

Alexander von Humboldt's idea of interconnectedness and its relationship to interdisciplinarity and communication

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ABSTRACT

Alexander von Humboldt, a German scientist and explorer of the 19th century, viewed the natural world holistically and described the harmony of nature among the diversity of the physical world as a conjoining between all physical disciplines. He noted in his diary: "Everything is interconnectedness."

The main feature of Humboldt's pioneering work was later named "Humboldtian science", meaning the accurate study of interconnected real phenomena in order to find a definite law and a dynamic cause.

Following Humboldt's idea of nature, an Internet edition of his works must preserve the author's original intention, retain an awareness of all relevant works, and still adhere to the requirements of scholarly edition.

At the present time, however, the highly unconventional form of his publications has undermined the awareness and a comprehensive study of Humboldt's works.

Digital libraries should supply dynamic links to sources, maps, images, graphs and relevant texts. New forms of interaction and synthesis between humanistic texts and scientific observation need to be created.

Information technology is the only way to do justice to the broad range of visions, descriptions and the idea of nature of Humboldt's legacy. It finally leads to virtual research environments as an adequate concept to redesign our digital archives, not only for Humboldt's documents, but for all interconnected data.

Keywords: Information Technology, Humboldtian Science, Internet Portal, Digital Library, Interconnectedness

1. ALEXANDER VON HUMBOLDT, GERMAN SCIENTIST

Alexander von Humboldt, a German scientist and explorer of the 19th century, viewed the natural world holistically and described the harmony of nature among the diversity of the physical world as a conjoining between all physical disciplines.

Between 1799 and 1804, Humboldt together with Aimé Bonpland travelled to the Americas, exploring and describing them for the first time from a modern scientific point of view. Humboldt made a short visit to the United States, staying in the White House as a guest of President Thomas Jefferson. Jefferson, a scientist himself, was delighted to have Humboldt as a guest [1].

Humboldt made a lasting impression on American culture and social history, possibly because he supplied the political leaders with information and maps showing the geography and geology west of the recently acquired Louisiana territory (present-day Texas) [2].

He finally settled in Paris in 1808 with the purpose of publishing his great work. This colossal task, which he at first hoped would occupy about two years, eventually cost him twenty-one, and even then it remained incomplete [1].

2. HUMBOLDT'S IDEA OF NATURE

Precise descriptions of phenomena

Humboldt saw the need to record everything with precision to detect the process behind it. He believed that the quantification and subdivision were destined at some point to reveal fundamental unity. With extensive observations and analyses written down after travels in Venezuela, Colombia, Ecuador, Peru, Mexico, Cuba, and the United States, he published and illustrated thirty volumes relating his travels in the Americas. Due to his youthful penchant for collecting and labelling plants, shells and insects, Humboldt received the playful title of

"the little apothecary"[1].

In the mid-19th century, Charles Darwin formulated the theory of evolution by natural selection, published in his book *On the Origin of Species* (1859). He used Humboldt's documents as a kind of a lexicon, appreciating the precision of the descriptions and the quality of specifications.

Holistic vision

Humboldt in fact viewed nature holistically, and tried to explain natural phenomena without any appeal to religious dogma. The natural systems (physical, geological, biological, chemical, social, and economic) and their properties should be viewed as wholes, not as collections of parts.

Because of the importance of the collected data, he made his observations and measurements with the most sophisticated scientific instruments available at that time.

To understand Humboldt's unique historical role, certain prevailing assumptions deserve attention and critical analysis. Biographers often place Humboldt's name next to Johann Wolfgang von Goethe's, another famous German intellectual. They shared many interests in literature and the sciences. Both articulated holistic views of nature [2].

In the preface of '*Cosmos*', Humboldt wrote [3]: "The principal impulse by which I was directed was the earnest endeavor to comprehend the phenomena of physical objects in their general connection and to represent nature as one great whole, moved and animated by internal forces."

Interdisciplinarity

After his travels to the Americas, he was admired for his ability to see the natural world and human nature in the context of a complex network of relationships that involved all known scientific and humanistic disciplines. He contributed with advances in diverse disciplines such as anthropology, history, archaeology, sociology, botany, zoology, geography, geology, astronomy and ecology. Later, his five-volume work, *Cosmos* [3], attempted to unify the various branches of scientific knowledge.

Humboldt was one of the first who proposed that the lands bordering the Atlantic Ocean were once joined (South America and Africa in particular). Alfred Wegener developed the theory of continental drifting more than 100 years later, which is today accepted by the geoscientific community.

Humboldt's services to geology were based mainly on his attentive study of the volcanoes of the New World, because there was an ongoing dispute about the origin of rocks:

Neptunism proposed that the Earth had originally consisted of water; and that the water contained material which settled out of suspension in a process of sedimentation to form the core of the planet and the continents as a series of layers, the oldest and hardest being granite, while newer layers showed an increasing number of fossils. A rival theory known as **plutonism** held that rocks were formed in fire, and affected by 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 [8].

Humboldt showed that the volcanoes fell naturally into linear groups, presumably corresponding with vast subterranean fissures; and by his demonstration of the igneous origin of rocks he contributed to the theory of plutonism [1].

Time and space dimension

Furthermore, Humboldt saw all phenomena in the context of a historical development. For him the historical perspective was an active dimension in the web of interconnectedness. Nature existed in space and time.

The documents of Humboldt provide the basis for reconstructing the five-year journey to the Americas in a strictly chronological sequence. But Humboldt's "*Personal Narrative of Travels*" [4] often strays from a strictly chronological order. After his return to Europe, Humboldt conducted research and often inserted discourses or articles of various lengths (see fig. 1). These digressions make it difficult for the reader to follow the sequence of events in the journey [2].

Hypertextuality

Humboldt's desire for an all-encompassing, all facts considering view of the world influenced his writing. The consideration of details is done in a myriad of notes and cross-references (see fig. 1). Humboldt always spanned a network of texts, subtexts and pictures to imitate nature itself; just because he recognized this structure in every relation between plants and animals [6].

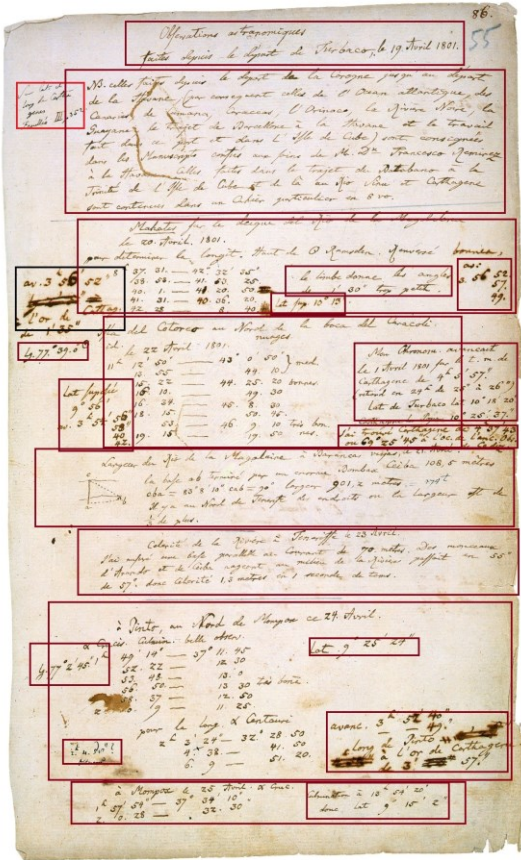


Fig. 1: Part of a travel diary from Alexander von Humboldt with marked information blocks and complementary text (Source: <http://www.von-humboldt.de/news---events-2013.html>; Staatsbibliothek zu Berlin - Fotostelle "Amerikanische Reisetagebücher", Humboldts Tagebuch VIIa/b, 55r.)

Interconnectedness

Humboldt was strongly convinced that the distinct disciplines represented artificial divisions of knowledge [5] and the key to understanding nature was interconnectedness. He noted in his diary: “Alles ist Wechselwirkung,” - “everything is interconnected and interdependent”.

As a result, he published a detailed narrative of his travels, constantly integrating his observations and data from various perspectives and disciplines. The need to make connections was characteristic of his publications.

Unity

Humboldt suggested that it would be possible to show the features of the tropics and the gradual changes up to the snow-capped mountains in nature [5], which he documented in his famous image of Mt. Chimborazo. The vision of unity is embodied there in a very specific way, indicated by the image of the mountain together with Latin plant names, marking the regions of occurrences, and data tables on both sides of the volcano's painting (see fig. 2). Measurements of altitude, air pressure,

comparisons with other mountains, and many more details were listed. For instance, he investigated the rate of decrease in mean temperature with the increase in elevation above sea level, and afforded, by his inquiries regarding the origin of tropical storms, the earliest clue to the detection of the more complicated law governing atmospheric disturbances in higher latitudes. By his delineation (in 1817) of "isothermal lines", he at once suggested the idea and devised the means of comparing the climatic conditions of various countries.

3. IMPACT ON NATURAL SCIENCES

Because of his profound grasp of a broad spectrum of knowledge and his insistence on precision, Humboldt was in a unique position to advance the natural sciences in the first half of the 19th century.

The main feature of Humboldt's pioneering work was described as a great event in professional science in the first half of the 19th century and was named “Humboldtian science” [7]:

- “1. A new insistence on accuracy, not for just a few fixed instruments, but for all instruments and all observations.
2. A new mental sophistication, expressed as contempt for the easy theories of the past, or as taking lightly the theoretical mechanisms and entities of the past.
3. A new set of conceptual tools: isomaps, theory of errors.
4. An application of these tools not to laboratory isolates but to the immense variety of real phenomena, so as to produce laws dealing with the very complex interrelationships of the physical, the biological, and even the human” [7].

Humboldt founded the branch of biogeography that is concerned with the geographic distribution of plant species and their influence on the earth's surface, while his essay on the geography of plants was based on the novel idea of studying the distribution of organic life as affected by varying physical conditions. His Chimborazo image is significant primarily for its dramatic emphasis on the geographic factor in plant distribution. Even in the folio edition, the data appear too small for the naked eye. Beyond an aesthetic impression, Humboldt's original display does not provide easy access to specific information [2].

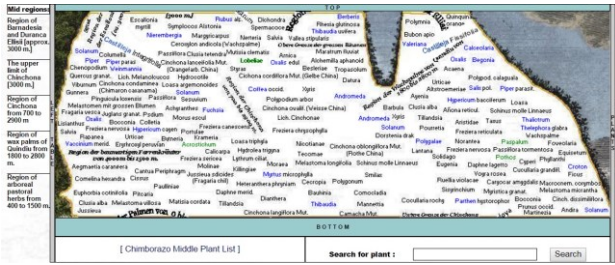


Fig. 2: Middle part of the image of the Chimborazo volcano with detailed information about plants and plant geography (Source: Humboldt Digital Library)

Sustainability

Humboldt always saw his observations in correlation with the natural phenomena in historical context and as interdependent. As a geoscientist he envisioned the interactions between the biosphere and the inanimate nature as a dynamic process. With this context of observations and the historical dimension Humboldt defined the basics of sustainability and sustainable development, which plays an important role in our society today [9].

Wolfgang Lucht stated in a 2009 lecture that Alexander von Humboldt asked himself, how a science of the earth would look like which represents the interactions between the earth, the life and the people [10].

4. ACCESSABILITY OF HUMBOLDT'S WORKS

Struggle with printed documents

Humboldt invested a fortune in creating extensive publications (folio volumes, frequently with plates colored by hand) available to a wider public, but complained about the price in a letter: "My books have not yielded the benefits that I imagined when I set about editing and publishing them; they are too expensive! Besides the one copy, which I own for my personal use, there are only two copies in Berlin of my American travel volumes. One of them is in the Royal Library and is complete, the second the king has in his private library, but it is incomplete, because even for the king, the installments became too expensive"[2].

Digital Libraries

At the present time, however, the highly unconventional form of his publications has undermined the awareness and a comprehensive study of Humboldt's works.

An Internet edition must preserve the author's original intention, retain an awareness of all relevant works, and still adhere to the requirements of scholarly edition.

The Humboldt Digital Library (HDL) is a prototype of a Humboldt information network and was created in 2001

as part of a cooperation project between the University of Kansas and Offenburg University [2]. It is still under ongoing research.

What is missing today is a system providing the overall data structure of internal and external data and the worldwide valid meta data information of those information objects. This has nothing to do with TEI standards [11], but should describe correlation methods and properties of information objects.

Maps, tables, cross-section

A thematic map focuses on a specific theme or subject area, whereas in a general map the various phenomena—geological, geographical, political, etc. appear together. The adequate presentation of Humboldt's maps represents a special challenge because of differences between his drawings and recent maps.

The Humboldt Portal is a first attempt of the combined graphical presentation of Humboldt's travels and the places of his travels in one map (see fig. 3), which was first implemented in the HDL by using the Application Programming Interface (API) of Google Maps to import the observation data [12]. To illustrate this for the user, a dynamic Google Maps application was developed. Route points and places are associated with the search function of the portal. This allows the user, by clicking on a location, to perform a search for the given place name in the portal.



Fig. 3: Google Maps with overlay map from Humboldt and imported place markers by the Humboldt Portal (Source: Humboldt Portal)

The search result lists all detected occurrences of the place name together with related information.

5. Consequences

Following Humboldt's idea of nature, an Internet edition must preserve the author's original intention, retain an awareness of all relevant works, and should supply dynamic links to sources, maps, images, graphs and relevant texts. New forms of interaction and synthesis between humanistic texts and scientific observation need to be created.

The Humboldt digital library (HDL) represents an innovative system to access the legacy of Alexander von Humboldt in a digital form on the Internet [12], following the generic guidelines for presenting texts according to the Text Encoding Initiative (TEI) [11]. It contributes to the key question of how to present interconnected data in a proper form using information technologies. The Humboldt digital library reflects the achievements of Humboldtian science, "as an accurate, measured study of interconnected real phenomena" [7].

At each point the digital library can create a path to relevant observations from Humboldt's documents, which contain the maps, data, and images or information about society, politics, landscapes, geological formations, plants, animals, etc. Together with the identification of almost any point along the Humboldt's route this can lead to the recovery of geographical, anthropological, and biological environment of the early 1800s.

The works of Alexander von Humboldt contain treasures of Humboldtian Science and require an adequate presentation on the Internet. Information technology is the only way to do justice to the broad range of visions, descriptions and idea of nature of Humboldt's legacy.

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