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From Laboratory Lichens to Colonial Symbiosis. Melchior Treub Bringing German Evolutionary Plant Embryology to Dutch Indonesia, 1880–1909

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ABSTRACT

In this article I demonstrate that Buitenzorg formed an important site for developmental botany or plant embryology. The research station at Buitenzorg was not only a place for colonial big science, but also a hotspot for new transformations in biology. This article focuses on the evolutionary science practice of Buitenzorg's director Melchior Treub and on how he adapted a German style of laboratory biology to the reality of the colonial tropics. In Buitenzorg, plant embryology evolved from a European taxonomic Hilfswissenschaft into a leading sub-discipline of colonial agricultural science. Studying cooperation in nature, Treub was extra keen on experimenting with new forms of political cooperation in the empire.

Keywords: Melchior Treub, plant embryology, research stations, development, imperialism, Buitenzorg

In contrast to previous directors, Melchior Treub was not overly excited when he moved to the Dutch colonies in Southeast Asia to take up the position of director of the Plantentuin in Buitenzorg. Treub had ambitions for a European professorship instead and would feel exiled during his first years in Java.[1] Nevertheless, he would stay for 29 years, until 1909. Under his directorship the Plantentuin transformed from a botanical garden with a handful of European staff – and already several more Javanese and Sundanese workers – into a central imperial office for science and agriculture, with more than ten laboratories in Java and Sumatra and hundreds of bureaucrats, scientists and labourers, not only from the Indonesian Archipelago but also from other parts of the world. The garden in Buitenzorg in 1909 had a double func-

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1 Letters Melchior Treub to Paulus Hoek, January 3rd 1881 and March 7th 1881, Hoek Correspondence, Artis Library Amsterdam (hereafter HALA); J. P. Lotsy, 'Levensbericht van Melchior Treub', *Jaarboek van de Maatschappij der Nederlandse Letterkunde* (1912) 1–31, at 16.

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tion. On the one hand, it was the seat of the colonial government department of agriculture which was in charge of rationalizing the Dutch Indies plantocracy. On the other hand, it was an impressive science complex in itself, a 'botanical agronomic institute'.[2]

Moreover, its famous visitors' laboratory (1885) had by then drawn hundreds of visitors from Europe, Asia, the Pacific, America and even Africa. It had become a hotspot for tropical botanists, which was both modelled on and almost on par with the zoological station of Naples, and formed itself a model again for other tropical field laboratories in other empires and their programs of agricultural colonial development, including the American Caribbean.[3]

This article analyses one of several ideological (re)sources of Buitenzorg's spectacular growth and transformation from a sleepy botanical garden in the 1850s into a centre of colonial big science, which I have already demonstrated elsewhere.[4] This article zooms in on Treub's evolutionary plant embryology and puts it in the context of developments in European laboratory biology. Evolutionary plant embryology was the combined effort in phylogenetic and ontogenetic botany encompassing the search for evolutionary family relations between different plant groups through the microscopical analysis of plant growth. Plant embryology, a somewhat neglected field in the history of biology, was a field within the larger area of experimental morphology, and was called in French *embryologie végétale*, or in Russian *embriologia rastenij*. However, already in 1849 Wilhelm Hofmeister had written about the embryos of phanerogam plants, and he was not the first to write about plant embryos.[5] Hofmeister was a self-taught German microscopical botanist who wrote *Die Entstehung des Embryos der Phanerogamen. Eine Reihe mikroskopischer Untersuchungen* in 1849 and who was the first to claim that the alternation of generations formed the general principle for the development of plants. Contemporaries such as Hugo de Vries saw Treub's research as amending the work of Wilhelm Hofmeister with Darwin.[6]

Treub's phylogenetic botany was the product of a double appropriation: Dutch biologists were adopting Germany's program of laboratory botany, while at the same time German

2 For more on this process, see both: Andrew Goss, *The floracrats: state-sponsored science and the failure of the Enlightenment in Indonesia* (Madison WI 2011) chapters 3 and 4; Robert-Jan Wille, *Mannen van de microscoop. De laboratoriumbiologie op veldtocht in Nederland en Indië, 1840–1910* (Nijmegen 2019), chapters 5 and 6.

3 Eugene Cittadino, *Nature as the laboratory: Darwinian plant ecology in the German Empire, 1880–1900* (Cambridge 1991); Ulrike Kirchberger, 'Wie entsteht eine Imperiale Infrastruktur? Zum Aufbau der Naturschutzbürokratie in Deutsch-Ostafrika', *Historische Zeitschrift* 291 (2010) 41–69; Raf De Bont, *Stations in the field: a history of place-based animal research, 1870–1930* (Chicago 2015); Megan Raby, *American Tropics. The Caribbean roots of biodiversity science* (Chapel Hill 2017); Florian Wagner, 'From the Western to the Eastern model of cash crop production: colonial agronomy and the global influence of Dutch Java's Buitenzorg laboratories, 1880s–1930s', in: Joe Regan and Cathal Smith eds., *Agrarian reform and resistance in an age of globalisation. The Euro-American World and Beyond, 1780–1914* (Abingdon & New York 2018);

4 Wille, *Mannen van de microscoop* (n. 2).

5 Interestingly, the 'history of plant embryology' has been mainly written in Russian or French between the 1930s and 1950s. René Souèges, *L'embryologie végétale: résumé Historique* (2 vols, Paris 1934); P. A. Baranov, *Istorija èmbriologii rastenij v svjazi s razvitiem predstavlenij o zaroždenii organizmov* (Moscow & Leningrad 1955). I wish to thank Anastasia Fedotova for translating and summarizing parts of Baranov's work. At the end of the nineteenth century even a kind of plant *evo-devo* avant-le-lettre emerged in the margins, in which plant embryology recapitulated plant evolution. For example, in 1894, the Belgian botanist and visitor to Treub's Buitenzorg, Jean Massart wrote a 100-page article called 'La récapitulation et l'innovation en embryologie végétale', Jean Massart, 'La récapitulation et l'innovation en embryologie végétale', *Bulletin de La Société Royale de Botanique de Belgique/Bulletin van de Koninklijke Belgische Botanische Vereniging* 33 (1894) 150–247.

6 Hugo de Vries, 'De oorsprong der bloemen', *De Gids* 68 (1904) 507–528, here 508.

Fig. 1: *Melchior Treub (above, third from the left) among international botanical (and zoological) peers at the Manchester meeting of the British Association for the Advancement of Science in 1887. Second row, third from the left is Anton de Bary*. W. R. Fisher, Photographer. 11/22/1926. Botanists at Manchester, England 1886 (sic!). Place: Cornell University. Plant Pathology Herbarium (CUP), CUP Collection. https://library.artstor.org/asset/SS33668_33668_3577919 (accessed February 19, 2019).

biologists struggled to incorporate Darwinism into the microscopical analysis of plant and animal development. As Eugene Cittadino has shown, the Dutch imperial gardens had a unique selling point: a tropical research laboratory aimed at developmental biologists, the result of Treub's bringing laboratory biology to Buitenzorg.

This article does not say that Treub was a visionary who immediately understood what Buitenzorg could do for a new type of European biology. He struggled with the idea that he had to further his academic career in the tropics. The transformation of Buitenzorg under Treub's direction was not the outcome of a grand strategy.[7] Treub's institute grew

7 Robert-Jan Wille, 'The co-production of station morphology and agricultural management in the tropics. Transformations in botany at the Botanical Garden at Buitenzorg, Java 1880–1904', in: Denise Phillips and

incrementally. The botanical-agronomical institute was set up from below and every laboratory and staff member had been lobbied for through alliances made with different parties. These parties included the state forest department, the military, Sumatra tobacco planters and Java tea planters. That several European national science academies, including the Royal Dutch Academy of Science, financially supported the stays of scientists in the visitors' laboratory was the result of diplomatic travel and one success generating another. The story of Buitenzorg as the result of a grand science strategy was a story that was told only later, for example famously so by the Utrecht botanist Frits A. F. C. Went, who had worked in the Dutch Indies and who had been a visiting student in the visitors' laboratory and would later become fundamental in the establishment of the Dutch Applied Science Organization TNO.[8]

From the beginning of Treub's directorship, it was not self-evident that Buitenzorg would become the main seat of Dutch Indies academic science. Of course, the cultivation of export crops formed the fundament of the imperial economy and there were no universities to compete with, so there were opportunities. But in the 1880s, it was even more unlikely than in earlier decades that Buitenzorg would become a global research centre. When Treub travelled to the Dutch Indies, botanical gardens in the tropics were not seen as stepping grounds for a career in scientific botany. Although Darwin and Wallace had inspired new generations of European students with an evolutionary biology based on fieldwork in South America and the Malay Archipelago, most young biologists in Europe felt that staying inside university laboratories was a much better strategy for pursuing their careers.[9] Darwin inspired students, but the methodologies of the German laboratory compelled them to stay inside the urban laboratory.[10]

So how did Buitenzorg become such an important site of study for laboratory biology in the tropics around 1900 and creating the ingredients for modern imperial politics including agricultural interventionism and a kind of developmental modernism? This article claims that Treub's political lobby and colonial ideology built on a specific scientific practice: plant embryology. From his scientific practice he moved to a political ideology of mutualism, in which national and international scientists worked together with the colonial government and the local planters to create a successful Dutch Indies technocracy, in which there was also a place for local workers, albeit in a subordinate position.

But with mutualism came also a parasitic tendency. Without access to a university in the Dutch Indies, local Javanese and Sundanese did not have the same chances, by far, that Europeans had in this new 'diploma empire', in which degrees were given by European or North American institutions. Thanks to the university as obligatory points of passage, Dutch or German academic migrants got top positions at the cost of local (Dutch, Javanese

Sharon Kingsland (eds.), *New perspectives on the History of Life Sciences and Agriculture*. Archimedes series in the history and philosophy of science (Dordrecht 2015) 256–281.

8 Wille, *Mannen van de microscoop*, chapters 5 and 6 (n. 2); David Baneke, *Synthetisch denken: natuurwetenschappers over hun rol in een moderne maatschappij, 1900–1940* (Hilversum 2008) 52, 116; F. A. F. C. Went, *De plicht der vaderlandsche wetenschap jegens tropisch Nederland. Redevoering uitgesproken bij de opening der 143e algemeene vergadering van het Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen* (Utrecht 1916). For more on Went, see also: Wim van der Schoor, 'Biologie en Landbouw. F. A. F. C. Went en de Indische proefstations', *Gewina* 17 (1994) 145–161.

9 Soraya De Chadarevian, 'Laboratory science versus country-house experiments. The controversy between Julius Sachs and Charles Darwin', *British Journal for the History of Science* 29 (1996) 17–41.

10 Erik Zevenhuizen, *Vast in het spoor van Darwin: biografie van Hugo de Vries* (Amsterdam 2008) 44–58.

and Sundanese) elites who had governed in Buitenzorg for centuries.[11] Indonesians became laboratory assistants, expedition leaders to New Guinea, photographers and gardeners, facilitating the evolutionary morphological work of Buitenzorg's staff members and their international visitors.[12] Cooperation and competition were inter-European themes that were producing new labour divisions in the Indonesian archipelago.

This is an article about the intellectual transformation at the base of this new labour division a generation later, in which laboratory biology stood lonely at the top of a colonial technocracy, with academic biologists leading the imperial department of agriculture.[13]

Botanical transformations

This article argues that in order to understand Buitenzorg's growth, we have to analyse the general transformations in botany around 1880 and look at them in a different light. Instead of focusing only on those practices in botany out of which emerged the new disciplines of the twentieth century, we need to take a broader and global look at the development of late nineteenth century evolutionary plant embryology.

Many historians of botany who focus on what we could call a global Progressive Era have focussed on proto-genetics and proto-ecology instead of plant physiology and plant embryology which were more dominant then.[14] They have analyzed the seeds of revolutionary practices either indoors (genetics) or outdoors (ecology). With the exception of historians of agricultural science, they have ignored the plant embryology which halfway through the nineteenth century became a normalized practice without having a clear revolutionary moment. The neglect of plant embryology is the result of historians focusing too much either on more revolutionary practices of urban laboratory physiology and genetics or on field ecology. Historians of botany – as opposed to historians of zoology –[15] have not focussed on the impact of field stations as third zones next to the laboratory and the field. The stations were more than just temporary nodes for dissatisfied laboratory biologists inventing the new field of ecology. Botanical stations such as Buitenzorg were important sites on their own.[16]

In zoology, field laboratories such as Naples became fundamental in creating a new international infrastructure of developmental zoology, both phylogenetic and experimentalist. Botanical stations such as Buitenzorg formed a niche for a large and inclusive form of plant embryology that was both more traditional and more ambitious than the new scientific

11 This is me paraphrasing Mark Bovens and Anchrit Wille, *Diploma democracy: the rise of political meritocracy* (Oxford 2017). The term of obligatory passage point is from Michel Callon, 'Some elements of a sociology of translation: domestication of the scallops and the fishermen of St. Brieuc Bay', in: John Law (ed.), *Power, action and belief: a new sociology of knowledge?* (London 1986) 196–223.

12 Robert-Jan Wille, 'Een Indische geschiedenis van parasitisme en symbiose. De tropen als laboratorium voor de vervlechting van politiek, wetenschap, maatschappij en natuur', *Groniek* 200 (2014) 295–316.

13 For more on the labour division: Wille, 'Een Indische geschiedenis' (n. 12); Wille, 'The co-production' (n. 7) and Wille, *Mannen van de microscoop*, chapters 3, 5 and 6 (n. 2). On academic botanical technocracy in the Dutch Indies, see also Goss, *The Floracrats* (n. 2) and Suzanne Moon, *Technology and ethical idealism: A history of development in the Netherlands East Indies* (Leiden 2007).

14 Compare for the same argument on twentieth century botanical physiology: Robert Meunier and Kärin Nickelsen, 'New perspectives in the history of twentieth-century life sciences: historical, historiographical and epistemological themes', *History and Philosophy of the Life Sciences* 40 (2018) 1–13.

15 Robert E. Kohler, *Landscapes and labscapes: exploring the lab-field border in biology* (Chicago 2002); De Bont, *Stations in the field* (n. 3).

16 Cittadino, *Nature as the laboratory* (n. 3).

ecology of botanists such as Eugen Warming, and which included plant chemistry, the study of plant-plant and plant-animal symbiosis and even comparative ecology, as this article will show through the analysis of Treub's embryology.

What mattered most in Buitenzorg was the 'holist materialist'[17] *biologie* of plants and the organisms that depended on them, the connection of plant physiology and embryology with phylogenetic taxonomy, ecology, and allied sciences such as entomology and organic chemistry.[18] Because Buitenzorg was a regional and imperial center, the biology of Treub had an impact on the Dutch empire as a whole, the Southeast Asian region, and global practices of colonial scientists. So, before dealing with Treub's embryological study of lycopods, lichens and orchids, and before dealing with Treub's embryology work in the Dutch empire, I need to stress the institutional leverage that Buitenzorg had at the turn of the century: imperial and global.

The institutional potential of Buitenzorg and the position of Treub

In 1899 Treub himself suggested the garden was not a proper garden anymore, and only kept to the name for historical reasons: under his directorship it had become a 'botanical agronomical institute' instead.[19] Treub had built a logistical center. He imported and exported seeds and books, he disseminated information and research results through several channels, correspondence with many European and American scientists included. Treub published several journals and monograph series, the 'scientific' *Annales du Jardin Botanique de Buitenzorg*, founded by his predecessor in 1876, but transformed into a European style quasi-academic journal; the more practical-economical Dutch language journal *Mededeelingen van 's-Lands Plantentuin* (1884–1905) which had become the *Mededeelingen uitgaande van het Departement van Landbouw*; the horticultural public journal *Teysmannia* (1890–); the more detailed taxonomic *Icones Bogorienses* (1897–), in Latin; the plant guide *Flore de Buitenzorg* (1897–) and the international and more practical *Bulletin de l'Institut botanique de Buitenzorg* (1898–).

Buitenzorg had developed into a global, regional and imperial center by the year 1905, when Treub became secretary-general of the department of Agriculture, and the German director of the Berlin Botanical Gardens, Adolf Engler, visited the Dutch Indies. More than 100 scientists had stayed at his visitor's laboratory, a third of them Germans, and more than half of them German-speaking (including Austrian-Hungarians and Swiss). The rest were equally divided between Dutch, Russians and others. Next to international visitors, many of its staff members were from outside the Netherlands, especially from Germany and Switzerland.[20]

Treub oversaw several sites. In 1905 there were three gardens: the main garden, an economic garden (*cultuurtuin*) close to the main garden, and further south on the slopes of the Gede volcano at Tjibodas, a mountain garden and ecological reserve which was originally a cinchona acclimation garden. In these gardens were several laboratories, including three botanical laboratories, an agricultural-chemical laboratory and a pharmacological laboratory. But there were also institutes allied to these laboratories: a herbarium and museum for systematic botany, a museum and information office for technical and economic botany

17 Garland E. Allen, *Life science in the twentieth century* (New York 1975) xxi–xxiii.

18 Wille, 'The co-production' (n. 7).

19 Melchior Treub, *Over de taak en den werkkring van 's Lands Plantentuin te Buitenzorg* (Buitenzorg 1899) 1–3.

20 K. W. Dammerman, 'A history of the visitors' laboratory ("Treub Laboratorium") of the Botanic Gardens, Buitenzorg, 1884–1934', in: Pieter Honig and Frans Verdoorn (eds.), *Science and scientists in the Netherlands Indies* (New York 1945) 59–75.

focussing on (potential) cash crops, a zoological museum and workshop, an agricultural college, a photography workshop, a large research library, and several administration buildings. In Batavia there was a dependent fisheries laboratory. Buitenzorg had several experiment stations[21] and demonstration fields at Java and Sumatra, for rice and secondary crops, for coffee, tea, indigo, and Sumatran tobacco. There was a different one for tobacco in the *Vorstenlanden*, a region comprising the four Javanese principalities with their own *kratons* but under Dutch rule: the sunanate of Surakarta, the sultanate of Yogyakarta, and the principalities of Pakualaman and Mangkunegaran.[22]

Treub organized big science. In 1898, 24 European staff members had been working at the different institutes, with 15 of them having academic degrees; more staff members would join them in the seven years to come.[23] The number of non-Europeans working for low wages as plant collectors, gardeners, laboratory assistants, builders, desk clerks, photographers and librarians had reached 200 in the early 1890s, at a time when there were still four laboratories and only a few other smaller sites of work, so this number must have grown enormously by 1905, even not including all the extra administrative staff that came with the new department.[24]

At that time, bureaucracy had fully taken over Treub's own science practice, but at the same time he was able to manage the science of many others. The buildings he had built and the staff members he oversaw stimulated developmental biology and its allied sciences. Treub saw himself as the commander of a 'Bogor ship', as he wrote to Ernst Haeckel, who had been very impressed by Treub's institute when the eminent German visited him at the end of the century to work on his *Kunstformen der Natur*.[25] In his *Malayische Reisebriefe*, Haeckel wrote that in 1893 the institute sent 1927 letters, two years later already 2350, and that in 1897 the number doubled: 4302 letters were sent.[26]

Treub also was a directing member of several scientific societies, a colonial exploration committee that became a national society ('the Society for the Advancement of Scientific Research in the Dutch Colonies', with two branches in the Netherlands and the Indies), and the Royal Physical Society of Batavia. He was the only full member from the Dutch Indies in the Royal Dutch Academy of Sciences in Amsterdam, with colonial residents normally being correspondents only; Treub always attended its meetings when he visited the Netherlands.

When the *Preussische Akademie der Wissenschaften* in Berlin celebrated its 200 year anniversary in 1900, it made two Dutchmen honorary members: the physicist Johannes van der Waals as the president of the Royal Dutch Academy of Sciences and Treub. He had been recognized as the official science leader of the Dutch Indies.[27] This had also been recognized by

21 For more on the Indies experiment stations, but with a focus on the private ones, see Wim van der Schoor, *Zuivere en toegepaste wetenschap in de tropen. Biologisch onderzoek aan particuliere proefstations in Nederlands-Indië, 1870–1940* (Apeldoorn 2012).

22 *Verslag omtrent de te Buitenzorg gevestigde Technische Afdeelingen van het Departement van Landbouw* (Batavia 1906).

23 Wille, 'The co-production' (n. 7) 264.

24 Wille, 'Een Indische geschiedenis' (n. 12); Melchior Treub (ed.), *Der botanische Garten' 's Lands Plantentuin' zu Buitenzorg auf Java. Festschrift zur Feier seines 75jährigen Bestehens 1817–1892* (Leipzig 1893). See also the Botanical Garden Yearbooks of these period for wages and information about individual Javanese and Sundanese staff members.

25 Letter Melchor Treub to Ernst Haeckel, August 14th 1901, Ernst Haeckel Haus, Jena, Correspondence Haeckel-Treub.

26 Ernst Haeckel, *Aus Insulinde; malayische Reisebriefe* (Bonn 1901) 70.

27 Frans H. van Lunteren, 'Wetenschap voor het vaderland. J. D. van der Waals en de Afdeling Natuurkunde', in: Klaas van Berkel (ed.), *De Akademie en de Tweede Gouden Eeuw* (Amsterdam 2004) 43–106, here 43–44.

Fig. 2: *Personnel of the Department of Agriculture, picture taken in the last year of Melchior Treub's directorship, 1909, Collection Tropenmuseum, Wikimedia, CC BY 3.0*.

the colonial state itself, which had endowed Treub in 1898 with a nominal professorship to celebrate the 25th anniversary of his doctorate, a legal decision that had no precedent in an archipelago without a college at that time.[28] This was not the only honor bestowed upon him. When Treub left the archipelago in 1909, he wore 17 insignias, five from the French colonial empire (*Legion d'honneur* and the order of the Star of Anjouan, for foreigners who had devoted themselves to the colonial expansion of Europe), three from German states, two each from the Netherlands, Belgium and Russia, and one each from Italy, Austria-Hungary and Siam.[29]

So, Treub and his reformed Gardens were a force to reckon with. Buitenzorg was in 1900 the biggest scientific institute of the empire as a whole, surpassing the four Dutch universities in budget and natural science staff.[30] According to the German journal *Minerva*, it was in 1913 (three years after Treub's death) the largest botanical science institute in the world after the United States Department of Agriculture (USDA), although ranking academic institutes and agricultural departments in one list on the base of budget alone maybe somewhat biased towards the latter.[31]

28 Jacob Boerlage, 'Het vijfentwintigjarig doctoraat van den heer Treub, 1873–1898', *Teysmannia* 9 (1899) 481–499.
29 Regeeringsalmanak van Nederlandsch-Indië (Batavia 1909).
30 *Handelingen van de Tweede Kamer der Staten-Generaal* [Parliamentary debates transcripts of the Dutch Second Chamber, hereafter HTK], 1886–1887, Appendices, nos. 4.27 and 2.2; *HTK* 1908–1908, Appendices, 4.26 and 2.2.
31 Andreas Zangger, *Koloniale Schweiz. Ein Stück Globalgeschichte zwischen Europa und Südostasien (1860–1930)* (Bielefeld 2011) 384–385.

Analyzing lichens at Leiden

It is one thing to say that Treub's Buitenzorg had was an important tool of empire. It is another thing to study the intellectual construction of this tool. Elsewhere I have explored the science of other Buitenzorg visitors and staff members; here I will deal more deeply with the director's biology.[32] The main reason that Buitenzorg became a global center of plant embryology in the decades before 1900 was that it reflected both the scientific practice and careering of a whole generation of biologists and the specific practice of Treub himself. What ended with Treub being a kind of general of the armed forces of Dutch Indies colonial science started with a young student studying lichens in a laboratory shed in the Leiden hortus. Lichens would become not model organisms for science, but model organisms for colonial politics.[33]

Treub's own practice was the product of a Dutch biology trying to model itself on German biology in the 1860s and 1870s, and an increasing community of botanists and zoologists working together, comparing the development of plants (and animals) on the cellular level, especially those organisms deemed 'primitive': cryptogam plants and invertebrate animals.[34] Treub's years at the university of Leiden in the 1860s and 1870s were formative; there, he was able to self-fashion himself as an academic laboratory biologist, an identity on which he depended more than others. He became a plant embryologist, starting as a researcher of lichen development. It was in Leiden that he built up a network of allies, such as William Burck, who would serve as Treub's under director in Buitenzorg, and Jacob Boerlage, the later director of the State Herbarium.

Treub was a team player. Where his fellow student Hugo de Vries openly confronted their supervisor Willem Suringar on his refusal to incorporate Darwin into his botanical teaching and his lack of support for physiology, Treub was prepared to cooperate with his supervisor. When Suringar came up with the idea of turning one of his students into an expert in lichen systematics, he turned to De Vries first, who in a friendly way declined the job. But when Suringar gave the task to Treub, he accepted it because he saw a great opportunity to turn it into an experimental embryological project. Later, De Vries wrote to his student Frits Went: 'When I did not do it, Treub had to do it, but it did not become systematics!'[35] In the dissertation that came out of this research, Treub showed that experimental studies could help systematics in classifying the lichens.

Treub used the lichens as an entry into the field of comparative embryology, and what better object for comparing plant development than a complex of algae and fungi developing together? He had taken his cue from the international literature, especially the Swiss Simon Schwendener and Anton de Bary. It was Schwendener who had concluded that lichens were composite organisms; it was De Bary who had suggested that 'lichens could be the product of parasite ascomycetes and algae', but who had not proved that yet, leaving to others to demonstrate this by successfully 'sowing specific lichen spores on specific algae' and constructing lichens from its components.[36] This is what Treub did in the end.

32 Wille, 'The co-production' (n. 7).

33 Ido de Haan, 'Het elan van het instinct. Organische metaforen en de politiek', in: Liesbeth Nys et al. (eds.), *De zieke natie: over de medicalisering van de samenleving 1860–1914* (Groningen 2002) 124–142.

34 For a deep analysis of this national scientific and political movement of field laboratory zoologists and botanists, see: Wille, *Mannen van de microscoop* (n. 2).

35 'Toen ik het niet deed, moest Treub het doen, maar toen werd het toch geen systematiek!', the citation can be found in a letter by Hugo de Vries to Frits Went, 10 Sept. 1900, Zevenhuizen, *Vast in het spoor van Darwin* (n. 10) 44.

36 Melchior Treub, *Onderzoekingen over de natuur der Lichenen* (Leiden 1873) 33.

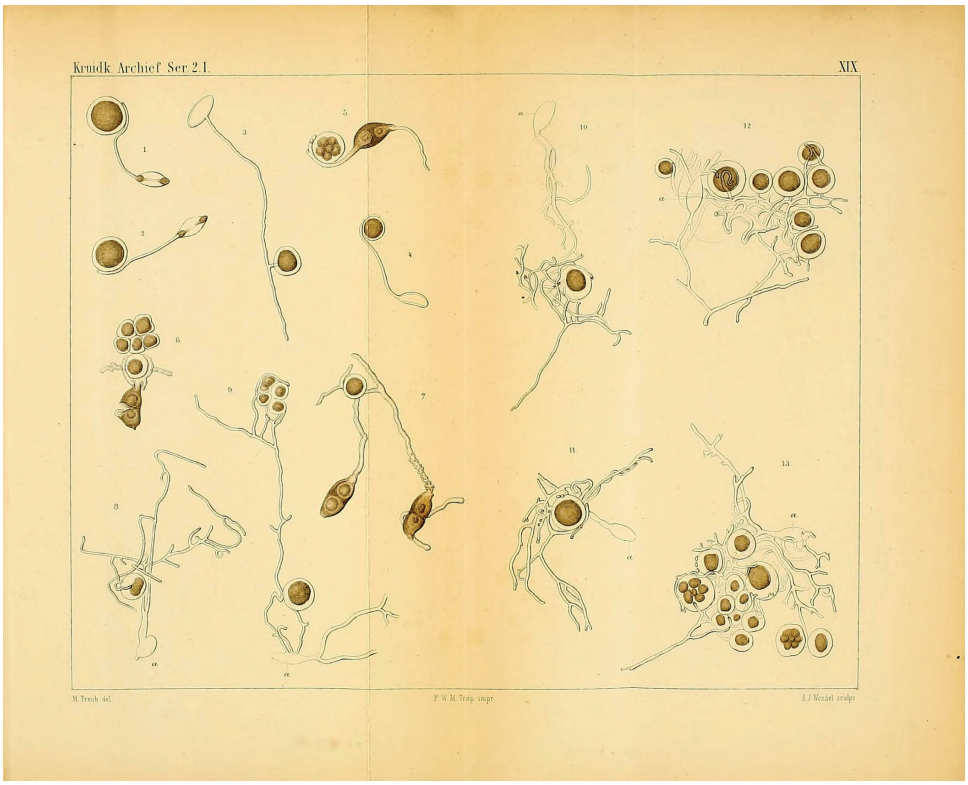

Fig. 3: *Microscopical anatomy of lichens, plate XIX belonging to: Melchior Treub, 'Onderzoekingen over de natuur der Lichenen', Kruidkundig Archief (1874) 336–358.*

Treub's contribution would turn out to be a minor one in a debate that touched on the nature of what constitutes a botanical organism and in what way composite organisms mess up taxonomic schemes ('how do lichens develop and how should we classify them?').[37] However, through studying lichens he found his scientific identity and at the same time learned using microscopical analysis of the development of different plant (and fungi) groups for the sake of evolutionary taxonomy. But what was done for the purpose of plant classification in the Netherlands became a science for the sake of agricultural development in the Dutch Indies.

Connecting systematics, paleobotany and embryology in a new laboratory

Treub became the country's first national evolutionary taxonomist in charge of a laboratory, a responsibility he would never abandon and which he would transfer to Buitenzorg later. In 1874 Treub was made an assistant to Suringar's new laboratory, a function that had not existed before in the Netherlands. Treub was to teach students in laboratory studies so that Suringar was able to focus on his work at the national State Herbarium in Leiden, of which he had been director for three years. This position made Suringar the Dutch taxonomer-in-chief who supervised the description of plant life in the Netherlands, Suriname, and the Dutch Indies.

37 Bruce Fink, 'The nature and classification of lichens II. The lichen and its algal host', *Mycologia* 5 (1913) 97–166.

Treub published in 1876 on undifferentiated meristem cells in root tips of several monocot plants such as *Asparagus officinalis* (edible asparagus), *Glyceria fluitans* (water mannagrass) and *Elodia canadensis* (Canadian waterweed).[38] In 1877 he published on cryptogam spore plants, a vascular plant, and published on the variegated spike moss *Selaginella martensii*, concluding it was a transitional form because of the shape of the meristemic cells.[39] In 1879 he returned to the development of orchid embryogenesis, suggesting that careful study of the development of orchids in comparison to the study of other plants would shed light on their phylogenetic relationship. The variation between specific forms of orchids could only be explained in evolutionary terms: adaptation and, since French was his second language, the 'lutte pour l'existence', the struggle for existence.[40] According to one of his early biographers, these studies brought him the prestigious membership in the Dutch Academy in 1879.[41]

Treub's laboratory botany and plant embryology was never meant to replace older ways of botanical knowing. It was to amend Suringar's grand classification project of all the large plant families in the empire. And instead of opposing Treub's evolutionary conclusions, Suringar gave him room to work out his evolutionary laboratory biology, even suggesting doing paleobotany, plant geography and the mechanism of natural selection, for Suringar felt that Darwinian botany needed much more evidence. Maybe Suringar believed Treub's research could steer botany away from evolutionary biology, or maybe Suringar was more sympathetic than he could publicly reveal because he felt he needed to keep the peace with some of his other more conservative botanical friends. What counted in the end was that Suringar gave Treub more leeway to develop his program than he had given his other student De Vries in the past.[42]

For Treub, evolution, plant growth, laboratory work and taxonomy were all connected under one grand theory. Treub's did not just jump species from lichens to monocot flowering plants for nothing, but connected his work on complex land plants to algae by comparing the growth of 'meristem' cells to the growth processes of gymnosperm plants and vascular cryptogams (such as ferns). Treub wanted to co-construct an 'arbre généalogique', an evolutionary tree on the base of 'principes morphologiques', a practice that was not exclusively the domain of Haeckelian zoologists.[43] Treub combined the tools of laboratory observation and experimentation with that of library studies. More than other botanists, he had to supplement doing his own research with studying that of others. The social reality of comparative plant embryology in the 1870s meant perusing hundreds to thousands of articles and monographs, not just other works in comparative anatomy and embryology, but also works in taxonomy, physiology and, crucially, paleobotany.[44]

The development of symbiosis

In the last years in Leiden and in his early years in Buitenzorg, Treub became more than an evolutionary taxonomist, and he was on his way of becoming a more 'total' evolutionary biologist, solving larger academic problems in evolutionary development.

38 Melchior Treub, *Le méristème primitif de la racine dans les monocotylédones* (Leiden 1876).

39 Melchior Treub, *Recherches sur les organes de la végétation du Selaginella Martensii Spring*. Musée Botanique de Leide (Leiden 1877).

40 Melchior Treub, 'Notes sur l'embryogénie de quelques orchidées', *VKAW* 19 (1879) 1–50, at 44–45.

41 H. H. Zeijlstra, *Melchior Treub. Pioneer of a new era in the history of the Malay Archipelago* (Amsterdam 1959) 21.

42 Zevenhuizen, *Vast in het spoor van Darwin* (n. 10).

43 Treub, *Le méristème primitif*, 71 (n. 38).

44 Melchior Treub, 'Eene feest-vergadering', *De Gids* 43 (1879) 128–156, at 149.

One theme stood out in Treub's unified science practice: the development of symbiosis between organisms, whether mutualist (organisms of different species benefiting each other), commensalist (one benefits, the other does not, but isn't harmed either) or parasitical (one benefits by harming the other). The term 'symbiosis' was coined in 1878 as an umbrella concept.[45] At the Kassel meeting of the *Gesellschaft deutscher Ärzte und Naturforscher* in 1878, De Bary raised the question of parasitism – an important agricultural theme – to an academic research problem of some magnitude (a problem he labeled *Der Erscheinung der Symbiose*) by stressing that biologists should not only study parasitism as the result of an evolutionary process but that they also should study co-developmental processes in connection to other forms of symbiosis, such as mutualism.[46]

Just as Treub did, biologists such as De Bary, Reinke and Frank then moved to a general analysis of symbiotic relationships, between different types (parasitism, competition, predation, mutualism, commensalism and other subtypes) or between different organisms. The lichens were leading objects of debate here: first, De Bary and Schwendener thought the algae were parasitized by fungi and Johannes Reinke thought the algae were the parasites; later it was concluded that they both formed a 'consortium'. This political economic labelling was echoed by Treub when he lectured Indies planters about symbiosis, and referred to lichens as 'firms'.[47]

Die Erscheinung der Symbiose was the articulation of a grand problem to be solved: how does symbiosis develop, both on the microlevel of development and the macrolevel of evolution? After the Kassel lecture, Treub continued working on the development of other symbiotic forms, becoming more reflective on the (evolutionary) development of biological alliances, either mutualist and parasitical.

Fanning out: comparative development as an instrument

After Treub settled in Buitenzorg, instead of studying embryological plant development for the sake of a virtual tree, he started to do so for the sake of studying the tropical environment. Instead of allying himself with paleobotany and geology, he now started to ally himself with entomology, ecology and organic chemistry.

Treub's cryptogam phylogeny made him well prepared for studying unique forms of associations where ferns, mosses or algae were involved, or where embryology came in, such as in studying micro-ecologies of Krakatoa, parasitic diseases, and the biodiversity of forests. He started working on the prothallium of lycopods and on the embryology of cycads. The latter he saw as transitional forms between vascular cryptogams and the other phanerogams.[48] This was again interesting in an evolutionary light because with lycopods and ferns, the sporophyte generation starts to dominate in mass and longevity, instead of the gametophyte generation that dominates with mosses.[49] Treub's research on lycopod alternate generations was internationally acknowledged. He published about it in 1887 in the *Annals*

45 Frank N. Egerton, 'History of Ecological Sciences, Part 52: Symbiosis Studies', *Bulletin of the Ecological Society of America* 96 (2015) 80–139, here 106.

46 Melchior Treub, *Parasitisme en infectie in het plantenrijk. Voordracht den 5en Juni gehouden in de Vergadering der Maatschappij van Nijverheid en Landbouw in Nederlandsch Indië* (Batavia 1889).

47 *Ibidem*.

48 Zeijlstra, *Melchior Treub*, 40 (n. 41).

49 Melchior Treub, 'Recherches sur les Cycadées 1', *Annales du Jardin Botanique de Buitenzorg* 2 (1882) 32–53; Melchior Treub, 'Recherches sur les Cycadées 2', *Annales du Jardin Botanique de Buitenzorg* 4 (1884) 1–11; Melchior Treub, 'Études sur les Lycopodiacées', *Annales du Jardin Botanique de Buitenzorg* 4 (1884) 107–138.

of Botany, after Kew's new director William Thiselton-Dyer, the first laboratory botanist to claim that position, introduced his 'friend' Treub's lycopod research to the British audience, referring to his 1884 article as marking 'its epoch in the history of Lycopodium'.[50] Already in 1889 it was called 'classical' in the journal *Nature*, and the inclusion of Treub's work even became a litmus test for a new botanical handbook.[51]

From 1883 onwards, Treub moved to even more complex forms of symbiosis. He studied climbing plants that were growing in the different gardens; he researched the symbiosis between plants and ants in the genera *Myrmecodia* and *Hydnophytum*, epiphyte plants with corms that seemed to have adapted to its use by insects. By growing a *Myrmecodia echinata* that provided shelter for ants instead of food, and isolating it from ants, and then showing that it still developed normally, he wanted to demonstrate that true symbiosis and the plant's 'myrmecophilism' were more loosely related than thought before.

In Buitenzorg he started to fan out. He started to study plant development in nature-at-large. He researched the periodicity and simultaneousness of flowering of the orchid epiphyte *Dendrobium crumenatum* across larger geographical spaces, in this case the humid west of Java. When in 1883 the volcanic island of Krakatoa exploded, Treub organized an expedition three years later to study its recolonization and community of plant pioneers. He concluded that ferns had been the first colonizers, preparing the ground for phanerogams.[52]

During later years he also took up physiological research. Treub investigated the 'location, transport and role' of cyanic acid in *Pangium edule*, and combined chemical analysis with embryological observation. More and more Treub's work became team work: he depended on earlier work by his chief pharmacologists and it was accompanied by the beautiful drawings of Mas Kromohardjo, whom he had sent for studies in the Netherlands in 1895,[53] and other members of his lithographical bureau. These embryological drawings became a showcase for the Buitenzorg laboratories and his *Annales* journal.[54]

More and more, Treub wrote articles starting up or overviewing a research line that was mainly practiced by a growing number of staff members. For example, he published on a sugar plant disease called *sereh*, in which he studied the vicious circle of interaction between in the embryological development of the sugar cane *Saccharum officinarum*, the animal parasite and nematode worm *Heterodera schachtii*, and the fungus *Pythium*.[55] This was part of a large program in laboratory plant pathology, with financial support from both the state and the many planter associations.

In the late 1880s and 1890s, Treub moved to the realm of politics, contributing to generalizing development and mutualism in a different way, and taking care that his staff members and his visitors could develop their research lines.[56]

50 Melchior Treub, 'Some words on the life-history of lycopods', *Annals of Botany* 1 (1887) 119–123; William T. Thiselton Dyer, 'The Life-History of the Lycopodiaceæ', *Nature* 31 (1885) 317–317.

51 D. H. S., 'Cryptogamic Botany', *Nature* 40 (1889) 217–219, here 218. See also: Harold Wager, 'Two Text-Books of Botany', *Nature* 50 (1894) 613–615, here 614.

52 Zeijlstra, *Melchior Treub*, 39–44 (n. 41); Melchior Treub, 'Notices sur la nouvelle flore de Krakatau', *Annales du Jardin Botanique de Buitenzorg* 7 (1888) 213–224; Wille, 'The co-production' (n. 7) 261–263.

53 Date of birth and death of Kromohardjo are unknown. *Verslag van 's-Lands Plantentuin* 1895, 4.

54 Melchior Treub, 'Sur la localisation, le transport et le rôle de l'acide cyanhydrique dans le Pangium edule Reinw', *Annales du Jardin Botanique de Buitenzorg* 13 (1896) 1–89.

55 Melchior Treub, *Onderzoeking over sereh-ziek suikerriet gedaan in 's Lands Plantentuin te Buitenzorg*. MLP (Batavia 1885).

56 Wille, *Mannen van de microscoop*, chapters 5 and 6 (n. 2).

A vision: comparative ecology

At the end of his career, in 1909, Treub returned to a theme which he had touched upon in one of his more popular writings when he had just arrived in Buitenzorg. In 1881 he had written to his Dutch audience about his visit to Tjibodas and the plebeian character of the tropical forest, where the Darwinian struggle for survival was very visible, and where Treub felt he had returned to a geological past.[57] The 'tropicality' in Treub's text was very present, with the tropical world presented as atavistic.[58] In 1909 he returned to his old notes and presented his view on the equatorial forest as an 'association', the same word he had used for lichens.[59] The article was much shorter than his earlier articles and should be indeed taken as a 'think piece', as Andrew Goss has proposed.[60]

It, however, shared with his earlier physiological research an extensive quoting of the work of one of his more famous Buitenzorg visitors, Andreas Schimper, best known for his 1898 work *Pflanzengeographie auf physiologischer Grundlage,* and who had after his studies with De Bary in Strassburg travelled across the globe. For Schimper, Buitenzorg was a model field station that had to be copied elsewhere, for example in the Arctic: this idea was immediately picked up by the Danish, who founded a research station on Disko island in Greenland.[61] But Treub's political ecology was only distantly related to the new scientific ecology of Schimper. It was a proposal for a 'comparative ecology'; the comparative embryology of organism development was applied to the ecology of different forests.

Treub's publication was only a ten-page agenda, and it is unknown what would have happened if he would not have died in 1910 in St. Raphaël in the south of France, where he decided to live on the way back from Java to Europe. But in these ten pages, readers can extract a program of comparative ecology modelled on his form of embryology.

In this article he compares two forests lying at the same altitude, on the same soil and with the same climate: a 'forêt vierge', an old forest, and a recent plantation of tea shrubs *Schima noronhae.* He counted 140 species of vascular plants in the tea plantation, but he did not encounter any epiphytes and lianes, which were growing in abundance in the old forest. How was this possible? What could explain the 'multiplicités des formes' in the old forest? These questions kept ecologists in the North busy at that time as well, and would later become important research questions related to 'biodiversity', especially in tropical field stations.[62]

The proposal tied together a lot of what he did: comparing the development of two distinct organisms, be it individuals or forests; analyzing colonization and plantation and its relation to the original habitat, a question of vital interest to European colonizers in Southeast Asia and other equatorial empires; travelling outside and processing science

57 Melchior Treub, 'Een tocht naar de bergtuinen van Tjibodas', *De Gids* 45 (1881) 1–30.

58 David Arnold, '"Illusory Riches": representations of the tropical world, 1840–1950', *Singapore Journal of Tropical Geography* 21 (2000) 6–18.

59 Melchior Treub, 'La forêt vierge équatoriale comme association', *Annales du Jardin Botanique de Buitenzorg* 22 (1908) 144–152; Treub, *Parasitisme en infectie in het plantenrijk*.

60 Andrew Goss, 'Decent colonialism? Pure science and colonial ideology in the Netherlands East Indies, 1910–1929', *Journal of Southeast Asian Studies* 40 (2009) 187–214, here 201.

61 Cittadino, *Nature as the laboratory*, 98–110 (n. 3); Sharon E. Kingsland, 'The role of place in the history of ecology', in: Ian Bilick and Mary Price (eds.), *The ecology of place. Contributions of place-based research to ecological and evolutionary understanding* (Chicago 2010) 15–39, here 24.

62 Megan Raby, 'Ark and Archive: Making a Place for Long-Term Research on Barro Colorado Island, Panama', *Isis* 106 (2015) 798–824.

inside afterwards; and most of all, an emerging focus on cooperation in biology and society, either human society or the *societé végétale*.

Studying the riches of the old forest, 'under the influence of' earlier 'views' (in French appropriately *sous l'empire des vues*) he stressed that next to struggle as an important factor in creating natural diversity, nature's societies were also driven by mutualism and cooperation.[63]

The rhetoric of mutualism and the practice of developmentalism

That Treub increasingly emphasized cooperation and symbiosis was not only thanks to the works of Prince Peter Kropotkin, De Bary and his own Buitenzorg visitors such as Schimper and Haberlandt, but it also emanated from almost thirty decades of scientific diplomacy and colonialism. It was through colonial mutualism that Treub was able to create an empire of plant science and agricultural extension in the tropics.

Treub's rhetoric of European mutualism and cooperation may have reflected the reality of the trans-imperial alliance between European scientists, civil servants and planters, although seen from the current perspective of global history, the colonial reality also had a possibly more parasitical nature.[64] As Moon, Hodge, Boomgaard, Goss, Storey and many others have shown, this kind of empire of course hid a much less beneficial relationship with the local economy of underpaid staff workers from Java and the many 'old forests' that succumbed to the need for tea, tobacco and coffee plantations.[65] Treub's political agenda was never that of ad hoc expeditionary science and slash and burn exploitation, and always had a more structural aim of scientific institutionalization, but the political ideology of development it birthed had a social and environmental impact that is still heavily understudied. Treub and his Europeans were a new invasive species.

It is tempting for historians to construct a narrative around Treub that places him in 'a faraway periphery' doing lip service to European institutions: this is an image to which Treub himself had contributed by referring to his career move to Java in 1880 as going into 'exile' and being in 'scientific isolation'.[66] However, in the Indies Treub was able to move from a German-style evolutionary morphology into agricultural development and ecology, as I have shown elsewhere, aggressively contributing to making these fields 'academic'.[67] In the Indies, he used embryology as a tool to create new colonial alliances. He created a new biological-industrial complex in the global South, where the Dutch Empire became a center of developmental science and politics. This is a global and even anthropocenic story of which only fragments have been told.

63 Treub, 'La forêt vierge équatoriale comme association', 146 (n. 59).

64 Wille, 'The co-production' (n. 12); Wagner, 'From the Western to the Eastern model' (n. 3); Bernhard C. Schär, *Tropenliebe. Schweizer Naturforscher und niederländischer Imperialismus in Südostasien um 1900* (Frankfurt am Main 2015).

65 Moon, *Technology and ethical idealism* (n. 13); Joseph Morgan Hodge, *Triumph of the expert. Agrarian doctrines of development and the legacies of British colonialism* (Athens OH 2007); Goss, *The floracrats* (n. 2); Peter Boomgaard, *Southeast Asia, an environmental history* (Santa Barbara 2007); William K. Storey, 'Plants, power and development: founding the Imperial Department of Agriculture for the West Indies, 1880–1914', in: Sheila Jasanoff (ed.), *States of knowledge. The co-production of science and social order* (London en New York 2004) 109–130.

66 Treub to Hoek, January 3rd, March 7th and June 8th 1881, HALA.

67 Wille, 'The co-production' (n. 7).