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Arnold GUYOT (1807–1884) and the Pestalozzian approach to geology education

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ABSTRACT

Swiss-American geologist and geographer, Arnold GUYOT's (1807–1884) Princeton University geology lectures employed three Pestalozzian methods: 1) studying local nature before comparing it with distant regions; 2) observing nature first hand, then later integrating this perceptual knowledge with more profound analytic and synthetic thinking; and 3) utilizing extensive visuals to clarify observations. These pedagogical methods remain crucial in provoking an understanding of the history of the globe and of mankind's interconnectedness with the cosmos.

ZUSAMMENFASSUNG

Der schweizerisch-amerikanische Geologe und Geograph Arnold GUYOT (1807–1884) gründete seine geologischen Vorlesungen an der Universität Princeton auf pestalozzische Methoden: 1) zuerst die Natur der näheren Umgebung zu untersuchen, ehe man Vergleiche mit entfernten Regionen anstellt, 2) zuerst die Natur selbst zu beobachten und diese Erkenntnisse erst später in ein vertieftes analytisches und synthetisches Gedankengebäude einzubringen; und 3) die Beobachtungen durch ausführliche bildliche Darstellung verständlich zu machen. Diese pädagogischen Methoden sind nach wie vor von grundlegender Bedeutung für das Verständnis der Geschichte der Erde und der Verbundenheit der Menschheit mit dem Kosmos.

The United States' National Education Association's 1894 Committee of Ten Curricular Report established physical geography as the model general science course for secondary education. Geography's nineteenth-century rise in stature among the sciences in American education was primarily due to the pedagogical prowess of the Neuchâtel-born geographer and geologist, Arnold GUYOT. GUYOT, through his education in Berlin, was exposed to the teaching doctrine of his fellow Swiss nationalist, Johann Heinrich PESTALOZZI, under the tutelage of his own natural history mentor, Carl RITTER. RITTER had visited PESTALOZZI in Yverdon – at the southern tip of Lake Neuchâtel – for several months in 1807. Although he later admitted that PESTALOZZI "knew less geography than a child in one of our primary schools", it was through him that RITTER admittedly gained "his chief knowledge of this science" (De Guimps 1900:264). For it was through his extensive interactions with PESTALOZZI that exposed him to the "natural method" of education. By applying this method to university geography teaching, he claimed to have reduced the "chaos" of the jumbled facts of this science to an attainable "order". Using PESTALOZZI's method, RITTER claimed "I hold in my hand, ... the clue to such a knowledge of the globe as will satisfy both the mind and the heart, reveal the laws of a higher wisdom, and contribute not a little to the science of physico-theology" (De Guimps 1900: 263–264).

RITTER espoused PESTALOZZI's method of this new science in his University of Berlin lectures which typically drew between 300 to 400 students and many fellow academics. One of these students was Arnold GUYOT. GUYOT later served as Professor of Physical Geography and Universal History at the Academy of Neuchâtel. When the 1848 Swiss revo-

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lution against Prussian rule closed the Academy, GUYOT, following his colleague and sometimes roommate, Louis AGASSIZ, fled to the United States. GUYOT was initially employed by the Massachusetts State Board of Education to conduct teacher's "institutes" (i.e., workshops) devoted to improving the methods of geography teaching. His local and national popularity in the states escalated as he spoke to over 1500 teachers a year between 1849 and 1855 at various normal schools and at teacher's institutes held at the Anderson School of Natural History on Penikese Island, Nantucket, Massachusetts (Libbey 1884:25). In 1855, he began what resulted in a thirty-year professorship in Physical Geography and Geology at the College of New Jersey (now, Princeton University). His professorship initiated the academic study of these two disciplines in the United States, and his influence through students including the geologist and paleontologist, William Berryman SCOTT, the physical geographer, William LIBBEY, and the comparative anatomist, Henry Fairfield OSBORN, secured Geology's academic and professional position in the United States.

GUYOT had previously gained geological renown in Switzerland for his studies on the morphology and temperatures of the lakes of Neuchâtel and Morat, and for uncovering the causes or laws of glacial motion as evidenced, in part, by the positions of extant erratic boulders – the latter resulting from his extensive glacial studies with AGASSIZ (Guyot 1838, 1842, 1846). In the US, his popularity soared following the 1849 publication of his *Earth and Man: Lectures on Comparative Physical Geography, in its Relation to the History of Mankind* – a work subsequently translated into German and French. In another physiographical arena, GUYOT's extensive and comparative hypsometric measurements allowed him to produce accurate topographical maps of the Appalachian, Allegheny, and Catskill Mountain ranges (Guyot, 1861, 1880). In addition, through the support of his friend, Joseph HENRY, then Secretary of the Smithsonian Institution, GUYOT established fifty weather stations in New York state – modeled upon the earlier design of stations he designed in Switzerland – from which he gathered standardized climatological data. These stations eventually expanded into the Government Signal Service, now known as the U.S. Weather Bureau (Flemming 1990:117–122). His geological contributions were commemorated by Harry H. HESS's designation of the flat-topped undersea mountains, or seamounts, as guyots (Hess 1946). More recently, a lunar crater has been named in his honor. Interestingly, one of GUYOT's first professional tasks, working under the direction of Alexander von HUMBOLDT, had been to "translate and prepare a notice of BAER and MAELDER's large map of the moon" (Libbey 1884:16). Little did he know that future selenographers would commemorate his own renown with a crater on their lunar cartography.

All of GUYOT's professional pursuits are central to my larger project, a scientific biography of this notable Swiss-American. Geologist Jean-Paul SCHAER has previously discussed GUYOT's contributions towards a better understanding of Neuchâtel's natural history (Schaer 1988). Geographers Sidney ROSEN and Robert ANSTEY described how the *Guyot Geographical Series* of grammar and secondary school textbooks which GUYOT collaboratively produced with Mary Howe SMITH from 1866 to 1882 "revolutionized" geography instruction in the United States (Rosen 1957, Anstey 1958). This paper focuses upon the methods GUYOT employed in teaching geology in New Jersey. I have analyzed GUYOT's Princeton University lecture notes, the notebooks of his students, and material from the university's archives to uncover the extent to which his own pedagogy of geology was tied to Pestalozzian principles. As GUYOT frequently lectured extemporaneously, using only scant notes, the historical importance of his students' formally prepared lecture notebooks remains paramount.

From the outset, I fully appreciate that for GUYOT and many of his contemporaries (especially those trained in the German tradition), geology and physical geography were intimately intertwined. Indeed, he specifically incorporated geology into his geography teaching as well as into his Biblical cosmogony lectures to the Princeton Theological Seminary. Thus, for GUYOT, it would have made little sense to focus on geology alone. However, as it was his framework of geological thinking that was most directly challenged by the evolutionary discourse beginning in the 1860s, I intentionally tease apart his geology and his geography for particular historiographical insight.

According to GUYOT's student, T. Pickney HUGER's 1859 geology class notes, his instructor defined geology as "the preface of the first part of the history of the world" (Huger 1859:2). Indeed, GUYOT often divided his professional pursuits into two distinct categories: Geology – the "Globe as it was" before mankind, and Physical Geography – the "Globe in its relation to man" (Smith 1873:56). Geology embraced not only the study of earlier terrestrial changes, but according to GUYOT, it also incorporated an understanding of the interactions between the earth and all previous living "lower stage" organisms as one ascended the scale of creation towards man. It was a "difficult task", GUYOT argued, to "trace out the history" of the globe before man without using "our imagination in saying what might have been". But the "method of geology" in 1859 was not what it once was. According to GUYOT, geology was no longer a "fanciful stringing together of facts". Rather, it had become a more sophisticated interpreation of facts based upon a "regular system" (Huger 1859:5–6). Specifically, GUYOT's new science of geology required a particular affinity with the facts. If we have only "simple facts in our memory, we have nothing unless they have some reality to us" (Huger 1859:20).

To understand what he meant by "particular affinity", I turn to an analogy, a rhetorical device to which GUYOT often resorted. GUYOT claimed that facts must "enter [the mind] as stone and brick" enter "a building". One can never have a stable or beautiful building of knowledge with "mere facts alone". Rather, the "idea" of a building is only complete when we

understand the "connection and relation[ship]" of the component parts. "We are to look at the prominent facts and trace their relations", he argued. "We may know every little part of a thing, but without knowing [its inter]connection[s], we know nothing [of] what we want." If we "don't see the relations-[ships], we are merely ... animal[s] of keen sharp sight and hearing: looking at these things and hearing them without understanding" (Smith 1873:57–58). HUMBOLDT studied the globe exclusive of man, and he tried to give us a "Cosmos", but "he failed", GUYOT decreed. Man "cannot be known thoroughly without [relative knowledge of] the lower forms". Man "is dependent upon the climate, animal and vegetable life, and upon the whole arrangements of the globe. The higher [forms of life] use the lower for instruments". Geology, therefore, must incorporate a study of the mutual dependence of how "one [life form] exists and furnishes subsistence for the other" (Smith 1873:65).

This "new" science incorporated a regular, systematic interpretation of the facts of geology. For GUYOT, "three great facts" existed: 1) The stratification of the Earth; 2) The dynamic forces which gave the globe its shape; and 3) The fossil evidence of a history of life forms (Huger 1859:20). As a history student of Jules MICHELET, and a former professor of Universal History and Geography himself, GUYOT envisioned that history implied succession and processes which naturally take time. The historical changes of our globe, for example, had he argued, occurred over millennia.

For the geologist, particularly a theistic, Christian geologist like GUYOT (who had initially pursued an education in theology), the dynamic forces and movements associated with recent structural changes of the earth must be considered in relation to the "processes which have been employed by the creator since the creation of the globe". GUYOT envisioned a "permanence" in what he termed the creative "laws of God" (Huger 1859:79–80). And God's laws were purposeful. For example, the marine fossils and bedrock that GUYOT found on mountaintops which many alleged to be mere "sports of nature" were actually there for a purpose: they provided evidence of dynamic geological forces. God does not sport with nature. Rather, GUYOT argued, a teleological pattern exists in nature which, when interpreted as part of a world view, reveals not only geology's realistic past history, but also "the beauty & intelligence of ... [God's entire] creation" (Huger 1859:6).

These glimpses of GUYOT as conveyed through his student's notes reinforce science historian Ronald NUMBER's analysis of GUYOT's harmonic vision between the nebular hypothesis of cosmogony and the Mosaic creation narrative (Numbers 1992:9–11). GUYOT, as a memorial epitaph signified, was ever the "devout student of Nature who loved to trace the Wisdom and Goodness of God in the works of Creation" (Memorial Tablet 1890). However, the university notes also reveal GUYOT's unflagging support of his mentor, Carl RITTER's expressed belief in "Zusammenhang" – or a literal "hanging togetherness" of all things. In organicist terms, the earth must be viewed as a whole, dynamic, developing organism comprising nature, man, and moral and intellectual life all interconnected or "hanging together".

In addition to reinforcing these theological and philosophical convictions, GUYOT's presentation of geology also reflects his strong conviction towards Pestalozzian pedagogy. Three of PESTALOZZI's methods are particularly prominent in GUYOT's lectures: 1) The importance placed upon students gaining a preliminary understanding of local nature before studying and comparing that of far away regions; 2) The importance of observing nature first hand, then progressing from this preparatory "perceptive" stage through later "analytic" and more profound "synthetic" stages through which the perceptual knowledge became interrelated; and 3) The importance of using visual arts to clarify and express students' observations.

As early as 1774, PESTALOZZI argued that schools were, through an unwavering tradition, institutions that actually destroyed students' originality and imagination. Students had become enslaved to a hopeless "bookish" catechism of education (Downs 1975:16). Through a series of writings, most notably, *Wie Gertrud ihre Kinder lehrt*, written while at Burgdorf in the canton of Bern, PESTALOZZI elaborated upon a novel method of education. Teaching, he argued, should proceed from the concrete to the abstract. For PESTALOZZI's students (actually children), this process involved intensely observing the local country, drawing maps of the familiar neighborhoods and landscapes, then revisiting the lands to allow students to refine the accuracy of their drawings. Only after formulating a more concrete knowledge of the local surrounds were his students permitted to expand their study towards distant lands. The ordinary, immediate surrounds were deemed to be particularly useful in cultivating a student's powers of observation. Through this power, they began to understand what was real in the world around them and to connect the natural relationships before extending their gaze more globally.

GUYOT, in his lectures, argued that it was only through direct observation of the solid earth, the water surrounding it, and the plants and animals in and on the earth that they would learn the facts of geology. From these facts, he argued, you can then inductively determine truths – truths such as the answer to whether the earth was "always as it now is" (Maclean 1857:1). To begin answering such critical questions, GUYOT first turned students' attention to their own Princeton campus and then to the Allegheny Mountains in nearby Pennsylvania. For instance, he claimed that an abundance of sandstone existed in both places. A "simple glance at another rock", he continued, was "sufficient to prove that it is made of slate ... [but] not an original [slate]". Rather, it is "sand coagulated with broken pieces of other rocks adhering to it" (Maclean 1857:1). Only after understanding the solid granite composition of the local Pennsylvania mountains should students compare and contrast it with that found further from home, such as in the Swiss Alps.

However, merely reading and reciting such details about these rock formations was, to GUYOT, a waste of time. PESTALOZZI had argued that "words apart from the ideas they represent have no value". He had envisioned that teachers should provide students with "fruitful and salutary impressions" which followed each other in a "natural" but "carefully graduated order" (De Guimps 1900:412–413). PESTALOZZI's educational psychology was based upon what he termed Anschauung – a perception or observation that enabled one to identify his or her interconnectedness with the universe. Such perception, he argued, was founded more upon first-hand observation than upon anything one ever read in books (Downs 1975:83).

Like PESTALOZZI, GUYOT began his course with a direct study of nature – not books. According to his student, William B. SCOTT, the professor "threw aside the old routine methods and brought the student face to face with nature, showing the bearing of the earth's physical features upon every department of human interest" (Scott 1884:263). Although GUYOT regularly imparted key findings of geological discoverers and debates from natural philosophers including CUVIER, WERNER, von BUCH, LYELL, PLAYFAIR, ARAGO, AGASSIZ, and DANA, he based his lectures – or rather demonstrations – upon the "reading" of natural specimens. When GUYOT assumed the chair at Princeton, no natural history collection existed at the school. He immediately gathered a small group of fossils and later purchased specimens from Europe of various geological ages. In 1874, the trustees at Princeton offered GUYOT the large room in Old Nassau Hall that had previously been used as the university library (and for five months in 1783, had served as the new nation's capital), for his own geological museum. He arranged the specimens in this museum – or "Synoptic Room" as he called it – in an order that they would "strike the eye as an open book, in which the student might read at a glance, the history of creation from the dawn of life to the appearance of man" (Libbey 1884:31). To paraphrase social theorist, Anne BUTTIMER, the "diachronic flow" of such an exhibit proved, for GUYOT, to be a "study of the terrestrial unfolding of a divine plan for humanity" (Buttimer 1993:108).

GUYOT later added further archeological specimens gathered from the Neolithic and Bronze Age Swiss Lake Dwellings together with over 5000 specimens of erratic rocks from Switzerland which illustrated eleven alpine erratic basins. The latter, collected and arranged by GUYOT himself, were organized so that they would demonstrate the "extension, thickness, and limits of the great ice masses which covered all [of] Switzerland in the Diluvian Age". Ever focused on factual evidence, Guyot taught that these specimens represented "proof of the theories generally accepted concerning the Glacial Epoch" (Libbey 1884:32).

GUYOT's insistence upon the study of natural specimens themselves prompted his organization of a transcontinental scientific expedition – the first of its kind in the United States – to gather further original evidence. The initial expedition in the summer of 1877 was organized and led by William B. "Geology Bill" SCOTT and Henry Fairfield OSBORN. This venture exposed and retrieved many paleontological specimens from the Bridger Basin area of Wyoming's Bad Lands which were subsequently added to GUYOT's teaching museum.

PESTALOZZI had argued that ideas became solidified through "graphic exercises" and through drawing. For geology – as was also true for geography – learning to design and read maps was viewed as essential for enhancing one's sense-impressions. That is, the words of geology became more meaningful, more useful, when reinforced through visual representation.

Like PESTALOZZI, GUYOT adopted the medium of multi-colored pictorial maps as part of his pedagogy. With the assistance of his nephew, Ernest SANDOZ, GUYOT designed at least 46 large wall hangings to illustrate central points of his lectures. Relevant to his geology course, six wall hangings focussed on "geologic processes" such as the formation of earthquakes, volcanoes, and glaciers, eleven presented pre-Pleistocene geology, and four were devoted to Pleistocene (Glacial) geology. One of the wall hangings was a 2.4×3.4-meter map of the distribution of glacially transported erratic boulders throughout Switzerland. The path of transport of each different rock type was depicted in a different color.

According to his student, William LIBBEY, GUYOT "aimed to teach the mind through the eye as well as by oral instruction". His "diagrams and maps were a good example of the way in which he met the demand for facts systematically arranged, . . . they always contained just the facts needed, no more, or no less, they were clearly expressed and printed so that every one in the room could see just exactly what was intended, and every other detail which might distract the attention from the main features . . . [was] banished from the maps as useless" (Libbey 1884:34).

Moving from the simple to the complex, from gathering facts to formulating conclusions, from observing the particular towards building the view of a harmonious, complete, interconnected universe – these Pestalozzian principles represent GUYOT's new epistemology of geological pedagogy. Not only would these processes build a complete intellectual foundation, GUYOT argued that a student's thorough understanding of his direct connectedness with the cosmos would help shape his moral values as well.

As a college instructor, I sense that some of GUYOT's (and thus, PESTALOZZI's) methods might be helpful to combat the rise of scientific illiteracy – at least as it is seen in America. Today, most science textbooks quickly immerse students into the "foreign" and abstract territory of cellular and intracellular phenomena without first addressing more local and global issues like ecology and diversity – two topics with which beginning college students are already likely to have some familiarity. GUYOT's methods seem to be most useful, practical guidelines for gradually adding to students' individual perceptions of the living world from an interconnected, macroscopic to an individual, microscopic view. Science education

specialists today argue that the most successful teaching methods build upon a student's "comfort zone" of knowledge. Rather than initially subjecting students to long lists of "foreign" scientific terminology, perhaps we would all benefit from allowing them to experience GUYOT's expressed belief that terms and concepts are only of lasting value if they are first engrained upon the familiar and then reinforced through visual, sense-impressions.

Perhaps we, as academicians, should consider how these methods might be further incorporated into our own classroom instruction today. Geology and geography remain crucial subjects through which students can gain an understanding of the history of the globe and their own interconnectedness with the cosmos. Perhaps by reinforcing some of GUYOT's beliefs about the interrelationship between earth and man, our students will develop a deeper understanding about what it means to be human.

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