The emerging field of plant physiology: Heinrich Friedrich Link, Mathias Jacob Schleiden and the *Jahresberichte für physiologische Botanik*.

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I. On June, 13, 1842, Heinrich Friedrich Link (1767 - 1851), holder of a professoral chair for botany at the Friedrich-Wilhelm-University in Berlin and director of the Royal botanical garden in nearby Schöneberg, sent a letter to the Prussian Ministry of ecclesiastic, medicinal and educational affairs. The authorities were pleased to find two of his latest works attached: first his *Alterthum und der Übergang zur neuern Zeit* and second yet another volume of the *Jahresbericht über die Arbeiten für physiologische Botanik im Jahre 1840*, the first he had edited on his own account after his co-editor's untimely death.

In Link's opinion it was especially the second work which he felt more than relevant to prevent from, what he called, premature opinions. Among others, as Link amplified, the volume presented works of a person called Schleiden, a man who had already tried to twice commit suicide and who continually came up with aspersions towards J. J. Berzelius and Link himself, things which characterized Schleiden sufficiently enough to not take further notice and to somehow endure his crude judgements.

II. History, and foremost the history of botany, has proven Link wrong for it was especially Matthias Jacob Schleiden's work Grundzüge der wissenschaftlichen Botanik (1842) which was taken as a programmatic textbook of Schleiden's own and also later generations of botanists. Particularly the historical account of Julius Sachs' (1832-1897), *History of botany. 1530-1860*, has led to the general assumption of lacking achievements within the science of botany and physiology in the decades prior to Schleiden and his contemporaries. By denying accurate and experimental research scholars such as Sachs only made out the most detrimental impacts due to the "frivolous dilettanteism" this older generation had been spending their time with. They dispised the times "where plant-collecting in wood and meadow and in rummaging in herbaria" made botany a rather dubious science. Works, such as Link's *Das Alterthum und der Uebergang zur neuern Zeit* (1842), a continuation of a book already published in 1821/22, and botanical works prominently inspired by natural philosophy surely were proof enough for this new generation to somehow challenge the achievements of the elder. This, however, does not mean that Schleiden in his late years did not publish historic works of similar rank and matter as well.

Link, as he remarked in the preface of the 1840 Jahresbericht (p. 1), wanted to stay away from such hostilities, as the proceedings of the anatomy and physiology of plants had been detained rather than promoted by such. But he did not hesitate to present the views and works of Schleiden in the light which he felt characterized his methods most. By citing long passages (p. 9) of the presented works Link wanted to hint at the overall assumptive character of Schleiden's theories. With the clarified view of the elder it was only necessary to let Schleiden speak for himself (p. 48).

In the opinion of Schleiden, Link was far away from understanding the at present very narrow circle of established facts let alone to compile those amongst an approriate and methodologically consistent point of view. In order to somehow broaden the so far constricted circle of established facts Schleiden in the first part of his *Grundzüge* put forward the inductive method as his and his contemporaries' botanical manifesto.

However, according to Schleiden, Link was only presenting hypotheses grounded on imperfect observations, although Schleiden himself clearly embraced observation as the most relevant method as all objects of botany were actual existences. Link explicitly argued that it was neither the new intellect that was to stimulate botany, as Schleiden had written in the preface of his *Grundzüge*, nor serious studies which would more and more supersede and replace the alleged *Speciesgetändel* (toying around with species). Rather these works were premature at best as the *Erklärungsgründe* (attempted explanations) of the *Erfahrungswissenschaft* (empirical science) of botany had been rather limited. - Schleiden, needless to say, on his own account was logically consistent following the natural sciences which he saw as an implementation of applied mathematical logic. That he disregarded, or even ingnored the many works of his predecessors, something he spelt out as innovative, was most likely one of the principal reasons for Link's negative approach.

III. Taking Schleiden's view *verbatim* one could assume that Link did not take the various spheres of the diverse natural sciences into an approriate account. This, in quintessence, had been one of the most essential accusations of the younger generation of botanists who only saw the older botanists chasing the ominous *Lebenskraft* - or vital principle - and by doing so, as the chemist Justus Liebig (1803-1873) in his *Organic chemistry in its application to agriculture and physiology* (1840) claimed, leaving both their senses and skills far behind.

This, however, has never actually been the case. The physiology of plants has already had a long history of its own prior to the 1840s. Already in the 1790s Alexander von Humboldt (1769-1859) was pursuing experimental research with plants that was inspired by the works of especially French chemists of the time. Much of this research was collected in the publication of his *Aphorismen aus der chemischen Physiologie der Pflanzen* (1793) which Humboldt dedicated to Carl Ludwig Willdenow (1765-1812), at the time director of the Royal botanical garden in Schöneberg. His introduction about the objects of plant physiology to the work of the Dutch physician Jan Ingen-Housz, *An essay on the food of plants and renovation of the soil*, published in German in 1798, was of highest influence to later generations of botanists, physiologists and agriculturalists who held the work in high esteem. According to Humboldt he had implemented some 4000 experiments between 1792 and 1798. Many of these dealt with various plant species and focussed on plant physiology within a chemically inspired research and observation, something he himself had termed "vital chemistry" or "chemical physiology of plants."

Only little later, Link - in his book *Grundlehren der Anatomie und Physiologie der Pflanzen* (1806, printed 1807) - brought many ideas forward which were, strictly speaking, of physiological nature. With this, he was in accordance with many renown botanists of his generation, such as Ludolf Christian Treviranus (1779-1864) and his books *Vom inwendigen Bau der Gewächse* (1806) and *Beiträge zur Pflanzenphysiologie* (1811), not to mention the contemporary works of Georg Dietrich von Kieser (1779-1862) and Paul Moldenhauer (1766-1827).

Many of therein discussed issues were stimulated by general physiology, which at the time was thought to clearly facilitate the study of the nature and life of plants. This general physiology of natural bodies, foremost a field of medicine, provided for the concurrent principles and fundamentals for the physiological investigation of the vegetable kingdom. Again it was the chemical analysis which in the eyes of the botanists supplied the means for identification of objects as it helped to aquire a much finer differentiation. Chemistry and physics not only in the Humboldtian, and later in Liebig's aggressive opinion were able to trustworthyly disseminate the brightest light on the physics, and the life, of all natural bodies.

Endowed with basic equipment, such as microscopes, lenses, scissors, anatomical knives and needles, these botanists ventured into an anatomical research studying the structural details and morphological designs of plants. By doing so they gave a rich account of how closely comparative and morphological as well as developmental studies had already been associated with contemporary physiological enquiries at the beginning of the 19th century. This, although usually presented otherwise, had not been too different in the late 1830s and early 1840s, as the works collected in the *Jahresberichte* clearly demonstrate. Many of these works primarely dealt with plant anatomical and morphological research which tried to gain insights into the principles of the living processes of plants.

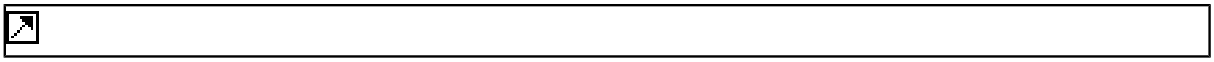
And it was, next to circumstantial taxonomical works in the realm of the botanical gardens, also the life and chemistry of plants which already in earlier times, around the turn of the century, was of highest importance to the doings of botanists. This is nicely illustrated again by Link who, after taking up the directorate of the Royal botanical garden in Schöneberg, set aside a laboratory within the greenhouses to further pursue, as he remarked in a report to the authorities in 1816, plant chemistry, or as he himself termed it, *vegetabilische Chemie*.

IV. Due to the foundation of the *Society for the advancement of horticulture in the Royal Prussian states* in Berlin in 1822, with Link as one of its founding members, much of this physiological research ventured outside, into the field and garden. Not only did the society supply beds for experimental trials on its premises close to the Royal botanical garden at Schöneberg but also at an observatorio nearby Sanssouci garden. These experimental beds were also generally used for the propagation of scientific knowledge by means of observation, cultivational trials and scientific analysis. The society's gardens provided for the visual demonstration of physiological research as part of a hands-on experience as well as for an ostensive visualisation of the living processes of plants. In this context it was an application of the Humboldtian vital chemistry in connection with the pursuit of the physical life of plants in the realm of the *Erfahrungswissenschaft* of botany. Thus, the society helped to establish an institutional framework for scientific and manageable experimental research which was not too different from later experimental work within laboratories.

The society further initialised a forum for continuing discussion where laymen as well as scientists of the various fields of the natural sciences could contribute and present results gained in their private gardens. Although many of these experimental trials concerned the growth of plants, the renovation of the soil or the comparison of various economically profitable plant species, known or unknown, those people nevertheless contributed tremendously to the field of botany and physiology alike. For once reported, these finding were discussed and looked over by scientists such as Link who in many instances reviewed and evaluated the contributions which later were brought to the interested public in the society's journal.

Already at this stage physiology has to be considered as a buzzword and the physiology of plants as a topic exceedingly *en vogue*. As almost every botanical detail was connected to plant physiology, also morphology and plant anatomy were examined in the light of the life and living features of plants. As anatomical and morphological characteristics of plants were taken as an image of their physical life nearly every amateur of science could become an experimenter. Botanical life was all but synonymously taken for physiology.

V. Some fifteen years after the foundation of the society Link and Julius Ferdinand Meyen (1804-1840) started to edit a series on the various accumulating works of physiological research in the fields of botany. Meyen had made his entrance into the scientific world with his work



Phytotomie (1830), and had also dedicated his *Plant physiology* (1837-1839) to Link as Link in his view had to be considered as the "founder of plant physiology" in German botany. Next to Link he reported many new findings and results of the field he was working in at the society's meetings.

The introduction to the first volume of the *Jahresberichte* (1838, p. 1), which most likely was composed by Meyen, almost casually reported of the outstanding success physiological research in the various botanical disciplines had experienced in the past which necessitated a series in which all of these works were collected and brought to the audience of its many researchers.

Meyen in his brief introduction also emphasised that much of this research was concerned with morphological and anatomical enquiries. Thus it did not differ too explicitely from the botanical research implemented in the decades before. Rather, it was regarded as a continuation of the works already done which also explains why the works of Schleiden, even though considered to be of assumptive character, had been among those presented most often. Given the amassment of material, the overall active participation and thus the provision of the most secure foundations the field was progressively advancing into a bright future.

VI. The annual *Jahresberichte* somehow shed light on this period where different attitudes of what botanical science actually meant collided - lifeless phrases and superficialities vs. premature opinions. This probably seems to provide the most tellingly and acurate statement of the period. It was not an argument about the materiality of the research objects as both Link and Schleiden surely could agree, e.g. on the importance of observation and the relevance of chemistry and physics to botanical and physiological research. Headmost it was an argument of the basic principles of the respective discipline. Both groups of botanists were persuing to understand the life of plants, and by undertaking physiological research to lay the simplest and most general foundation of the science of botany. In that respect they did not differ too much.

It by no means had been the case that older botanists were solely working at a time "where plant-describing was comfourtly flourishing" - as Julius Sachs would later paraphrase the time. As the first volume, and also all sucessive seven volumes of the *Jahresberichte* edited until 1847, covered almost all relevant contributions of the many botanists, chemists and physiologists working in the field, both generations took part in the defining work of the new field of plant physiology.

This physiology in its earliest stages, and without actually having a precise name and meaning that later generations would find for it, did initially progress by seeing, be it through the active engagement of the eyes of the many observers, visual experimentation or the microscopical study of the processes thought to be associated with the diverse and omnipresently experienced living features of plants.

The older generation of botanists, for which Link might act as a representative, did not adhere to the older conviction but rather managed to provide an itself establishing and defining discipline a panel taking into account the works of Schleiden and also Theodor Schwann (1810-1882), who together and in competition with Meyen and Schleiden put forward a theory of cell development.

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