Geology - During Werner’s 40-year tenure at the Freiburg School of Mining, he promoted a theory called neptunism for the formation of rocks.



Werner and Neptunism

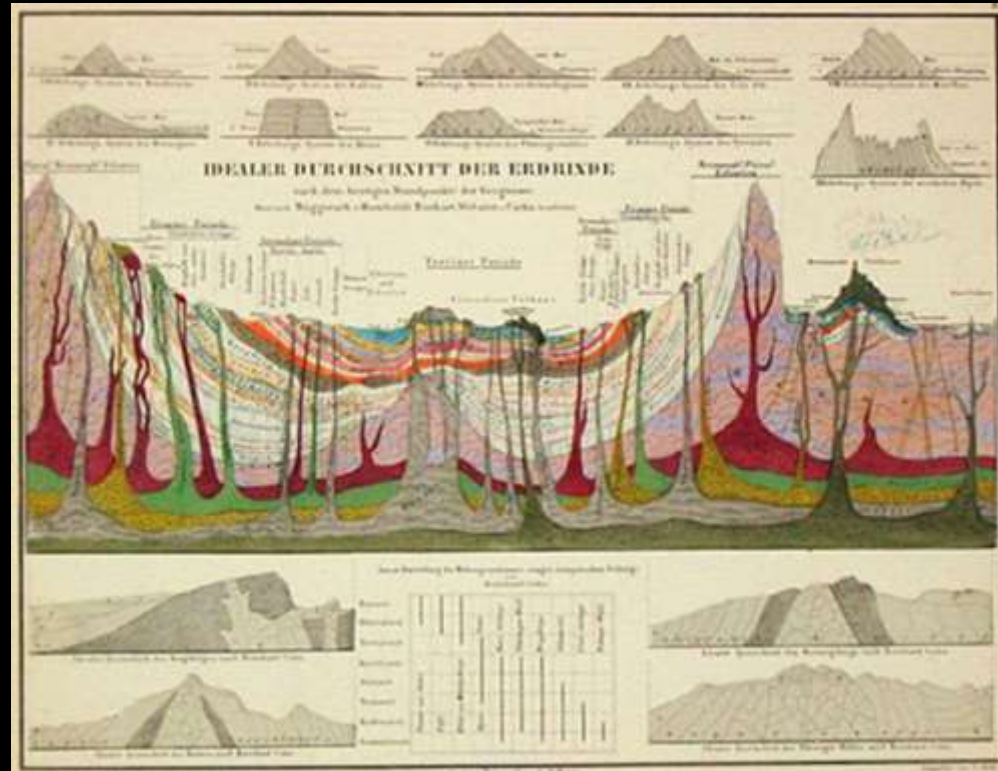
- All the rocks observable on Earth's surface were once precipitated out of a vast ocean that covered the entire earth.
- Volcanos had a minor effect, modifying the continents and adding more sediment as well as some volcanic rocks, and successive lesser floods added more layers, so that most rocks resulted from precipitates settling out of water.
- Neptunists argued that basalt was a sedimentary deposit which included fossils and so could not be of volcanic origin.



Plutonism vs. Neptunism

- A rival theory - plutonism (or vulcanism) held that rocks were formed in fire.
- James Hutton correctly asserted that basalt never contained fossils and was always insoluble, hard, and crystalline. He found geological formations in which basalt cut through layers of other rocks, supporting his theory that it originated from molten rock under the Earth's crust.
- Goethe took sides with the neptunists. The fourth act of *Faust* contains a dialogue between a neptunist and a plutonist, the latter being Mephistopheles, the antagonist of the play who is a devil.

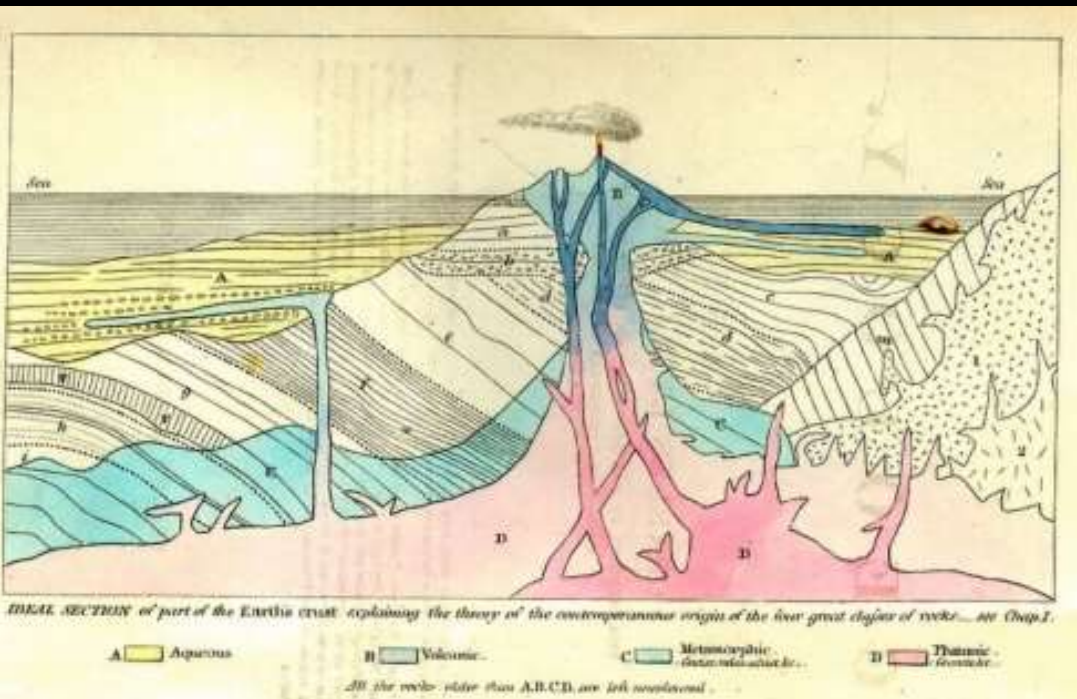
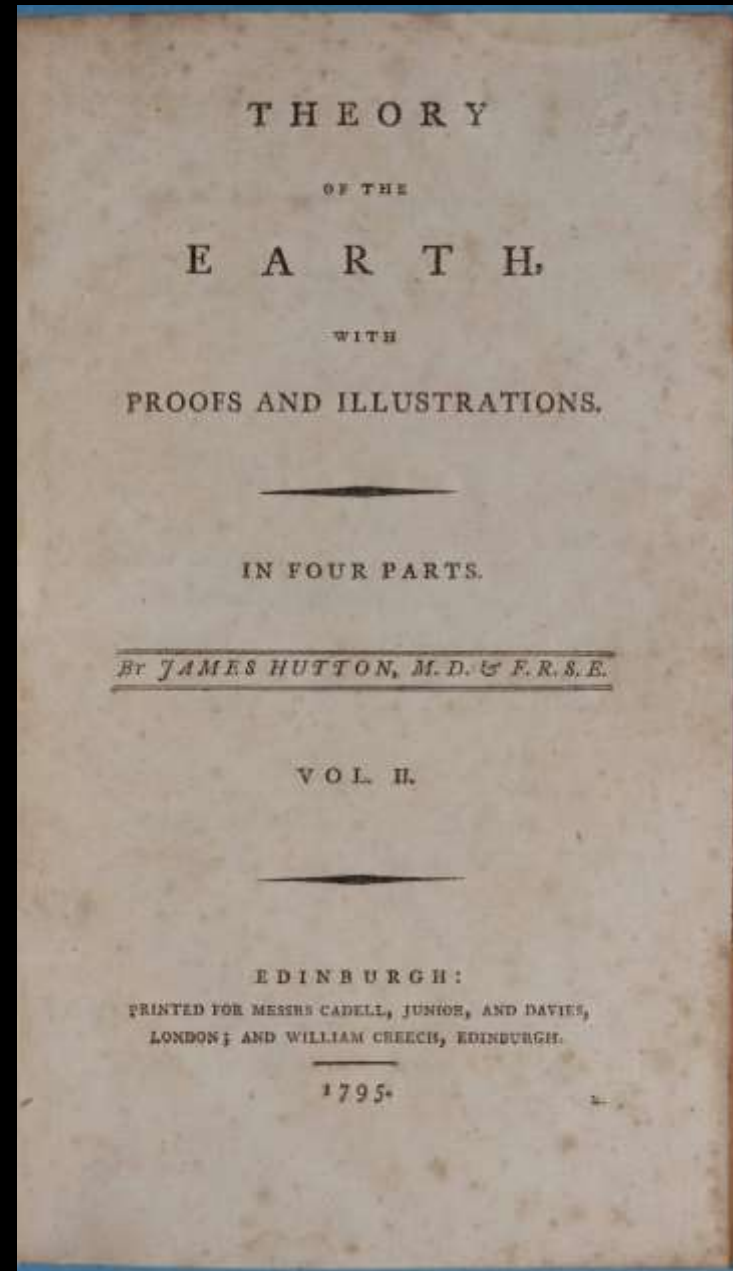
James Hutton (1726 – 1797)



Plutonism and the Science of Geology

James Hutton who put forward a uniformitarian theory of a rock cycle extending over infinite time in which rocks were worn away by weathering and erosion, then were re-formed and uplifted by heat and pressure.

Charles Lyell *Principles of Geology* (1830-33) developed Hutton's idea that the earth was shaped entirely by slow-moving forces still in operation today, acting over a very long period of time.



Humboldt the Geologist

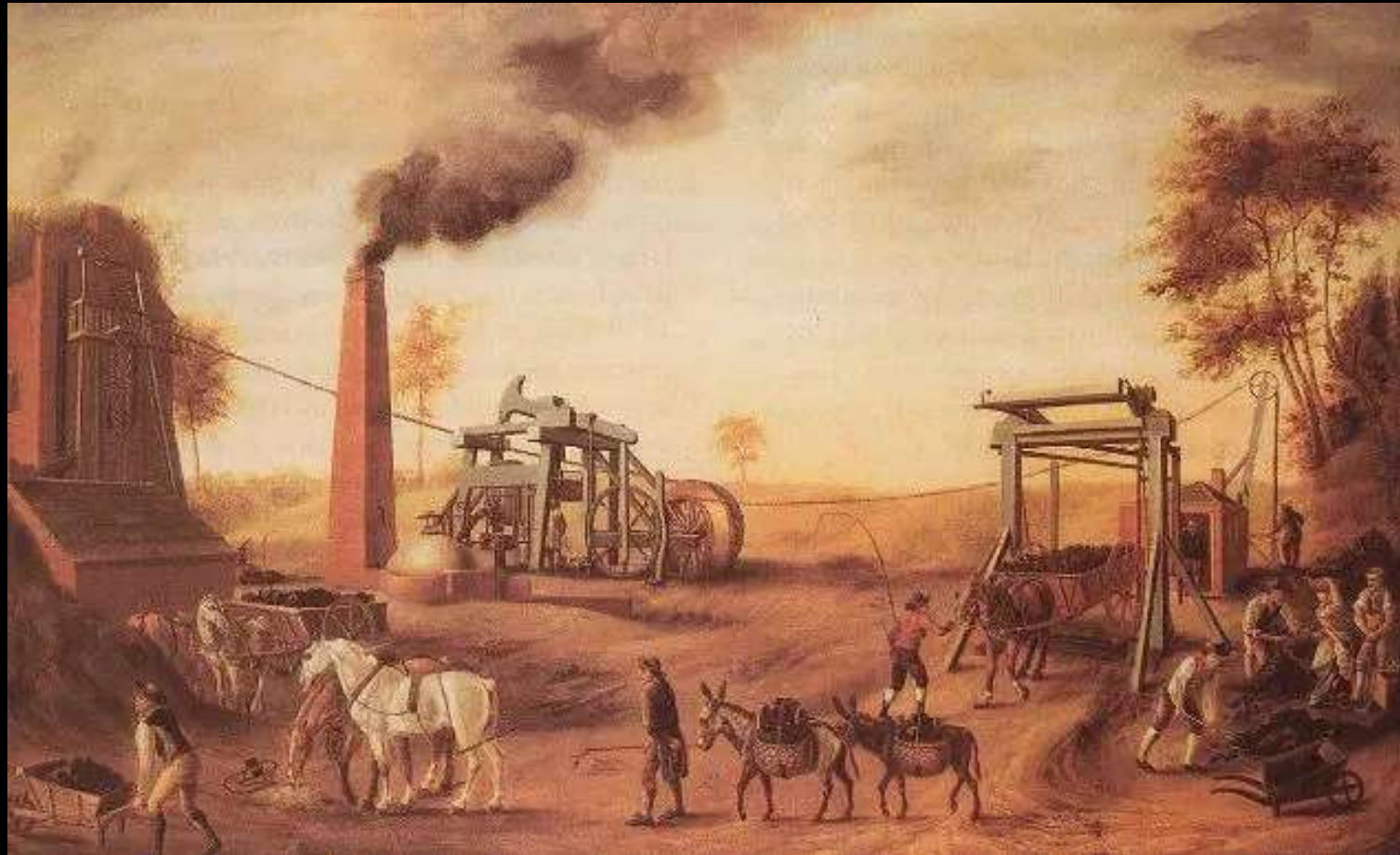
Humboldt graduated from the Freiberg School of Mines in 1792



Humboldt the Miner

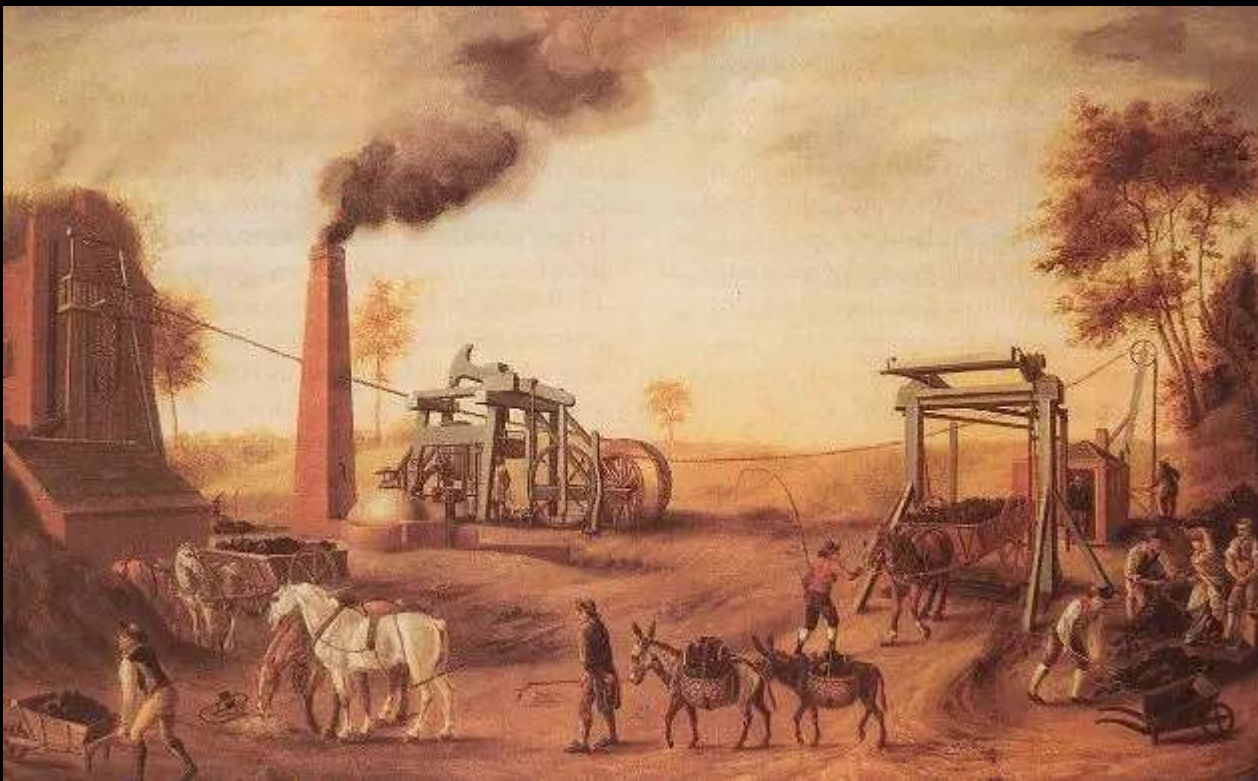
Mining and Geology 1792-97

Humboldt was appointed to a Prussian government position in the Department of Mines as an inspector in Bayreuth and the Fichtel mountains.



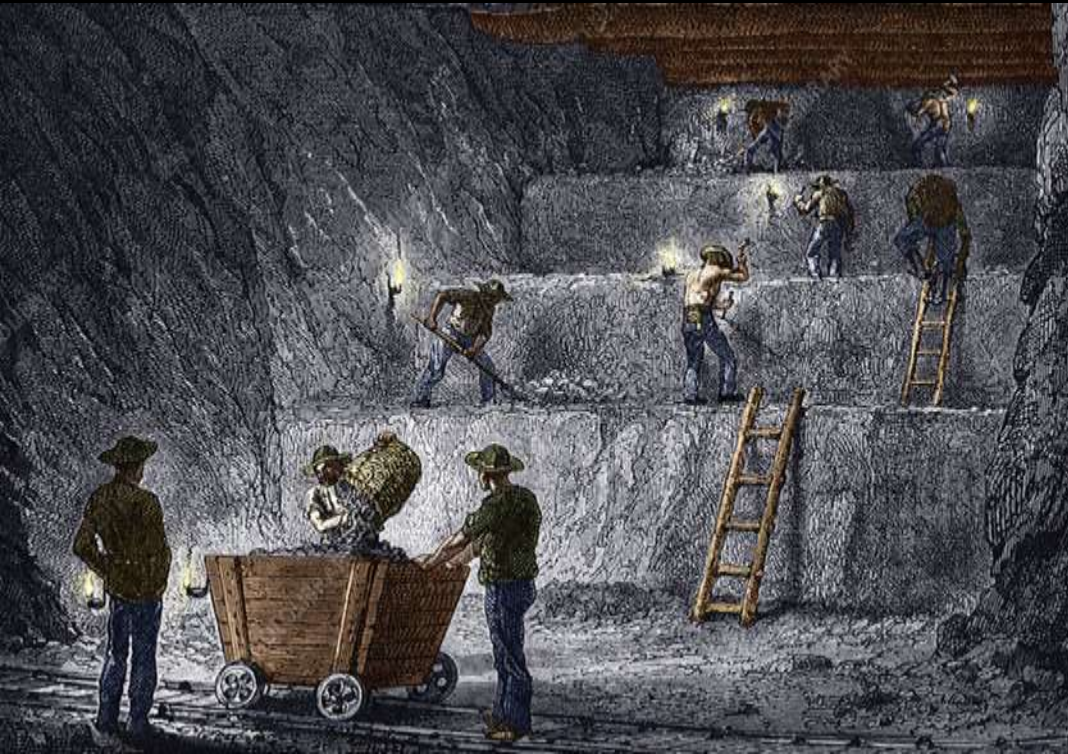
Humboldt the Mining Official

- Humboldt was excellent at his job, with production of gold ore in his first year outstripping the previous eight years.
- Promoted to director of mines for the Prussian principality of Bayreuth where he works until 1797
- He opened a free school for miners, paid for out of his own pocket, which became an unchartered government training school for labor and an emergency relief fund



Humboldt – Science and Workers

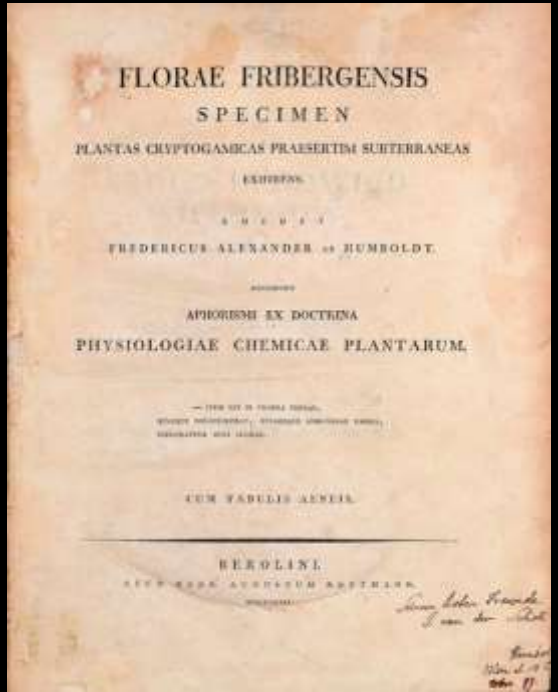
- Concerned by working conditions in the mines, he invented two tools that would contribute to the miners' chances of survival in case of emergency: a miner's lamp that could function without oxygen and a breathing apparatus.
- He tests these devices himself and nearly dies.



Humboldt, Mines, and Botany

Plant Geography – *The Flora of Freiberg* 1793

- He was interested in the mosses and fungi that grew in mines.
- Humboldt's research led to the publication in Latin of *Florae Fribergensis (The Flora of Freiberg)* in 1793
- A treatise on the vegetation in and around the mines of Freiberg in Saxony, giving habitat, locality and abundance for each species.



Plant Geography – *The Flora of Freiberg 1793*

Beyond Descriptive Botany

Dynamic Nature

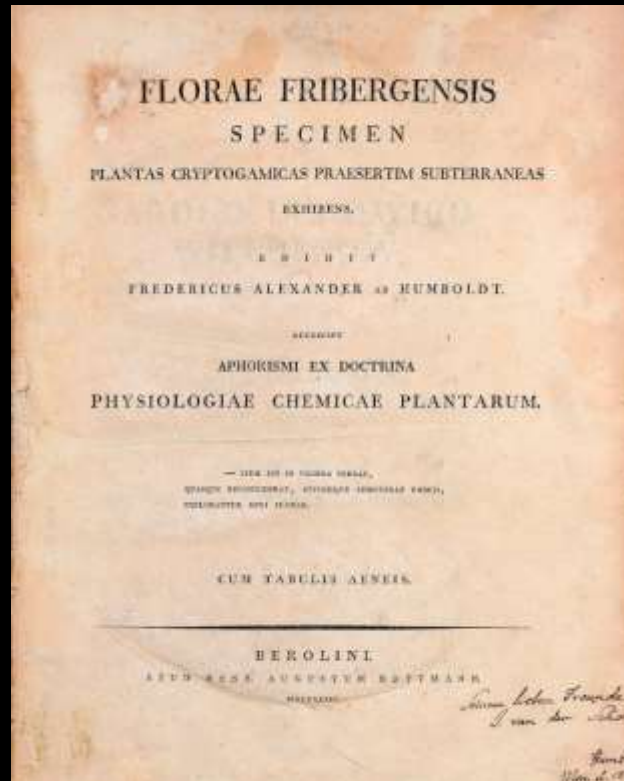
- “...plant geography traces the connections and relations by which all plants are bound together among themselves, designates in what lands they are found, in what atmospheric conditions they live, and tells of the destruction of rocks and stones by what primitive forms of the most powerful algae, by what roots of trees, and describes the surface of the earth in which humus is prepared.”
- Not just descriptive natural history
- Explanation - How plants and plant communities change (adapt) to their environment – metamorphosis
- Willdenow and phytogeography



Humboldt and Goethe

- This book brought him to the attention of Goethe who had become friends with Wilhelm.
- Goethe was now interested in meeting the young scientist to discuss metamorphism of plants.
- An introduction was arranged by Wilhelm, who lived in the university town of Jena, not far from Goethe...

June Lecture – *The Romance of Nature: Science, Imagination, and the Poets of Nature*



The Science of Nature: Humboldt and the Empirical Earth

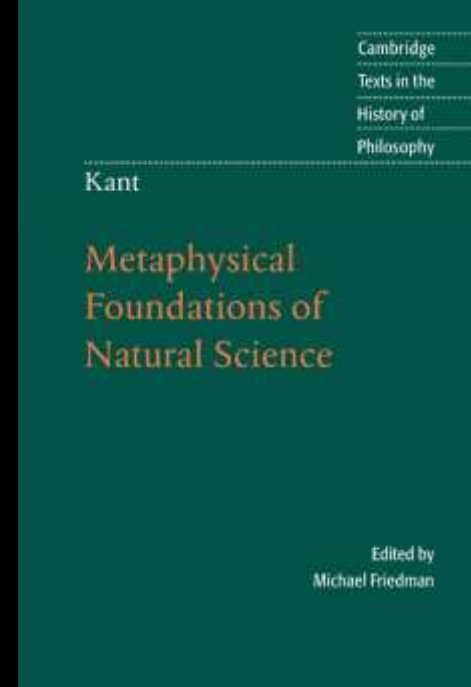


Description and the Science of Nature

Natural History – purely descriptive “Earth sciences”

- Biology
- Botany
- Mineralogy
- Geognosy (Geology)
- Physical Geography

“History” with no history - no temporal explanation



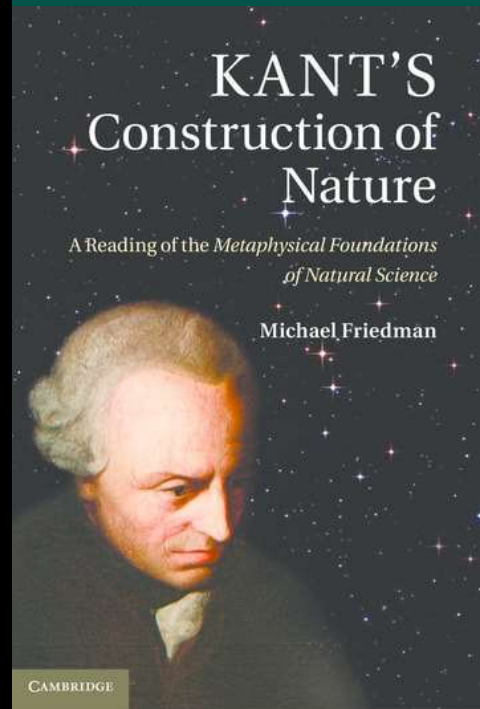
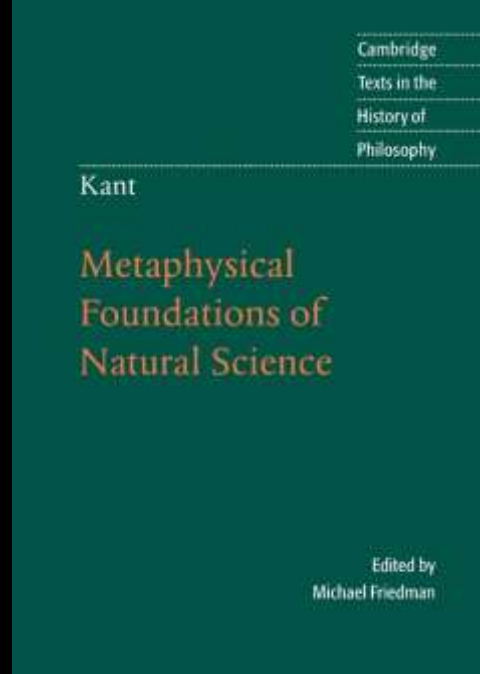
Explanation and the Science of Nature

Natural Philosophy – The Explanative Science

- The causal science
- Temporal explanation – Earth history

Earth Physics (Earth science)

- “regularities amongst the phenomena of the descriptive Earth sciences with a view to determine their causes”
- Time/History – origins of valleys
- The Earth must have a history (either biblical or not) and so a theory of the Earth about origins and development is needed to explain the present
- Kant rejected biblical explanation and timeline



Humboldtian Science

Physique du monde, Universal Natural Science

- “the accurate measured study of widespread but interconnected real phenomena in order to find a definite law and a dynamic cause”
- “to recognize unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes.” *Cosmos*

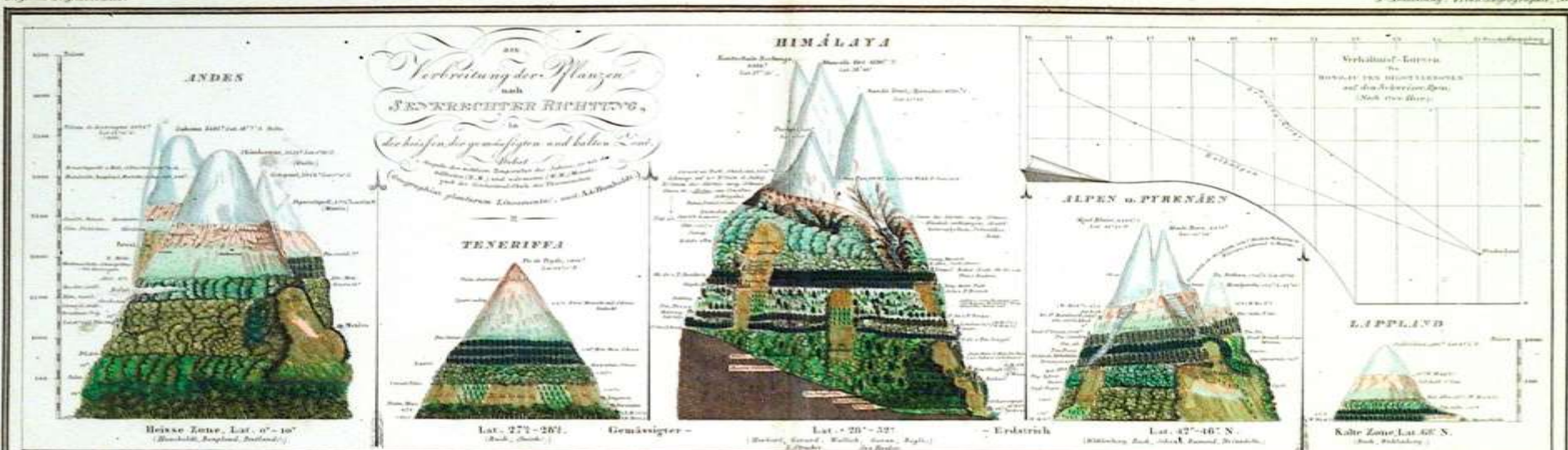


Kant
1724-1804



Humboldt
1769-1859

UMRISSE DER PFLANZENGEOGRAPHIE.



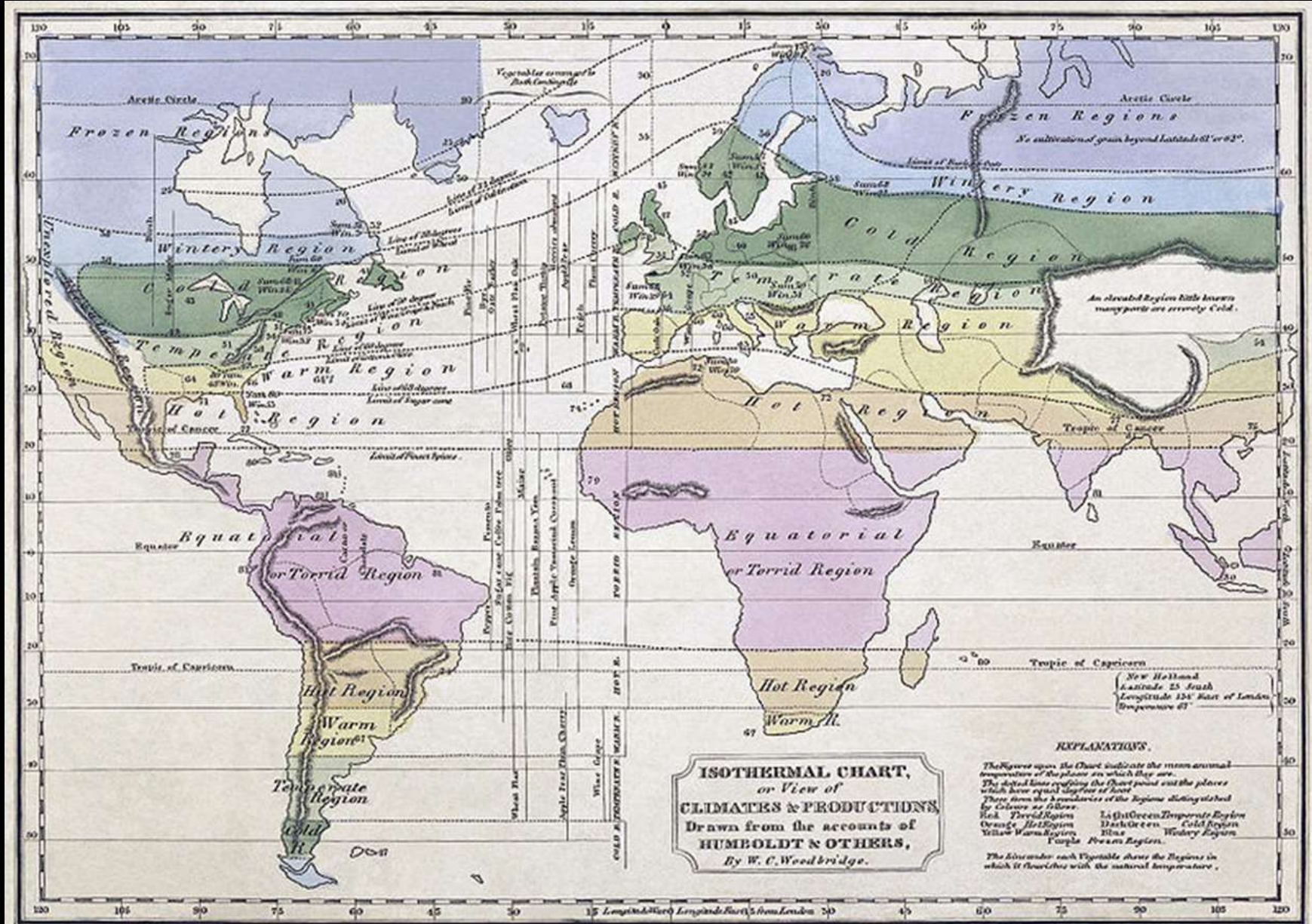
To Explain Order and Change in the Cosmos

1. Explore – “Nature speaks and the scientist must go out and listen”
2. Collect – gather data for and against an idea/theory
3. Measure – widespread, accurate, collaborative
4. Connect – detect patterns that point to underlying laws
5. Cosmopolitan science – international collaboration



Humboldtian Science of Nature – Order and Change

To map and to explain the patterns of variation in geographical phenomena



Humboldtian Cosmos - A Vision of the Unity of Nature

- The Cosmos is both ordered and beautiful.
- Nature and the human mind are a unity
- To know nature better is thus to know ourselves better, for knowledge is a deeply human project combining understanding and imagination.

June Lecture – *The Romance of Nature: Science, Imagination, and the Poets of Nature*



*Geographie der Pflanzen in den Tropen-Ländern.
ein Naturgemälde der Anden.*

*gegründet auf Beobachtungen und Messungen, welche von A. G. von Humboldt bei einer in G. G. von Humboldt's Auftrag unternommenen Reise in die Tropen-Länder
von ALEXANDER VON HUMBOLDT und A. G. BORTLAND.*



Applause

