Ber. Deutsch. Bot. Ges. Bd. 100 (1987), S. 107—141

History of Forest Botany (Forstbotanik) in Germany from the Beginning in 1800 until 1940 — Science in the Tension Field between University and Professional Responsibility —

Geschichte der Forstbotanik in Deutschland von den Anfängen um 1800 bis 1940 — Wissenschaft im Spannungsfeld zwischen Universität und fachbezogener Verantwortlichkeit —

Von

Aloys Hüttermann

Göttingen

Forstbotanik (translated in this article to Forest Botany) as such is a rather special scientific discipline, being restricted mainly to the German Universities. No such discipline can be found either in most of the Anglo-Saxonian Schools of Colleges of Forestry or in the Eastern European or Chinese University systems. The closest related disciplines are Forest Biology or Ecology. In these systems,

education for Forestry students in the basic facts of plant life are provided by the Biology Departments in classes together with all the other students they teach. There seems to be no necessity for the creation of professorships or even large and well equipped institutes for Forest Botany outside of Germany.

To understand this special development in Science History, one has to go back about 200 years ago and follow the very special path which education in Forestry, together with research in Forestry, has taken since then.

Historical Development of Forestry Education in Germany

Unlike the situation for instance in the USA, where Schools of Forestry educate students who later can find jobs in a rather wide range of professions (e.g. Handouts from the School of Forest Resources North Carolina State University, Raleigh, NC), Forestry Education in Germany almost exclusively leads to the profession of a high ranked officer in the Forest Administration of states, communes and private forest owners, the Head of a Forest District being the ultimate educational goal at the Universities (c.f. SPELLMANN 1983, LUNDERSTÄDT 1986). Therefore, the development of the Forest Service during the last two centuries greatly influenced the fate of academic education in forestry and, of course, vive versa, in a way which is unusual in other scientific disciplines.

In the 18th and still at the beginning of the 19th century, there were two main ways of entering the rank and file of the forest service in Prussia (which is given here as the example of the most influential Forest administration) (for more details see ROSENSTOCK 1975, EBERTS 1951a and b, 1952a and b, 1957): initially the majority of future foresters started as apprentices under the guidance of an experienced forester. After three or more years of such practice in an forest district, they enrolled in the "Königliche Feldjäger Corps", a special army branch which served as reconnaissance and couriers in wars. When the military service was finished and after some additional years of practice i.e. apprenticeship in a Forest District, they then were appointed as "Oberförster" and Head of a Forest District (some 1.000—3.000 hectars in size). There they had 3 to 5 "Förster" (foresters), workers, office clerks, altogether a crew of about 30—50 subordinates, which altogether were managing the sustained yield forests (nachhaltig bewirtschaftete Wälder), the system which emerged at that time in Germany. During their apprenticeship, usually no formal education or curriculum was offered, the main focus laying on practical education, "training on the job".

In addition to this very unacademic curriculum, forestry was taught at some universities within the frame of the so called "Kamaralistische Wissenschaften" (i.e. "Science" of administration at the small feudal courts of that time). This way, of course, was sought for by rather well to do students. Thus, for example, HEINRICH CHRISTIAN BURCKHARD, the leading forester in the second half of the 19th century in northern Germany, studied forestry at the University of Göttingen, as a law student, where J. BECKMANN gave lectures in this subject. University education was then by no means mandatory and only an exception among the high ranking foresters.

With the increasing need for a solid theoretical background in the education of foresters, changes in the education during the apprenticeship-years developed at several places in Germany at the end of the 18th century: some influential and experienced foresters opened small private schools which, closely attached to the Forest District Office, with the scholars actually living in the house of the forester

himself, offered a full-time education in forestry which included part-time school and most of the time practical teaching in the forests under the guidance of the Head of the Forest District.

The most influential of such schools was the one founded by GEORG LUDWIG HARTIG in 1789, when he was 25 years old, in Hungen (Wetterau, Hessen), where he served as the Head of a Forest District. The school was run as a completely private enterprise on the account of HARTIG. According to the testimony of his wife (THEODORA HARTIG 1826), it served two purposes: one was the need of better education of foresters, the other was to provide additional income which was badly needed for the HARTIG family, which in the end numbered 12 children (salaries of civil servants at that time were incredibly low: the HARTIGS even could not afford to buy a sofa. Although at that time a garden usually was included in the allowances a forester could expect, they did not get one and his wife had to sell all her few jewels in order to purchase a garden).

The education HARTIG gave and the credit he got for this venture must have been rather excellent, because within three years, his school attracted 20 students, who were willing to pay the 100 Gulden tuition per year (the Forstakademie in Hann. Münden had, on the basis of a 2.5 years curriculum, between the years 1868 and 1911, an average student body of about 50 students, the minimum for one semester being 20 students in 1891). In addition to the teaching he gave himself, HARTIG hired teachers from outside who helped him with the education of the ever increasing number of his "Forsteleven". In 1802 he had 60 students which eventually became an important economic factor in the small town where he had his residence as Head of the Forest District. It should be noted that there was no formal degree available at his school, except that succesful students got a letter of recommendation.

HARTIG enjoyed a rather steady career, which lead him from Hungen to Dillenburg, Stuttgart, and, finally in 1811, to Berlin, where he became the Head of the Prussian Forest Administration (Oberlandforstmeister und Staatsrat), a position which made him the most influential forester of his time. All the time and at all the different places, he was operating his school which developed to a kind of Forest Academy and always attracted a considerable number of students.

The promotion of HARTIG to Berlin in 1811 can be considered as one of the starting points of an organized education in forestry with an academic curriculum in Germany as a whole. Prussia at that time was the state with the biggest forests and thus of rather high influence in other states as well. In addition, it increased its territory considerably, first after the Napoleonic wars and then after the so called "cabinet wars" of 1864 against Schleswig-Holstein and Danmark and 1866 against Austria and her allies.

When HARTIG got a closer view on the standard of education and knowledge of his higher officials in the Prussian Forest Service, he was rather shocked and disappointed by the low standard of professional education. So he worked out plans for an academic education with a profound curriculum for foresters, a task for which he found excellent support from WILHELM and ALEXANDER VON HUMBOLDT, the great reformers of the university and academic education in Prussia.

In 1820, by Royal Edict, a Forest Academy was established in Berlin, which was closely attached to the newly founded university and was supplied with all the means and facilities as well as staff of the Berlin University. The basic sciences were taught by professors of the university, (Forest) Botany was given by F. G. HAYNE. Thus all the requirements for a well established School of Forestry were there. In

1830, HARTIG even became Professor Honorarius of the Royal University in Berlin, although he never received a degree from a university, thus he became more closely connected to this school of higher teaching.

However, when the first graduates of this Forest Academy were examined by the Provincial Commission of Forest Examinations (which were, like the ones in the Department of Justice, established independently from the university system), the candidates from the Forstakademie Berlin did not perform as well as had been expected regard to basics and practical aspects of Forestry, which meant that they had no chance to actually enter the Forest Service. It should be noted in this connection, that the system quoted above, i.e. examinations by a Commission which is independent from the university system, still is in operation today. After their graduation from the universities with a Diplom (considered equivalent to a Masters Degree) they have two additional years of practical training at the Forest Services of the states, which finish with a thorough examination of all aspects of forestry, including those which have been taught at the universities. This fact is of utmost importance for the organisation of any curriculum in forestry in Germany (cf. SPELLMANN 1983).

This disastruous performance of the graduates from the newly established Forest Academy in Berlin at the entrance examinations into the Prussian Forest Service had tremendously far reaching consequences: The whole system of academic education of foresters was reconsidered. After consulting ALEXANDER and WILHELM VON HUMBOLDT, a completely new type of forest academy was created. It was a small school of higher learning, attached both by organisation and by budget to the forest administration, placed into a small town within the typical forests of that State, completely separated from the university system. This academy had a dual function: i. it had to educate forestry students and ii. it served as an experimental station of the Forest Service of the State.

This system allowed both a theoretical and practical education and served in addition as research institution for the forest administration.

Because of this development, forest academies had a different constitution and organisation than the universities. Instead of having a rector which the professors elected, they were run like a government administration with a director at the top of the administrative hierarchy. This meant that although the academic teachers at the Forest Academy were rewarded the position, title and theoretically the rights of a full professor in the German University system (Professor Ordinarius), they still were under the supervision of the Director of the Forest Academy who was superior in the administrative rank. This dualism between the "freedom of research and teaching" of a German Professor and the construction of a forest academy with a constitutional director as head, naturally was the source of all kinds of tensions within the teaching staff and eventually lead to the abandonment of this system in the 1920's. But for the time being, it was the most influential and efficient system both for teaching and research in forestry all over Germany.

The curriculum in these newly established forest academies was not too different from the one in Berlin. It required not only the teaching of typical subjects of forestry, but in the basic sciences, too, like chemistry, zoology, botany, mathematics (today biometrics), and others. Since the distances between these new schools and the universities were too large to allow the students to join the classes given there, they had to be given at the same place where the students were. Therefore in the newly established forest academies, professors for these subjects had to be hired.

This then was the origin of Forest Botany as a special subject and denomonation of a professorship: it was triggered by the disastruous performance of forestry students in Berlin at the provincial examinations and it was kept alive by the necessity of both teaching in botany at the newly established forest academies and the need for research for the forest administrations.

It should be noted in this connection that although today all Schools of Forestry in West-Germany are located in Universities with Biology Departments, the need for Forest Botany as a field of its own still exists. In teaching, the requirements of the curriculum in forestry are such, that special courses for forestry students would have to be given anyway, by professors with an intimate knowledge of problems of forestry which can be achieved only by doing research on forestry related topics. In addition, since no other research institutions are available in Germany, the necessity for research in Forest Botany still exists today. In view of the little knowledge we have on the function of forest ecosystems, basic research on physiology and ecophysiology is badly needed.

The first Forstakademie was established in 1830 in Neustadt-Eberswalde (now in the territory of the GDR), which is still a small town, located in a rather rural area with many forests typical for that part of former Prussia. Another was to follow later: Hannoversch Münden (40 km south of Göttingen) in 1868. The two academies were operated as independent units within the budget of the Forest Administration until almost the Second World War. In 1939, the Forstakademie in Hann. Münden was merged to the University of Göttingen as the seventh Faculty*), but it still took more than 30 more years, until it moved to Göttingen (in 1970/72). Eberswalde still operates at the same location, now being incorporated into the University System of the GDR, as extension of the Humboldt University in Berlin.

This system of education in forestry as well as the close connections between academic education and research in forestry (for the Forest Administrations) apparently proved to be extremely efficient and advantageous. When in Munich a Forestry Faculty was added to the University in 1878, the system of the Forest Academy was adopted as closely as possible: at the same time, the Bayerische Forstliche Versuchsanstalt (Bavarian Forest Experimental Station) was established and the Professors at the School of Forestry being appointed Head of Divisions of this Experimental Station. The Forest Botany was included into the tasks of the new School of Forestry, inspite of the already existing Botanisches Institut of the Science Faculty.

The appreciation the academy system enjoyed, in comparison to the education at the University, can be seen from the decision to close the Division of Forestry in Giessen, which was made in the 30's of this century. At that time, it was felt in Prussia, that three Schools of Forestry, i.e. the two forest academies in Eberswalde and Hann. Münden plus the one forest division at the university of Giessen were to expensive to run at the same time to allow for a healthy and steady development of all of the 3 places. Therefore the decision was made to discontinue one place of forest education, leaving altogether only three. Not surprisingly, Giessen, although being the oldest division of Forestry at any German University, was closed and the

*) In this manuscript, the term "faculty" is used as translation of the German word "Fakultät", which is actually the correct translation. In the Anglo-Saxonian university system, the most suitable expression would be "school", while the term "faculty" has been transferred to the professors working there.

teaching staff was emulgamated into Hannoversch Münden, which at the same time was incorporated into the University of Göttingen. Obviously the Forest Academy System "beat" the university system by far.

The Biltmore-"Experiment" in Education of Forestry in the USA

It might be of interest in this connection to note, especially for readers from the USA, that the two different systems of academic forestry education were operating in the USA for a period of 15 years as well.

The first School of Forestry which was established in the USA followed excactly the regulations and principles of the school system operated by G. L. HARTIG. It was the Biltmore Forestry School, North Carolina. It opened its doors in 1898, being the first School of Forestry in the New World, preceding the school at Cornell by a few months.

The founder of this school was Dr. CARL ALWIN SCHENCK, who was born in Darmstadt, Germany, in 1868. He studied forestry, worked at the State Forest Service in Hessen-Darmstadt and was granted the degree Doctor of Philosophy by the University of Giessen in 1894.

SCHENCK came to America in 1895 where he worked on the estate of GEORGE W. VANDERBILT, near Asheville, North Carolina. At that time, there were only two other trained foresters in the United States, GIFFORD PINCHOT and BERNHARD FERNOW. Therefore the need for a forestry school was obvious. Dr. SCHENCK established his Biltmore School of Forestry, following very closely the system GEORG LUDWIG HARTIG had used some 100 years before. His school was amidst the Biltmore forest. His curriculum combined classroom courses with practice, thus taking full advantage of the surrounding forest. It is reported that, even in the middle of a lecture, he could turn to his class, saying: "Now let us take a look to our real school master, the forest itself." This was the signal for all to get on horseback and SCHENCK, after reaching his object in mind, would continue the lecture in the forest, demonstrating his teaching object "in situ".

Unfortunately, SCHENCK had to quit his position in the Vanderbilt estate in 1913, which meant that the school ceased immediately, after graduating about 400 students, many of whom achieved prominence in US forestry. After leaving Biltmore, Dr. SCHENCK went back to Germany, where he, after recruitment in World War I as a lieutenant, finally practiced forestry in Darmstadt.

The relations between SCHENCK and his students, which he called "my boys", must have been truly amazing. School reunions were held until 1957, 44 years after the school closed. In 1951, at the age of 83, ALWIN SCHENCK returned to the United States as Special Guest of the American Forestry Association and toured all around the States from coast to coast (c.f. FROST 1952). He was honoured by the dedication of several plots to him: among them forty acres of redwoods in California and a Weyerhauser Douglas-Fir working circle. His last visit to the USA was in 1952, when he was awarded the honorary degree Doctor of Forest Science by North Carolina State College, Raleigh. On this occasion, speaking to the Biltmore alumni, Dr. SCHENCK stated that he looked upon the School of Forestry at North Carolina State College as the continuation of his Biltmore School. This lead to the fascinating development, in that both the School of Forestry of NCSC "adopted" the Biltmore tradition and, vice versa, the Biltmore alumni got interested in the NCSC School of Forestry. Thus the Biltmore tradition became firmly associated with the present School of Forest Resources at NCSU and resulted in several actions which consider-

ably strengthened the programs there. In 1955, the CARL ALWIN SCHENCK Professorship in Forestry was endowed. Following SCHENCK's death in 1955, the Trustees of the University renamed the Schools Richland Creek Forest the CARL ALWIN SCHENCK Memorial Forest. Here the asches of SCHENCK were scattered among the trees he loved. In 1958, three Biltmore Scholarships were endowed by Biltmore alumni and funds were made available for furnishing a Biltmore Library in the newly built Biltmore Hall of the School of Forst Resources. In 1962, one of the former Biltmore graduates, EDWIN F. CONGER, made a magnificent gift to the School, consisting of two-fifths of the proceed from the sale of his Conger woods near Alken, SC. Funds from this sale endowed several scholarships and the EDWIN F. CONGER Professorship in Forestry (PRESTON 1973). Thus the Biltmore tradition proved rather profitable for the School of Forest Resources at NCSU, where the memory of ALWIN SCHENCK still is alive and kept up for the future.

It is rather unfortunate, that the fate of this first School of Forestry in the USA was so closely connected to the position of CARL ALWIN SCHENCK with the Vanderbilts. It would have been extremely interesting to see how this system of education in Forestry would in the long run have competed with the "purely academic" university system in the United States and what development would have taken place there eventually. The history of the Biltmore graduates, however, strongly shows the deep affection they had both for their teacher and the system he used in educating them.

Conclusion: Role of Forest Botany at Schools of Forestry

To summarize the history of forestry education in Germany and its impact on Botany, one comes to the following conclusion:

Forest Botany as an individual field in science developed in Germany, and almost exclusively there, because of the fact that during the 19th century, education of foresters was taking place mainly at forest academies. Since these academies geographically and by organization were separated from the university system, forestry students had to receive their lectures and courses in botany from staff which were attached to the forest academies.

Professors in Forest Botany thus always had a particular and special status:

On the one hand, they theoretically were rather independent and free to select their field of research because of principle of "freedom of science", which was granted to all professors in Germany. Therefore they were free to choose any topic they were interested in.

On the other hand, they were part of the Forest Administration with the Director of the Academy as their supervisor.

Therefore, both the scientific community in the Forest Academy they were part of and living together with, and the Forest Administration expected them to work on problems which were related to the needs of Forestry of their time.

A very important function these scientists always had, was to serve as a bridge between basic sciences and applied forestry. In many cases the relations between the professors of forest botany and their colleagues as well as the forest administration developed in a way that they became respected and trusted by the side of the foresters. This "bridging" in the form of consulting and influence had a highly beneficial impact on both forest science and forest administration.

The historical development of Forest Botany can best be demonstrated by the biographies of its scientifically most influential and important representatives,

therefore, the focus of the forthcoming part of this communication will be on leading figures in the field.

Forest Botany in the 19th Century — The HARTIG Family

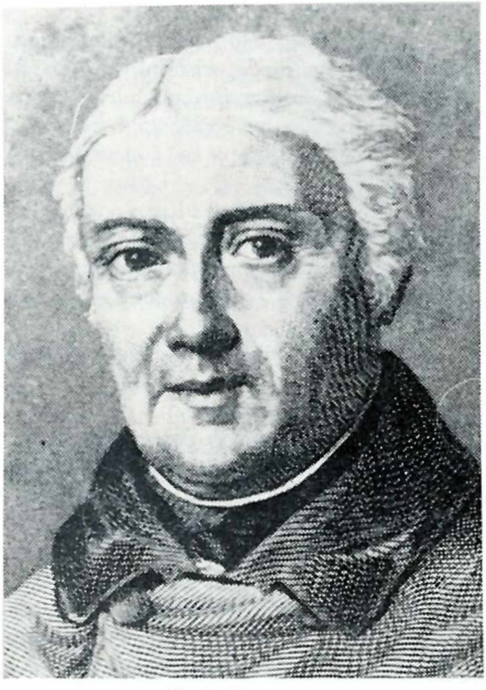
The history of forestry science and, later on, Forest Botany in the nineteenth century, was almost completely dominated by the "HARTIG-Dynasty" starting with GEORG LUDWIG HARTIG, his son THEODOR HARTIG and his grandson ROBERT HARTIG.

These three scientists dominated their scientific fields in a way, which is unsurpassed until today.

GEORG LUDWIG HARTIG

GEORG LUDWIG HARTIG, already mentioned above because of his merits in forestry education, was born in 1764 as the second of 10 children of the Head of Forest District in Gladenbach, Hessen. The HARTIG family had lived there already for about one century, always being closely connected to forestry. At the age of 14, G. L. HARTIG entered an apprenticeship at the Forest District of his uncle, KARL LUDWIG HARTIG, in Harzburg, which ended in 1780. In the same year he enrolled at the University of Giessen as a student, for a two years study of Kamaralwissenschaften and mathematics. Thus HARTIG became the first forester, who in his personal education and curriculum combined the very practical work as an apprentice in the forest with an university education in Kamaralistik and mathematics.

From 1782—1785 he worked in the forests of his father and then, still without salary, in the State Forest Service at Darmstadt, Hessen. There he must have done so



G. L. HARTIG

well, that, at a very young age, in 1786, he was appointed as Oberförster (Head of a Forest District) in Hungen, Hessen.

Being asked to act as a teacher in forestry for his younger brother ERNST-FRIEDRICH, on the usual basis of an apprenticeship, he established, in 1789, the school for young forester. He kept this school in continuous operation during his whole carreer, which lead him in 1797 from Hungen to Dillenburg, in 1806 to Stuttgart and, finally in 1811 to Berlin.

During the 26 years he served as the head of the Prussian Forest Administration as "Staatsrath und Oberlandforstmeister", he became the most influential forester and forest educator of his time.

This was not only because he was the head of the biggest forest administration in Central Europe. Of the same importance or even more was his scientific work and the textbooks in Forestry written by him, which became the classic textbooks of his time: "Anweisungen zur Holzzucht für Förster" (Instructions for the growing of timber for foresters) (eight editions between 1791—1818); Lehrbuch für Förster (Text-book for foresters) (1808, ten editions). Being the Head of an influential forest service, he was able to transfer his theoretical ideas and concepts directly into the practice of forestry. This unique combination of an academic leader of forestry science and mentor of forest education being the head of the biggest Forest Administration never occurred again in the history of forestry in Germany. He thus not only greatly influenced forestry education, determining the mode of teaching for the next 130 years, his concept of forest management influenced German forestry as a whole for an even longer time.

From all his scientific work and publications, two single issues should be mentioned here, although the connection to forest botany appears to be rather remote. Both, however, show that HARTIG in a very critical period came up with the right concepts and, even more important, was able to enforce them.

The first thing to mention is the fact that HARTIG was a strong supporter of sustained yield forestry (Nachhaltigkeit in der Forstwirtschaft) and forest management as a whole. The concept of sustained yield forestry was not developed by HARTIG himself, it was already in discussion a long time before. Even King Frederic II of Prussia tried to enforce this principle in his domains. However, at the time HARTIG came into office, the management of Prussian forests and forests in Germany as a whole was far away from being carefully done in the mode of sustained yield forestry. At that time, the old traditions and practices of use of forest land were still kept up: such as removing litter for the stables, using the forests for cattle grazing etc. In this very difficult situation for the forests, HARTIG was the most influential promoter of the practice of sustained yield forestry, both with a strong theoretical backing in his books and with his influence as forest administrator. One of his everlasting merits is the fact, that he used all his talent and power to favor sustained yield forestry. In doing so, this way of management and utilisation of the only renewable resource we have in the world, became the basis and fundamental rule of Forestry in Central Europe as a whole.

The influence of HARTIG's conceptual thinking can be felt even today in German forests by every ordinary citizen. HARTIG's time in office was the period when the former exploitative overuse of forests was to end and managed forestry of today started to develop. This was a rather painful process, especially in view of the fact, that it implied a change in the ownership of a large portion of forests in Germany: e.g. when a farmer was not allowed anymore to feed his livestock in the forests, he was forced to give up rights of ownership. How terribly complicated the

whole story could be, can be derived from the fact that different groups of owners actually had different rights of use in an individual forest.

In this situation, HARTIG defined the ownership of forests in general in a completely new and novel way (c.f. ROSENSTOCK 1975):

Instead of giving the individual owner full and complete use of the area, he defined the use of forests as the sum of different rigths, which could be issued and practiced seperately:

1. the right to use the timber
2. the right for cattle grazing
3. the right to harvest hay
4. the right to harvest litter
5. the right to scrape off and take out resin
6. the right to hunt
7. the right to take out stones and clay
8. the right to fish in the streams and rivers of a forest
9. the right to walk in a forest
10. the right to drive cattle through a forest

(The rights to pick berries and mushrooms in the forests by any person were taken for granted anyway, so HARTIG did not bother to mention them.)

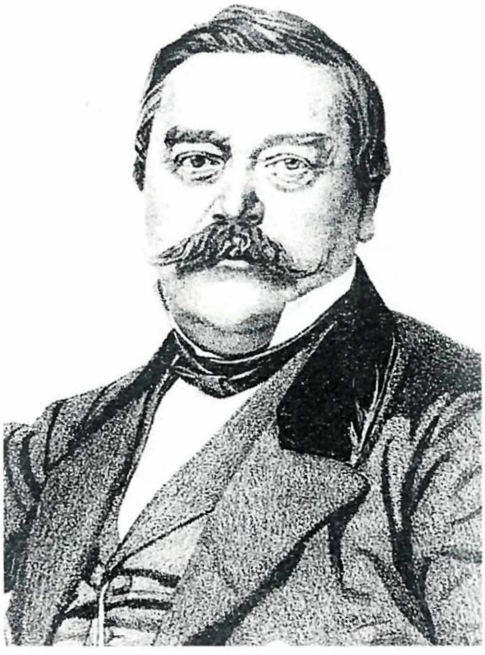
HARTIG in addition held the notion that these rights could be granted and practiced separately as long as they did not harm forestry as such. Therefore it was not necessary to grant a new owner of a given forest the right to expell people from his property. Thus the right to walk through any forest, regardless of its ownership, which is now part of all forestry legislation in Germany, and is cherished by and benefits the whole population, goes back to this concept of thinking introduced into the legal discussion by HARTIG.

Although not being a forest botanist as such, he was the founder of scientific forestry as a whole and of the concept of forestry education. Therefore he rightly has his place in this a compilation of the history of Forest Botany in Germany.

THEODOR HARTIG

THEODOR HARTIG was born 1805, in Dillenburg, as the 10th child of the aforementioned G. L. HARTIG. Being influenced by his great father, he entered the forest service as an apprentice and, in 1824, he entered the Forest Academy in Berlin, were he attended the lectures given by his father, F. W. L. PFEIL, and others. After the seven semesters of study and an additional apprenticeship in the forest service, he passed in 1829 the Forest Examination and worked for a short time as an interim head of a forest district (in Liebenwalde). Already in 1831 he was appointed lecturer at the Institute of Forestry Science in Berlin, where he held lectures on forest botany, meteorology, soil science, and entomology. In 1833 he passed his doctorate with a thesis on wood decay caused by fungi and butt rot of trees. In 1835 he was appointed full professor in Berlin and in 1838 he moved to Braunschweig where he worked at the newly founded Forest Academy there. He stayed there and gave lectures in forest botany, entomology, soil science and climatology, until this Institution was closed in 1877. THEODOR HARTIG died in Braunschweig in 1880.

TH. HARTIG was the first influential figure and teacher in Forestry who came to the conclusion that without a precise knowledge on the anatomy and physiology of trees and their development, the problems of raising forests and production of timber could not be solved in the long run (c.f. HORN 1880). This statement is by no



THEODOR HARTIG

means self-evident, was in remarkable contrast to the development of forestry science in Germany as a whole. It was and still in part at least is a strong belief among German forestry scientists, that no high priority should be given to this part of science. The philosophy and reasoning behind this at first glance puzzling statement can be summarized as follows:

As long as sustained yield forestry is possible and the ultimate rule in German Forestry, it is not the first priority to have a deep insight into the mechanisms of physiology of growth of the trees. All that is necessary is to learn about the management of such forests, the best techniques of establishment, and harvest of such forests as a whole.

This rather surprising view of forestry science as a whole, which has a great impact on the curriculum and teaching at the universities (c.f. SPELLMANN 1983, LUNDERSTÄDT 1986), is not so illogical as it might appear at the first glance. Today 80 % of the everyday work of an academically trained forester indeed is legal and administrative work (c.f. HEEG and OESTEN 1973). On the other hand, until "Waldsterben" became obvious to the German forest administration, German forests indeed were completely managed sustained yield forests, and the understanding of its physiology seemed to be of low priority to everybody.

The scientific work of TH. HARTIG indeed followed the guideline which is set above: to deepen the unterstanding of the anatomy and physiology of trees. One part of his research was the nutrition of forest trees, where he concentrated on the organic nutrition of the roots. There he could show that roots are not able to incorporate organic material, especially humic acids, the substance which was of highest interest in his time. These experiments found their way into the famous

book of LIEBIG: "Die Organische Chemie in ihrer Anwendung auf Agriculturchemie und Physiologie", which first appeared in 1840 and became of paramount influence insofar as it virtually established the science of plant nutrition and fertilization. HARTIG published about the ideas and concepts of LIEBIG and their practical implications in the German Forestry literature, thus making these ideas available to forest practitioners too.

Another important field of his study was plant anatomy. Here he was able to come up with several important observations, which are major milestones in this field. One is the discovery of the sieve-tubes and sieve pores in the phloem of trees (HARTIG 1851). He came to the conclusion, that both the xylem and the phloem of the secondary growth are formed by the same "mothercell", which is permanently active in the tree (HARTIG 1878, pp. 49—50).

The discovery of the sieve tubes with the perforations through their walls was the first major exception of H. VON MOHLS rule, that the partition-walls in cellular tissues are never perforated and plant cells always are surrounded by a complete cell wall. This was a major part of VON MOHLS idea of the cell tissue and one to which he firmly adhered. Therefore the discovery of the perforated sieve tubes by HARTIG was met with strong opposition by VON MOHL. Although he could confirm basically all of HARTIGS observations, he argued against the perforation of the walls and explained these structures with lattice-like thickenings of the otherwise intact cell walls. Only in 1861, C. NÄGELI showed that at least in some cases there could be no doubt that the walls are actually perforated, JULIUS SACHS, in 1863, came to similar conclusions. J. HANSTEIN finally settled this issue in 1865, by ascertaining with certainty that HARTIG'S sieve plates indeed are perforated (c.f. JULIUS SACHS, p. 342—343).

TH. HARTIG was not aware of the fact that the sieve tubes which were discovered by him are indeed responsible for the transport of assimilates in plants. However, the subject of the "descending sap" (phloem transport in todays terms) occupied considerably his thinking and imagination. He came to the conclusion that this "descending sap" must be a formless primary mucilage from which the various substances in the plant were deposited as it travelled through the plant (HARTIG 1858). This concept was completely confirmed by the later discoveries on the nature of ploem transport. In a series of careful studies, he analysed the nature of the phloem sap, giving the first chemical analysis of phloem sap available in the literature (HARTIG 1860). These studies apparently at first did not arouse too much attention in the plant physiological literature, because MÜNCH, who repeated and confirmed these experiments, even quoted them in his book in almost full length, stating they had never been mentioned in the botanical literature (MÜNCH 1930, pp. 124—127).

A very detailed work of his was concerned with the anatomy of plant cells and cell walls. His paper on the formation and dissolution of plant cell walls was the first serious and coherent attempt to recognise plant cells as individuals and entities (c.f. MÖBIUS 1937). Although his cell-theory, which he developed in this study, was a mistake (SACHS 1890, p. 314), he recognized for the first time the universal nature and occurrence of the tertiary layer of the plant cell wall, which until then was considered to be present only in special cases (SACHS 1890, p. 301). In addition, he was the first to discover the aleuron grains in seeds and the crystalloids, there too, and to deliver evidence for the fact that these bodies are formed by the protoplasm. His notion, however, that these inclusions of the cytoplasm are built by substances of the cell nucleus, could not be confirmed by later studies, as we all know by now.

TH. HARTIGS work was much broader than can be demonstrated by the few examples given here. He made rather significant contributions in mycology, too. Interested in the formation and decay of cell walls, as mentioned above, he soon came to notice the connection of fungi with the decay of wood. However, his concept at that time still was obscure. He believed that with age, or as the result of unfavourable external condition, the tree looses its vitality. The content of the wood cells then round up and form little balls, "monads" in his terminology, which then align themselves and eventually form a fungal hyphae, which is able to infect sound wood and cause decay there. He called this fungus *Nyctomyces* and could only speculate on the relation of an externally produced fruiting body to the decay. He was not the only prominent mycologist with this belief. The famous ELIAS FRIES, in his Introduction to his "Systema" (1821) declared that smut of pollen, *Uredo anthearum*, was nothing else but pollen in a morbid state ("Pollen in statu morbosa") and that the Mucedinae were plant hairs ("sunt tantum pili plantarum in statu morbosa") and FRANZ UNGER, in his book "Die Exantheme der Pflanzen" (1833) concluded that parasitic fungi (called endophytes by him), arose from morbid sap and thus were signs rather than the cause of disease. This question was not solved until HARTIGS son, ROBERT HARTIG, entered science some 48 years later.

Being an excellent observer and interested in the anatomy of trees he did not fail to observe the association between roots and fungi, the mycorrhizae, and the HARTIG-net of the ectomycorrhizae was first described by him in 1840. The term "HARTIG-net" was coined 25 years later by O. NICOLAI (NICOLAI 1865). The function of this close association between fungi and living cells, however, was still obscure at that time and not until 1885 did A. B. FRANK describe this phenomenon accurately as symbiosis and introduced the term mycorrhiza. The discovery of the HARTIG-net alone will make his name quoted as long as scientists will dig after and study roots of trees.

Another milestone in mycology and understanding of symbiotic associations among organisms was his discovery of the fungal nature of the white substance lining the burrows of certain woodboring beetles on which the larvae feed. It was first described and termed as "ambrosia" in 1836 by J. SCHMIDBERGER (SCHMIDBERGER 1836). In 1844 (HARTIG 1844), he recognised it to be of fungal nature. This observation finally lead to a series of studies on this rather intimate association between beetles and the fungi which is now recognised as a highly developed symbiosis, in which the beetles have developed some intruiging means of taking care of the fungi, which they use as livestock for their living, and to bequeath them to the next generation of beetles.

In his last and very important book "Anatomie und Physiologie der Holzgewächse" (1878), TH. HARTIG not only summarized the knowledge of his time in that field. In addition, he turned to philosophical matters, especially to the question of vitalism, the existence or non-existence of the so called "vis vitalis" (Lebenskraft, vital energy). The point which HARTIG takes in this rather important discussion of his time is very interesting, and, at least in his central statements, very modern. Living matter is for HARTIG something so wonderful and astonishing, that he is unable to join the view of LIEBIG and other physiologists of his time which adhered to an universal materialism and declared vitalism and vital force as a "bugbear" (Popanz). On the other hand, he had no doubt in the fact that all changes, movements, and developments in living matter have their origin in the properties and reactions of matter, "daß auch im lebenden Organismus keine anderen als die Kräfte des Stoffs arbeiten" (that in the living organisms no reactions take place other

than the forces of matter) (HARTIG 1878, p. 2). This notion is somewhat breathtaking considering the discussion on this subject in philosophy and biology during the following 60 years.

Perhaps it should be mentioned in this connection that even the famous textbook "Molecular Biology of the Gene" of JAMES D. WATSON, first edition in 1965, surely the most important and influential textbook in biology of the '60s and '70s of the twentieth century, includes a special chapter "Cells obey the laws of chemistry" with a special introduction on vitalism. WATSON comes to the conclusion that ". . . it still was possible, as late as 1940, for some scientists to believe that these molecules (i.e. proteins) would eventually be shown to have features unique to living systems" (WATSON, p. 28).

It was the great ERWIN SCHRÖDINGER who settled the matter (at least for serious scientists) in his lectures "What is Life, the physical aspect of the living cell", held at Trinity College in Dublin, 1943 (SCHRÖDINGER 1944), where he actually included the chapter: "Is life based on the laws of physics?" and still left an option open: ". . . from all what we have learnt about the structure of living matter, we must be prepared to find it working in a manner that cannot be reduced to the ordinary laws of physics. And that not on the ground that there is any "new force" or what not, directing the behaviour of the single atoms within the living organism, but because the construction is different from anything we have yet tested in the physical laboratory" (SCHRÖDINGER 1944, p. 80).

On this background, HARTIG was really ahead of his time. On the other hand, he still was deep in his heart a "vitalist" in the sense of being a believer in a supreme being. The solution of this obvious dilemma of being a vitalist but excluding nonmaterial forces in the function of living organisms is rather interesting still today: he believed in a universal force, which does not interfere with the very function of life but exists besides the forces of matter as superior force which rules the universe. According to LÖW (1983) and SPAEMANN and LÖW (1985) this philosophy is much more logical and consequent than the "dualistic tradition" held up by some modern day biologists (c.f. MOHR 1984).

Altogether THEODOR HARTIG has to be considered as the first forest botanist, who on the basis of exact and experimental sciences, layed down the foundations of this scientific discipline.

ROBERT HARTIG, 1839—1901

ROBERT HARTIG the son of TH. HARTIG was born in 1839 in Braunschweig, where his father was, as mentioned above, Professor of Forest Botany. After finishing high school, in 1859, he started his apprenticeship in the Forest Service. Under the wise guidance of his father, R. HARTIG used this time for his first scientific study, measuring the growth of the trees in the most important and representative forests in Germany. Doing this, he used the technique of representative stands (Weiserbestandsverfahren) which was first introduced by his father. His results were published as a book in 1865 by the very renowned publishing company Cotta in Stuttgart ("Vergleichende Untersuchungen über Wachstumsgang und Ertrag der Rotbuche und Eiche im Spessart, der Rotbuche im östlichen Wesergebirge, der Kiefer in Pommern und der Weißtanne im Schwarzwalde"). Really a remarkable achievement of an apprenticeship, during which time the would-be foresters usually have problems to distinguish a beech from an oak.

After two years of apprenticeship, he entered the University of Braunschweig, graduated after two years as forester and continued his studies in Berlin. In autumn 1864 he entered the forest service of the state of Braunschweig, which, however, he left in 1866, being utterly bored by the administrative work required there, leaving him no time for research in the forests. For the next two years he had no fixed position, using his time both for collecting material for the listing of growth tables of the most important trees and completing his academic education. In 1866 he graduated as Doctor of Philosophy from the University of Marburg, the results of his work in the fields was published in 1868 ("Rentabilität der Fichtenutz- und Buchenbrennholzwirthschaft im Harz und Wesergebirge").

ROBERT HARTIG

It was CHRISTIAN BURCKHARDT, the leading forester in Northern Germany of the second half of the last century, who invited him to join the newly established forest planning commission in the now Prussian Province of Hannover, which was gladly accepted by R. HARTIG. He left this position rather soon, however, to join the staff of the Forest Academy in Eberswalde, where he helped and partially replaced Professor Geheimrath RATZEBURG, who suddenly was struck by a disease.

On May 14th 1867 ROBERT HARTIG gave his first lecture in Eberswalde, 1869 he was appointed Dozent in botany and zoology, 1871 professor of (Forest) Botany. In Eberswalde he started his extremely fruitful career as forest botanist and mycologist. He soon gained highest respect in his field and, when the new Faculty of Forestry at the University of München was founded, together with the Bavarian Forest Experimental Station, he was offered the Chair of Forest Botany and did not hesitate for one moment to accept. For the 23 years, until his death in 1901, he stayed at and was Head of the Forstbotanisches Institut in München.

R. HARTIGS main research area were the wood-destroying and tree-pathogenic fungi. He wrote six books on wood decay and forest pathogens, in which he layed down the foundations both for the research on wood-destroying fungi and on forest pathogens. His book "Die Zersetzungserscheinungen des Holzes der Nadelbäume und der Eiche" (The phenomena of decay of wood of conifers and oak) which appeared in 1878 was the beginning of systematic research in this field. His book "Wichtige Krankheiten der Waldbäume" (Important Diseases of Forest trees) first edition 1874, was translated and reprinted by The American Phytopathological Society in 1975 as Volume 12 of the series Phytopathology Classics. His "Lehrbuch der Baumkrankheiten" (1882) which still is regarded as the classic textbook in the field, was translated into English in 1894 (by H. SOMMERVILLE and H. M. WARD, "Textbook of Diseases of Trees" London).

As mycologist he thus took up the line of work of his father, although with much better and newer methods, and with much deeper insight into the role fungi have in the decay of wood and the diseases of plants.

It can be clearly stated, that R. HARTIG was the one, who in his main fields, forest pathology and wood decay, made the decisive experiments and observations which led to the scientific victory of the "germ-theory". He was the first who presented convincing evidence that fungi are the causes both of diseases of forest trees and the rotting of timber, thus accepting and extending the ideas of PASTEUR.

This achievement has to be seen in relation to the scientific background and discussion of his time. The last half of the ninetienth century was the time period, when the question whether germs are the causes of diseases was still in debate. It was the time when LOUIS PASTEUR still made statements regarding "the theory of the spontaneity of all diseases. This is an error which, I again repeat, is injurious to medical progress" (quoted from NETER 1973).

This struggle of contradictory hypothesis was in full movement in the literature on both subjects. In addition , it was part of his family history, too. His grandfather, G. L. HARTIG had regarded decay as a natural process of metamorphosis during the aging of wood (c.f. MERRILL et al. 1975). His father (HARTIG, TH., 1833), had connected the occurrence of deterioration of timber with the presence of fungal hyphae, but misunderstood the cause and effect relationships and made speculations only on the role of the nearby fruiting bodies of fungi. This wrong interpretation of the situation in rotting timber and plant cells still was upheld both by SCHACHT (1863) and even WILLKOMM (1866—67) in his book on "Die mikroskopischen Feinde des Waldes".

In the field of plant pathology this confusion about cause and effect was even worse, where the role of fungi as pathogens was discussed in the same controversial manner and with the same lack of understanding (c.f. AINSWORTH 1976, pp. 154—156).

It was R. HARTIG who definitely settled the matter in the fields of forest pathology and timber decay. His famous book "Wichtige Krankheiten der Waldbäume" (HARTIG 1874) is nowadays regarded as the beginning of Forest Pathology. He in addition opened the modern area of understanding of timber decay in his famous book "Die Zersetzungserscheinungen des Holzes" (HARTIG, R., 1878). These two contributions to the literature ". . well earned him the title FATHER OF FOREST PATHOLOGY" (quotation from MERRILL et al. 1975).

One example of his careful way of research is the discovery of the life cycle of *Armillaria mellea* and final and decisive proof of the fact that the rhizomorphs found in infested forest soils belong to that very species of basidiomycetes. In doing

so, he had to argue against almost all leading mycologists of that time, proving that they all were wrong in their interpretations. DE BARY (1887, pp. 28—29) gives a record of the different views on the nature of rhizomorphs which were held at that time, including an impressive list of mycologists, against which R. HARTIG had to argue: ROTH, PERSOON, DE CANDOLLE, ESCHWEILER, ACHARIUS, FUCKEL, OTTH, PALISOTH DE BEAUVAIS, CASPARY and TULASNE. They all had worked on this very extraordinary feature of a fungus, and all were proven to be wrong by ROBERT HARTIG. His description of this fungus in his book still is valid (c.f. BUTIN 1983). "After reading his descriptions of certain diseases, like those following, one has to admit that relatively little has been added to our knowledge on symptomlogy and mode of action during the past 100 years!" (quotation from MERRILL et al. 1975).

It is absolutely impossible to review all aspects of the work of R. HARTIG. His list of publications consists of about 170 contributions, including an impressive list of books and monographs. In his research he covered virtually all aspects of Forest Botany, also including the effects of air pollution on trees.

One little facet, which has not been mentioned in any one of the obituaries quoted in the literature, however, should be mentioned here: his importance as educator of foreign mycologists. It is well known that during the last half of the century, the Institute of the famous DE BARY, first in Tübingen and later in Straßburg was the "Mecca" of mycology at that time, where numerous mycologists and botanists from all over the world worked as students and post-doctorals (c.f. AINSWORTH 1976, p. 283). A minor center of attraction, however, had developed in ROBERT HARTIGS laboratory. It is recorded that at least two scientists, who later became famous enough to be included into "A brief History of Mycology in North America", where for longer periods working in the laboratory of HARTIG: BULLER (ROGERS 1977, p. 53) and FAULL (ROGERS 1977, p. 21). In those times, such an international resonance was by no means selfevident as it might be today, it was truly a sign of excellence which speaks for R. HARTIG and his laboratory.

RICHARD FALCK

RICHARD FALCK was born in 1873 as the son of a jewish merchant and owner of a dyer's works in Landeck, West Prussia. He studied pharmacy in Königsberg, where he got the degree in 1897, in the same year he moved to Göttingen, worked at the Lebensmitteluntersuchungsamt (Food analysis laboratory), and, in addition, studied food chemistry at the University of Göttingen, where he got the degree as a state registered food chemist in 1899.

In the same year, he was drafted to the army and served as registered pharmacist in the medical corps in Breslau. During his free time, he established the first contacts with Geheimrat OSKAR BREFELD at the University of Breslau, who was the most prominent German mycologist at that time. He started to work in BREFELDS laboratory, first during his spare time, then, after his military service, as his assistent.

Two years later, in 1902, he was graduated as Ph. D. at the University of Breslau.

His thesis had the apparently boring title: "Die Kultur der Oidien und ihre Rückführung in die höheren Fruchtformen bei den Basidiomyceten" (The culture of oidia and their restitution into higher fruiting forms of the Basidiomycetes). This impression, however, is misleading. FALCK's vision of mycology was much wider, as can be drawn from the introduction of his thesis:

RICHARD FALCK

". . only part of the cultivated crop plants can be used for human consumption. There are many and important plant constituents which are resistant to degradation by the digestive apparatus of animals and man. Especially today, there are many efforts to make use of these products, particularly the waste products, like sawdust from saw mills. It is tried with chemical means to convert them into more usable compounds for the use of humans.

There is, however, in the kingdom of nature a big class of organisms which are excellently suited to digest and convert especially those recalcitrant parts of plants that are resistant to digestion by animals. These organisms are fungi, especially their higher forms.

If it were possible to exploit the fungi under economic considerations so that they convert as much material as possible into useable food, their ability to digest such indigestible waste materials would be as superior to any chemical process as is the photosynthesis of the green plant to any possible chemical procedure . . ."

As far as I know, this is the first program for an envisaged conversion of forest biomass and agricultural waste into edible food. It still could very well be the introduction of a grant proposal in biotechnology or of any related thesis in this field today. The efficient conversion of lignocellulose into food still remains to be solved and it is still very likely that fungi do in fact carry the key to the solution of this task.

To imagine how revolutionary this concept of FALCK was, one has to take a short look at the state of knowledge in mycology at the beginning of this century.

The leading figure in mycology at that time was DE BARY, who summarized the knowledge of mycology of his time in his famous book "Vergleichende Morphologie und Biologie der Pilze, Mycetozoen und Bakterien" (DE BARY 1884) (its English translation in 1887: "Comparative Morphology and Biology of the Fungi Mycetozoa and bacteria" was introduced in the preface by ISAAC BAYLEY BALFOUR, Sherardian Professor of Botany in Oxford, as "the most thorough and comprehensive treatise upon these groups (of organisms) which has appeared in any language"). If one consults this book for any physiological and biochemical information, one will find out that DE BARY needed for the summary of the work which had been conducted on this topic only 2 pages out of the 560 which the book contains in total, so little work was done in this field.

During the next years in BREFELDS laboratory, FALCK layed down the foundations for his future scientific work. His general approach was remarkably different from the mainly descriptive work of his fellow mycologists. His strategy was problem-oriented to begin with. There is almost no publication of his which does not start with the description of a severe problem, either damage or economic loss. To tackle such problems, he used his excellent background in chemistry and in addition he was eager to include any new or emerging technique which could be used either for his experiments or the evaluation of his data. Already in 1903 he used stringent statistical methods for the processing of his data, his publication being the second one in German biological literature which did so.

In 1905, after retirement of BREFELD, FALCK was appointed as head of the Mycological Laboratory at the University of Breslau.

The first major problem he started to work at when he still was in Breslau was the Hausschwamm, the dry rot of domestic structural timber, which was the major problem in buildings at that time in Germany. In a brilliant study, using for the first time in fungal taxonomy physiological parameters as a basis for species classification, RICHARD FALCK could prove the existence of different species of *Merulius*, which occurred either in the forests or in the buildings, indicating the main infection occurred in the buildings rather than already in the forests as was suspected at that time. This study placed him immediately in the front of dry-rot research and got him acquainted with ALFRED MÖLLER, who was the most influential figure in academic forestry at that time. A. MÖLLER was not only the Director of the Forest Academy in Eberswalde and Head of the Mycological Institute there, but in addition, he was the scientific head of the "Hausschwamm-Kommission" (Advisory Board of dry-rot in buildings) which was established in 1905 by the Prussian Government. When the Prussian Forest Administration offered MÖLLER an additional special laboratory for Hausschwamm-Research in Eberswalde, he, together with K. FRICKE, the Director of the Forest Academy in Hann. Münden, convinced them to establish one in Hannoversch Münden and to appoint R. FALCK as its head.

This was in 1910, and during the next 23 years, R. FALCKS "Institut für Technische Mykologie", inspite of World War I, postwar depression, inflation, and world wide economic crisis, developed to the leading center of applied mycology in Germany, if not central Europe. He came out with some 80 publications and got about 10 patents, not including those which were applied by industrial companies on the basis of results obtained in the institute.

This extremely high productivity could not be achieved with the regular staff of the institute which amounted to altogether 4 permanent positions including FALCK himself. It was possible only on the basis of extramural sources, which came both from the Prussian Government, who funded the institute with some 5—10.000

Marks each year and from the German chemical and wood-protection industry. This support more than doubled his staff, at the climax of his cooperation with the industry, he had 3 positions for full assistants financed by the industrial partners. This probably was one of the best and most successful examples for scientific-industrial cooperation outside chemistry and medicine of his time. Converted to our present value in money, he was able to raise funds in the range of at least 250—500.000,— DM each year.

The results of his work, however, justified every Mark which was invested into his laboratory. This can best be shown by the results of his work on dry rot of timber. In a series of excellent studies, he built the foundation of the present-day successful control of Hausschwamm. His research covered virtually all aspects of control of this fungus, starting with the physiology, the way of action on the wood, chemical control, and even methods for the evaluation of the efficiency of the control-chemicals, which are still the international standard procedure of today.

His work on chemical control reduced the Hausschwamm-problem in Germany from a major factor in building deterioration, causing some hundred millions of Mark each year to virtually a minor problem, appearing only under special conditions. He was the first to introduce the tremenduously successful respiratory poisons for control of fungi in timber. The well-known trade mark "Xylamon" for instance goes back to his studies.

Since deterioration of wood was his main topic, he was interested also in the basic mechanisms of degradation of wood by fungi. He discovered the biochemical basis for the fundamental differences in the mode of action of the two main types of wood-degrading fungi, which had been previously termed as white-rot and brown-rot fungi. He could show that the white-rot fungi preferably degrade the lignin part of lignocellulose, whereas the prime target of the brown-rot fungi is the cellulose. On the basis of these findings, which were obtained both by chemical and anatomical analysis, he coined the terms "Corrosive Rot" for the white rot and "Destructive Rot" for the brown rot mode of decay, terms which still are in use in basic textbooks of botany in Germany (e.g. "STRASBURGERS Lehrbuch der Botanik"). The quality of his research on lignin degradation with regard to the methods he used and the results he obtained was not surpassed until the year 1975, that is after about 50 years, when independently KIRK and his group in Madison and HAIDER and TROJANOWSKI (Braunschweig and Lublin) introduced entireley new techniques using radioactive labeled lignin for such studies (KIRK et al. 1975, HAIDER and TROJANOWSKI 1975).

The quality and scientific standard of his research becomes best apparent probably by a sideline of his research, the discovery of the antibiotic reaction of the fungus *Sparassis crispa* against other microorganisms, the successful isolation and even crystallization of the antibiotic principle by him, and finally the determination of the complete chemical structure by the chemist EDGAR WEDEKIND from the Forest Academy in Hann. Münden.

The starting point of this discovery was exactly opposite to the one of penicillin by Sir ALEXANDER FLEMING (for a description see AINSWORTH 1976). Whereas the discovery of penicillin "was due to a most extraordinary series of coincidences" and "apparently FLEMING himself did not unterstand what had happened" (quotations from AINSWORTH 1976, p. 218). FALCK became interested in the phenomenon by the observation that, opposite to the normal experience with infections, cultures of *Sparassis crispa*, and of this species only, did not get contaminated, even after very long storage, whereas cultures from other fungi did have this problem of infections.

FALCK observed that these protected cultures formed small crystals of a substance, which apparently were responsible for this lower frequeny of infections. He isolated the antibiotic by steam distillation and was even able to obtain it in a pure crystalline form. During the years 1920—22 he thus produced some 2 grams of sparassol, whose structure then was determined by Professor WEDEKIND, from the Forstliche Hochschule in Hann. Münden, too (WEDEKIND and FLEISCHER 1923).

Three main steps are necessary for the recognition and exploitation of a given antibiotic:

1. Recognition of its antibiotic action
2. Isolation from the culture as a pure compound
3. Determination of its chemical structure.

R. FALCK and E. WEDEKIND by no doubt were the first scientists in history to achieve all these three steps together, almost twenty years before the same level of achievements were reached by the joint ventures of FLEMING and the Oxford group. This fact is fully acknowledged for instance in the first monograph on antibiotics which was written in 1949 (FLOREY et al. 1949).

Unfortunately, the echo FALCK got for this part of his work, was rather dim. He tried to get professors of the Medical School in Göttingen interested in this phenomenon, but was met with complete lack of response (MARIANNA FALCK-BARANAN, personal communication). On the other hand, he was extremely busy with other things, therefore he never got around to publish the data on the biological action of sparassol, although this was announced by him in his publication in 1923. It was not until 1986, when CWIELONG in his doctoral thesis repeated the basic work on sparassol, that any scientist bothered to work on this antibiotic again (CWIELONG 1986). It is not surprising that he could confirm everything which had been published on this subject by FALCK and WEDEKIND and that sparassol proved to be the most active natural compound in the biochemical control of pathogenic fungi. It fits into this picture that, in his rather voluminous laudatio on FALCK on the occasion of FALCKS 65th birthday, REICHERT did not mention the sparassol-story at all (REICHERT 1938).

Another milestone of scientific work and deduction of rather complex systems is his discovery of the so called "chain-diseases" of forest trees. In 1911 he was asked by the forest administration to investigate about some apparently new decline diseases occurring with oak and spruce in some areas in the Solling and other parts of Northern Germany. FALCK soon found out that the fungus which by no doubts was killing the trees, could not be responsible as the only cause for this problem, since under the conditions of controlled field experiments, the fungus isolated from the declining stands could not attack the trees at all. Thus the attempt to apply KOCHS postulates to this case study failed. Therefore FALCK considered much more complex factors to be responsible for the damage and postulated a chain of events, which finally resulted into the observed decline:

1. the predisposition of the stand (age, soil factors etc.)
2. factors which lead to a physiological weakness of the tree (e.g. climate) and
3. parasites which finally kill the tree.

This concept, which is considered as a major key to the understanding of the "Waldsterben" in Germany (c.f. Umweltforschung zu Waldschäden, 1985) was developed almost 70 years before the very similar "decline disease"-concept of MANION (MANION 1981).

RICHARD FALCK was not allowed to really enjoy the harvest of his scientific life. 1933, when he was 60, he was forced into exile from Germany and the next 22 years

of his life can at best be characterized by continuous migration, poverty, war; the geographical stations being: Palestine, Poland, Russia, Iran, Palestine and, finally, USA (for details see HÜTTERMANN, 1982, 1986).

These years of exile and migration, by no means, were futile with him being inactive. In Palestine, affiliated with the Institute of Polymer Chemistry of the Hebrew University, Jerusalem, he finished, together with a post doctoral fellow who followed him to his new place, his study on wood preservation and physical properties of wood. In Poland, he established a new Institute for Wood Protection for the Polish Forestry Service. The 40th anniversary of this event was celebrated by the dedication of the Ninth Polish Congres of Wood Protection (1976) to the memory of R. FALCK (WAZNY and LIESE 1977).

The last highlight in his life was a stay in England, in 1947, where he stayed for a six months period as an advisor for the building-up of a new laboratory and factory for wood protecting agents. During his stay in England, he attended the Jubilee-Meeting of the British Mycological Society, where he was elected as Honorary Member of the society, which is the highest honor which is available for any mycologist as such. He was the first and only German scientist so far rewarded with this honor.

After his return to Palestine, he was faced with the quarrels about the future of the country and the last war during his lifetime, the War of Liberation after the declaration of the State of Israel in 1948. He served for the new Israelian government as scientific advisor on problems of decay of timber in the Israelian naval forces and tents in the Israelian army. Although he did very well, his tasks being completely solved, the new State of Israel had no means to support him further, so he followed his daughter and her husband to Atlanta, GA, USA, where he died in 1955 at the age of 81.

MORITZ BÜSGEN

MORITZ BÜSGEN was born in 1858 as son of the Sanitätsrat Dr. med. MORITZ BÜSGEN in Weilburg an der Lahn. After his highschool years, he studied science at the universities of Bonn, Berlin, and Strasburg, where he passed the examination in science and got the Ph. D. During the Winter 1882/83 he worked at the Zoological Station in Neapel on marine algae, went back to Strasburg and became assistant of DE BARY at the Botanical Institute there. After a short stay in Strasburg, he went to Jena and got his Habilitation (equivalent to Dr. Sc.) there in 1885, at the Botanical Institute of ERNST STAHL. 1891 he got promoted to an "außerordentlicher Professor" in Jena and went in April 1893 as Professor to the Forest Academy in Eisenach. Eight years later he was appointed to a full professorship at the Forest Academy in Hann. Münden, where he stayed until the end of his life in 1921.

Soon after his move to Hann. Münden, he was granted a "Reichsstipendium" (Fellowship from the Empire) for an eight month period of work in the Botanical Garden of Buitenzorg, Java, which at that time was a Dutch colony. This required a leave of absence for the newly appointed Professor and resulted in quite an amount of red tape until he got it. (It was interesting and amusing at the same time for the "amateur historian" to find traces of this "struggle" in the various obituaries and commemoration-literature on the occasion of his 100th birthday: according to SCHMUCKER (1958) he had a significant reduction in payment and a delay in promotion; RHUMBLER (1924) reports about the same incident and states that he had no problems to get the leave and the money and points out that at that time this

generousity of the Forestry Administration by no means was self-evident; the "full story" can be found in HASEL's book (HASEL 1968, pp. 214—216) where the whole correspondence on this "case" is recorded: BÜSGEN first had problems to get full payment, but after insisting on it and with full support and help from the Director of the Forest Academy, WEISE, he finally got what he wanted and deserved).

Another longer period of research in the tropics followed when he was asked by the German Imperial Colonial Office and Ministry of Agriculture to work for them in Kamerun, which was a German colony then. In autumn of 1908 he went there as the head of a small group of scientists and stayed again for eight months in the Tropics (this time with no recorded salary-problems).

MORITZ BÜSGEN

The broad background in science which he got during his studies and the geographical stations of his life are reflected in his scientific work:

Being a student of DE BARY, it is not surprising that he started by working with fungi: Phycomycetes, *Eurotium oryzae, Cladocchytriacea* (including the newly described species *Physoderma graminis* Büsg.) are the genera and species he published on.

Under the influence of ERNST STAHL in Jena he developed his interests in topics of general biological importance, especially cases where insects and plants were interacting:

The first and most important to mention is his book "Der Honigtau; biologische Studien an Pflanzen und Pflanzenläusen" (1891). (The Honeydew; Studies on Plants and Plant-Lice). In this work he analyses the complex situation of

the interaction between aphids and plants, covering virtually all aspects which possibly could be studied at that time: the anatomy of the stylae of the aphids, the location where the stylae are placed by the aphids (the phloem), the interrelation between aphids and their antagonists like lady-birds and their larvae. the mechanisms of defense of the aphids, the effect of the drainage of the phloem by the aphids on the plant's physiology. This study is a masterpiece of early ecophysiological work.

The same broad set-up and ecological analysis can be found in similar although shorter papers on carnivorous plants like *Drosera* and *Utricularia* and the importance of the catchment of insects on the nutrition of the plants which grow in ecological niches with very little supply of nitrogen. The same approach was followed in his studies on galls from beech and pine.

The main line of his research and publications, however, was on all aspects of trees. In 1897 he published his famous book "Bau und Leben unserer Waldbäume", which in its altogether three editions, (the last came out in 1927 and was edited by E. MÜNCH) was for more than half a century the standard text- and reference book in the German literature on trees, it still has no equivalent in more recent literature. An English translation was published in 1929 (BÜSGEN and MÜNCH 1929). He was not only the leading authority in the scientific literature, but also wrote books for the general public. His book "Der deutsche Wald" (1908) (The German forests) where he explains the biological features of forests to the public, was written in such an amiable way that complete passages of it were incorporated into German reading-books for schools. This truly is the highest compliment any author of scientific literature designed for the broader public can get.

The third theme of his scientific life, naturally, was the tropics and their botany. He is considered the founder of German tropical forest botany, being the first one who endevoured to travel and work in the tropics. The scientific harvest of his two study tours is published in several reports and monographs, not to mention the fact that one tropical tree was named after him (*Uyaria büsgeni*).

BÜSGEN must have been an inspiring teacher for his students and graduate students, among which J. OELKERS was the most prominent one later on. It is worthwhile to mention this fact, especially since for the time from 1911 until his death, RICHARD FALCK's presence on the staff of the Forest Academy created in itself a problem to any woodbe professor of Forest Botany at the same place. This possible source of tension between the two Institutions naturally was created by the fact that FALCK's newly established "Institut für Technische Mykologie" from the beginning got much better equipment and much more attention and funds by the Forest Administration than the likewise spartanic hold "Institut für Forstbotanik" which was more a simple laboratory than deserved the designation "Institut". In this likewise uneasy situation, which could have been even more complicated by the fact that R. FALCK was a Jew, M. BÜSGEN showed the grandeur of a great person, who appreciated the great achievements of his collegue without getting jealous and never posed any problem to him. As long as BÜSGEN was Professor für Forstbotanik, FALCK had no problems with him nor with the other professors of the Forest Academy (MARIANNE FALCK-BARANAN, his daughter, personal communication). This situation changed, however, when after the death of BÜSGEN his successor took office (c.f. HASEL 1968, p. 360, FALCK, R., statements after the war in letters to Prof. SCHMUCKER).

It is perhaps the best indication of the very high appreciation which still is conferred to MORITZ BÜSGEN, that when the Forstliche Fakultät der Universität

Göttingen finally in 1970 moved from Hann. Münden to Göttingen, the street where the new buildings are located was named after him: "Büsgenweg", obviously one of the highest honor any academic board can reward.

Ernst Münch

Ernst Münch was born in 1876 as son of a pastor in Ruchheim, Pfalz. He went to the Gymnasium in Landau (Pfalz) and started, perhaps influenced by one of his uncles who was a forester, a career in Forestry. He studied in Aschaffenburg and München, passed the first examination (Diplom) and after his Referendarzeit and second examination, applied 1904 for an assistantship by von Tubeuf, Institut für Forstbotanik, who had become the successor of Robert Hartig. He stayed there, as an assistant of von Tubeuf, until 1910.

After his time in München, he entered the Forest Service (Regierungsforstamt Speyer), where he remained until 1921. There he had an appreciative superior, Geheimrath Wappes, who allowed him some freedom for scientific work, which he mainly conducted in the Stiftswald near Kaiserslautern. During the times of the First World War he was detached to the Biologische Reichsanstalt für Land- und Forstwirtschaft (Biological State Institute for Agriculture and Forestry) in Berlin, where he worked on the problem of resin collection from pines.

In 1921, already at the age of 45, he was offered the Professorship of Forstbotanik at the Forstliche Hochschule in Tharandt, near Dresden where he stayed for about 12 years, until in 1933 he became, as the successor of von Tubeuf and Robert Hartig, the director of the Forstbotanisches Institut in München, which was the last assignment in his rather unusual and long career.

The impressive scientific work of Münch focuses on several, apparently unrelated fields.

One is mycology and phytopathology, the theme of his doctoral thesis (in 1909) and the main studies in the laboratory of von Tubeuf. Until 1929 he published about 15 papers on this general subject, which made his name so well known, that he was asked to review the Hymenomycetes for the famous "Sorauers Handbuch der Pflanzenkrankheiten".

The work on pine resin during the war lead to a series of publications on this subject including a voluminous monograph (140 pages) on the plant physiological basis of this phenomenon (Münch 1919).

The work on the basics of resin collection, including experiments on the depletion of the resin channels and physics of movement of liquids in tubes of small diameter together with the construction of a model of the fluid dynamics of this process, apparently was an excellent training for his most important contribution to plant physiology: his model of phloem transport, the now called "Münch'sche Druckstromtheorie", which he published in 1930, in his book "Die Stoffbewegungen in der Pflanze" (The movement of substances in plants) (Münch 1930).

Reading this book about 60 years later, it is still fascinating to follow how Münch came to his theory and how far ahead of his time he really was. In his introduction, Münch summarizes the knowledge on assimilate transport in the following words, quoting the leading textbook in Botany and Plant Physiology of his time, Strasburgers Lehrbuch der Botanik (15. Aufl., 1921, pp. 236 f.):
"For the movements of substances within the plants, a diffusiongradient must be generated and sustained all the time. This happens in the following way: in the cells which are the goal of the movement of substances, the molecules coming in are

removed either by growth or storage, e.g. sugar to starch. This gives space for a subsequent molecule of sugar, which then moves after." ... "Whereas for the stream of transpiration the mechanical basis of the movement at least in part is known, as far as transpiration of water is concerned, the driving forces for the mass-movement of substances in the phloem are unknown." It was excactly the later part, the driving forces of the movement of substances in the phloem, for which he developed a theory, which in its basic features still is accepted even today (c.f. STRASBURGERS Lehrbuch der Botanik, 31. Aufl., 1978).

ERNST MÜNCH

To fully appreciate the achievement of MÜNCH, one has to consider his scientific background as well as that of the fellow botanists of his time. Coming from practical forestry, he was professor of Forstbotanik at an relatively isolated and remote Forest Academy in Tharandt, which was part of the Technische Hochschule Dresden, with no direct connection to a major university. How far (or how little) the average plant physiologists at that time were acquainted with thermodynamics etc. can be deducted from the leading text- and handbook of plant physiology of that time (BENECKE and JOST 1924, c.f. MEVIUS 1955). It includes a special chapter on energy, which in a very unprecise way deals with different "forms" of energy, but with very little understanding of it, no mentioning of caloric values etc. The chemical energy is dealt with only marginally and the relation between caloric energy of the molecule and chemical energy which can be drawn from it by the cell, is not even mentioned. To be fair to BENECKE, one should mention that terms like enthalpy etc. were almost unknown to the majority of German botanists until the German translation of LEHNINGERS book on Bioenerge-

tics appeared on the German scene in 1970. A discussion on energy which includes thermodynamic principles, for instance did not enter the above mentioned textbook until its 31st edition (1978), when H. ZIEGLER was in charge of the section on plant physiology. (It should be recorded in this connection, that with this edition, MÜNCH's "Druckstromtheorie" entered this famous and widely distributed textbook, 48 years after its first publication!!)

Against this background, MÜNCH's book really is fascinating. He comes up with a clear concept of energy, precisely distinguishing between the caloric energy of a given molecule and its osmotic potential, clearly stating that these two parameters are not linked energetically. MÜNCH gives precice calculations on the physics of fluid mechanics of laminar flow and builds them into his model of phloem transport. In summary, MÜNCH, with excellent reason, disposess of the idea that diffusion can be responsible for the transport of assimilates and replaces it by the stream of water driven by osmotic forces which are the result of the differences in the osmotic potentials of the cells at both ends of the line of conducting sieve elements. He takes into calculation the mechanical friction of the sieve tubes and shows that the osmotic forces are big enough to cope with this problem. In short, his book covers all aspects of phloem transport, from the physical basics and models to numerous field experiments which he either conducted himself or took from the literature and tested his hypothesis against.

Although his theory is admirably solid and compact, and as such a great masterpiece and example of how plant physiological deductions and conclusions should be made, he is surprisingly open. Far from thinking that his theory has solved all problems in phloem transport mechanisms, he states in his foreword that all he wants is to initiate new research in this field. This he surely did.

Although his theory could not explain every feature of phloem transport, it is not yet "replaced" by another one and still discussed in the textbooks of botany and biology for university students as the main explanation for the driving forces of assimilate transport and quoted regularly each year in the plant physiological literature (see below). This says more than anything on the quality of his concept and of the way of thinking of MÜNCH.

The main focus of MÜNCH's work, however, was on forest breeding and forest genetics. More than half of his publications and most of the contributions from his time in München are on topics related to this field. His last large monograph carries the title "Beiträge zur Forstpflanzenzüchtung" (MÜNCH 1949) and summarizes all his field work conducted both in Tharandt and in München.

The longer lasting impact of this part of his life's work apparently is much less impressing today. It was of tremenduous value for tree breeding during his life time and thereafter. ROHMEDER and SCHÖNBACH (1959) in their book "Genetik und Züchtung der Waldbäume" (Genetics and breeding of forest trees) quote him more than any other author. There are some concepts detectable in his papers which still are interesting today:

In a case study on alder decline, he came to the conclusion that in this case, the combination between genetic factors and environmental stress leads to drastic changes in the gene frequencies, which do not obey the HARDY-WEINBERG formula any more and result into selctive pressure against certain genes (MÜNCH 1936).

In his last book, he reports on physiological traits which lead to genetic isolation of certain parts of the tree population as a reaction to certain features of our climate (early and late spring) (MÜNCH 1949).

The main result of his 1949 book is the precise description of progeny lines within breeding experiments, clearly indicating that freely mating trees cannot be used in progeny tests.

But these results, apparently do not have the incentive and degree of erudition as had his "Druckstromtheorie". In later books of Forest Genetics (e.g. STERN and ROCHE 1974, STERN and TIGERSTEDT 1974) MÜNCH is not quoted anymore at all. This, however, does not diminuish the value of his impressive scientific work at all, it shows where he was within the mainstream of scientific progress and where he was far ahead of his time.

What remained? — Analysis of the Citation Pattern via SCI

Scientific work lives as long as other scientists remember. From this viewpoint it is interesting to analyse the degree of citation of the scientists dealt with in this communication in the Science Citation Index for the last eight years from 1978—1985.

The results are given in the following Table:

Table
Citation incidence as shown in Science Citation Index:

Name	Total numbers of quotations in the year: 1978	1979	1980	1981	1982	1983	1984	1985
THEODOR HARTIG	9	11	11	7	5	2	10	3
ROBERT HARTIG	7	2	3	7	5	5	8	8
MORITZ BÜSGEN	3	8	9	7	5	11	9	8
RICHARD FALCK	4	5	5	5	6	5	2	4
ERNST MÜNCH	13	17	14	18	11	14	10	13
for comparison:								
BURGEFF	24	11	14	10	12	14	4	16
Quotations from MÜNCHs Druckstromtheorie:								
(Stoffbewegung)	8	5	9	12	5	5	5	8

In summary, it is remarkable how frequently the scientists discussed in this contribution still are cited in current scientific journals.

It is reasonable that the authors which have dealt with subjects of more broader interest in the direction of tree viz. plant physiology (TH. HARTIG, BÜSGEN and MÜNCH) have been quoted more frequently than the ones who have been more mycologists. It should be noted, however, that the quotation frequency in the area of forestry literature is covered rather incompletely by SCI (c.f. HÜTTERMANN 1981). Therefore it is reasonable to assume an additional "dark figure" of at least the same order as the one given above. Keeping this in mind, the degree of citation of the leading forest botanists can well be compared to the citation frequency of one of the leading scientists in plant physiology in the twenties and thirties of this century, BURGEFF, whose field of study — endomycorrhiza — could be compared in its importance to the ones of the forest botanists.

Special attention should be given to the impact MÜNCH still has on plant physiology. His "Druckstromtheory" of phloem transport, judged at least by the

constancy and frequency of citation, still appears to be the accepted theory on the general mechanism of assimilate transport.

MAX PLANCK once made a famous statement on how scientific truth disseminates and gets accepted (PLANCK 1958):

"Eine neue wissenschaftliche Wahrheit pflegt sich nicht in der Weise durchzusetzen, daß ihre Gegner überzeugt werden und sich als belehrt erklären, sondern vielmehr dadurch, daß die Gegner allmählich aussterben und daß die heranwachsende Generation von vornherein mit der Wahrheit vertraut gemacht ist."

"New scientific truth does not get accepted in the way that the opponents get convinced and declare themselves advised otherwise, but only by the way that the opponents gradually become extinct and that the new generation gets familiar with the truth in the beginning."

On the basis of this view, the "truths" discovered by the scientists to which this communication is devoted, appear to be fairly viable, which is the best judgement which anybody possibly can make about any scientists work.

Literature

AINSWORTH, G. C.: Introduction to the History of Mycology. Cambridge University Press, 1976.

BARY, DE A.: Comparative Morphology and Biology of the Fungi. Transl. H. E. F. GARNSEY. 525 pp. Oxford: At the Clarendon press (1887). Reprint: Johnson Reprint Corp. New York (1966).

BENECKE, W., und L. JOST: Pflanzenphysiologie, 4., umgearbeitete Auflage von JOST: Vorlesungen über Pflanzenphysiologie. Vol. I, 441 pp. Jena: Fischer, 1924.

BÜSGEN, M.: Der Honigtau; biologische Studien an Pflanzen und Pflanzenläusen. Jena: Fischer, 1891.

— —, und E. MÜNCH: Bau und Leben unserer Waldbäume. Engl. Translation by T. THOMSON: "The structure and life of forest tree". London: Chapman and Hall, 1929.

BUTIN, H.: Krankheiten der Wald- und Parkbäume. Stuttgart, New York: Thieme, 1983.

CWIELONG, P.: Mechanismen der Resistenz und der Pathogenität von fungizid wirksamen Naturstoffen gegenüber dem Erreger der Rotfäule *Heterobasidion annosum* (Fr.) Bref. Dissertation Forstwiss. Fachbereich, Göttingen, 1986.

EBERTS, H.: Die Forstverwaltung im Umbruch der Zeit. Teil I. Forst und Holz Nr. **12**, 47—50 (1951a). Teil II. Forst und Holz Nr. **17**, 67—70 (1951b). Teil III. Forst und Holz Nr. **2**, 5—7 (1952a). Teil IV. Forst und Holz Nr. **3**, 9—15 (1952b).

— —, Die Verlegung der Forstlichen Fakultät der Georg-August-Universität von Münden nach Göttingen. Forst-Holzwirt **12**, 193—201 (1957).

FLOREY, H. W., E. CHAIN, N. G. HEATLEY, M. A. JENNINGS, A. G. SANDERS, E. P. ABRAHAM, und M. E. FLOREY: Antibiotics, 2 Vol. p. 356 Oxford University Press, 1949.

FRANK, A. B.: Über die auf Wurzelsymbiose beruhende Ernährung gewisser Bäume durch unterirdische Pilze. Ber. Deutsch. Bot. Ges. **3**, 128—145 (1885).

FRIES, E.: Systema mycologicum, sistens fungorum ordines, genera et species. 3 Vols. Lund: Greifswald, 1821—32.

FROST, S., L. (ed.): Trees for the Great, C. A. SCHENCK Memorial. 41 pp. American Forestry Association, 1952.

HAIDER, K., and J. TROJANOWSKI: Decomposition of specifically 14C-labelled phenols and dehydropolymers of coniferylalcohol as models for lignin degradation by soft and white-rot fungi. Arch. Microbiol. **105**, 33—41 (1975).

HARTIG, R.: Vergleichende Untersuchungen über den Ertrag der Rothbuche und Eiche im Spessart, der Rothbuche im östlichen Wesergebirge, der Tanne im Schwarzwalde und der Kiefer in Pommern. Stuttgart: Cotta, 1865.

— —, Die Rentabilität der Fichtennutzholz- und Buchenbrennholzwirthschaft im Harze und im Wesergebirge. Stuttgart: Cotta, 1868.

— —, Wichtige Krankheiten der Waldbäume. Beiträge zur Mycologie und Phytopathologie für Botaniker und Forstmänner. Berlin: Springer, 1874.

——, Important Diseases of Forest Trees. Contributions to Mycology and Phytopathology for Botanists and Foresters. Berlin: Springer 1874. Translation: W. MERRILL, D. H. LAMBERT, W. LIESE. St. Paul: The American Phytopathological Society (1975) Phytopathological Classics, Nr. 12.
——, Die Zersetzungserscheinungen des Holzes der Nadelholzbäume und der Eiche in forstlicher, botanischer und chemischer Richtung. Berlin: Springer, 1878.
——, Lehrbuch der Baumkrankheiten. Berlin: Springer, 1882. Engl. translation (by W. SOMMERVILLE and H. M. WARD): Textbook of diseases of trees. London, 1894.
HARTIG, TH.: Abhandlungen über die Verwandlung der polycotyledonischen Pflanzenzelle in Pilze und Schwammgebilde und der daraus hervorgehenden sogenannten Fäulniss des Holzes. 46 p. Berlin: 1833.
——, Vollständige Naturgeschichte der forstlichen Culturpflanzen Deutschlands. Berlin: Springer, 1840.
——, Ambrosia des *Bostrychus dispar*. Allg. Forst-Jagdzeit. **13,** 73—74 (1844).
——, Lehrbuch der Pflanzenkunde in ihrer Anwendung auf die Forstwirtschaft. Für Forstleute, Landwirthe und Freunde der Botanik. 2. Bde, Berlin: Springer, 1851.
——, Über den Herbstsaft der Holzpflanzen. Bot. Ztg. **16,** 369 (1858).
——, Beitr. zur physiologischen Forstbotanik. Allg. Forst- u. Jagdztg. **257** (1860).
——, Anatomie und Physiologie der Holzpflanzen. Dargestellt in der Entstehungsweise und im Entwicklungsverlaufe der Einzelzelle, der Zellsysteme, der Pflanzenglieder und der Gesamtpflanze. Berlin, 1878.
——, GEORG-LUDWIG HARTIG im Kreis seiner Familie. HASEL, K., und W. MANTEL (Herausg.), 101 pp. Göttingen (1976).
HASEL, K.: Quellen zur Geschichte der Forstlichen Fakultät der Georg-August-Universität Göttingen. 422 pp. Hann. Münden: Bretz und Gutzeit (1968).
HEEG, B., und G. OESTEN: Untersuchungen über die Berufsorientierungen von Studienanfängern der Forstwissenschaften und Bewerbern für den Höheren Forstdienst. Forst- u. Holzwirt. **10,** 190—194 (1973).
HORN, W.: THEODOR HARTIG. Z. Forst- u. Jagdwes. **12,** 292—309 (1880).
HÜTTERMANN, A.: Die Forstliche Fakultät 10 Jahre in Göttingen — Versuch einer Zwischenbilanz. Forstarchiv **52,** 29—36 (1981).
——, Ein rastloses Leben. Zum Gedenken an RICHARD FALCK. Informationen Univ. Göttingen, Nov. 1982, 6—10 (1982).
——, In memoriam: RICHARD FALCK. In: HÜTTERMANN, A., and I. CHET (eds.), Soil-plant-interaction. pp. 1—14, Göttinger Bodenkundl. Ber. Vol. **85,** Göttingen, 1986.
KIRK, T. K., W. J. CONNORS, R. D. BLEAM, W. F. HACKETT, and J. G. ZEIKUS: Preparation and microbial decomposition of synthetic 14C-lignins. Proc. Nat. Acad. Sci. (USA) **72,** 2515—2519 (1975).
Lehrbuch der Botanik für Hochschulen, begr. von E. STRASBURGER, 5. Aufl. Jena: Fischer, 1921. 17. Aufl. Jena: Fischer, 1928. 28. Aufl. Stuttgart: Fischer, 1962. 31. Aufl. Stuttgart, New York: Fischer, 1978.
LOEW, R.: Evolution und Erkenntnis. Tragweite und Grenzen der evolutionären Erkenntnistheorie in philosophischer Absicht. In: LORENZ, K., und F. M. WUKETITS (Herausg.), Die Evolution des Denkens. pp. 331—360. München: Piper, 1983.
LUNDERSTÄDT, J.: Zur Reform des forstwissenschaftlichen Studiums an der Universität Göttingen. Allg. Forstzschr. **41,** 1026—1027 (1985).
MANION, P. D.: Tree disease concepts. Prentice Hall, 1981.
MERRILL, W., D. H. LAMBERT, und W. LIESE: ROBERT HARTIG, 1839—1901 (editorial notes). In: HARTIG, R., Important Diseases of Forest Trees. Contributions to Mycology and Phytopathology for Botanists and Foresters. Berlin: Springer, 1874. Translation: W. MERRILL, D. H. LAMBERT, and W. LIESE. St. Paul: The American Phytopathological Society (1975) Phytopathological Classics, Nr. 12.
MEVIUS, W.: FRIEDRICH WILHELM BENECKE. Ber. Deutsch. Bot. Ges. **48A,** 125—131 (1955).
MÖBIUS, M.: Geschichte der Botanik, von den ersten Anfängen bis zur Gegenwart. 458 pp. Jena: Fischer, 1937.
MÜNCH, E.: Naturwissenschaftliche Grundlagen der Kiefernharznutzung. Arb. Biol. Reichsanst. Land- u. Forstw. **10,** 1—140 (1919).
——, Die Stoffbewegungen in der Pflanze. 234 pp. Jena: Fischer, 1930.
——, Das Erlensterben. Forstwiss. Cbl. **58,** 173—194 and 230—248 (1936).
——, Beiträge zur Forstpflanzenzüchtung. (aus dem wissenschaftlichen Nachlaß herausgegeben von B. HUBER) 118 pp. München: Bayerischer Landwirtschaftsverlag, 1949.
NETER, E.: PASTEUR's contributions to infectious diseases. ASM News **39,** 39—41 (1973) (Sesquicentennal Commemorative Symposium).

NICOLAI, O.: Das Wachstum der Wurzel. Schriften der K. phys. oekon. Ges. zu Königsberg, Abh. **6**, 33—78.
PLACK, M.: Physikalische Abhandlungen, Vol. III, p. 389, Braunschweig, 1958.
PRESTON, R. J.: CARL ALWIN SCHENCK, America's pioneer advocate of sound forestry practice. Pinetum pp. 1—3, Raleigh: NSCU, College of Forest Resources, 1973.
REICHERT, I.: RICHARD FALCK (to his 65th birthday). Pal. J. Horticult. Botany **2**, 113—125 (138).
RHUMBLER, L.: MORITZ BÜSGEN. Z. Forst-Jagdwesen **56**, 4—14 (1921).
ROGERS, D. P.: A brief History of Mycology in North America. 65 pp. Amherst: Newell Inc., 1977 (Second International Mycological Congres Inc.).
ROHMEDER, E., und H. SCHÖNBACH: Genetik und Züchtung der Waldbäume. Hamburg und Berlin, 1959.
ROSENSTOCK, H. A.: Zur Geschichte der preussischen Staatsforstverwaltung. Diss. Forstl. Fakultät, Göttingen 1975.
SACHS, J.: History of Botany (1530—1860). Transl.: H. E. F. GARNSLEY, Oxford: At the Clarendon 1890, Reprint: New York, Russel and Russel, 1967.
SCHACHT, V. H.: Über die Veränderungen durch Pilze in abgestorbenen Pflanzenzellen. Jahrb. f. wiss. Botanik **3**, 442—483 (1863).
SCHMIDBERGER, J.: Beiträge zur Obstbaumzucht und zur Naturgeschichte der den Obstbäumen schedlichen Insecten. Linz 1827—1836, IV. Heft, 213 (1836).
SCHMUCKER, TH.: MORITZ BÜSGEN. Zum Gedächtnis anläßlich seines 100. Geburtstages. Allg. Forstzschr. **13**, 467 (1958).
SCHRÖDINGER, E.: What is Life? & Mind and Matter (first published 1944). Cambridge University Press, 1967.
SPAEMANN, R., und R. LÖW: Evolutionstheorie und menschliches Selbstverständnis. Weinheim: Verlag Chemie (Acta humaniora), 1985.
SPELLMANN, H.: Zur Studienreform am Forstwissenschaftlichen Fachbereich der Universität Göttingen. Forstarchiv **54**, 21—26 (1983).
STERN, K., and L. ROCHE: Genetics of Forest Ecosystems. Heidelberg, New York: Springer, 1974.
— —, und P. M. A. TIGERSTEDT: Ökologische Genetik. Stuttgart: Fischer, 1974.
Umweltforschung zu Waldschäden. 3. Bericht. Der Bundesminister für Forschung und Technologie (Herausgeber). pp. 37—38, Bonn, 1985.
UNGER, F.: Die Exantheme der Pflanzen und einige mit diesen verwandte Krankheiten der Gewächse, pathogenisch und nosographisch dargestellt. Wien, 1833.
WATSON, J. D.: Molecular Biology of the Gene. 3rd edition, Menlo Park: Benjamin Inc., 1976.
WAZNY, J., und W. LIESE: IX. Polnische Holzschutztagung im Gedenken an Prof. Dr. RICHARD FALCK. Holz-Zentralbl. **41/42**, 642 (1977).
WEDEKIND, E., und K. FLEISCHER: Über die Konstitution des Sparassols. Ber. Deutsch. Chem. Ges. **56**, 2556—2563 (1923).
WILLKOMM, M.: Die mikroskopischen Feinde des Waldes. Vol. I. pp. 31—100. Dresden: (1866—67).

BIBLIOGRAPHIES, OBITUARIES AND MONOGRAPHS:
(other than quoted above)

MORITZ BÜSGEN:

Ber. Deutsch. Bot. Ges. **39**, (87)—(96) (1921) (W. BENECKE).
Z. Forst-Jagdwesen **56**, 4—14 (1921) (L. RHUMBLER).
Forstarchiv **29**, 158 (1958) (H. H. HILF).
Allg. Forst-Jagdzeit. **129**, 252 (1958) (H. H. HILF).

RICHARD FALCK:

Ann., Holz Roh-Werkst. **11**, 196—198 (1953).
Forstarchiv **26**, 107—109 (1955) (TH. SCHMUCKER).
Holz-Zentralblatt **41/42**, 642 (1977) (J. WAZNY, W. LIESE).

GEORG LUDWIG HARTIG:

MANTEL, K.: GEORG LUDWIG HARTIG zur 200jährigen Wiederkehr seines Geburtstages. Forst-Holzwirt. **19,** 383—385 (1964).
— —, und J. PACHER: Forstliche Biographie vom 14. Jahrhundert bis zur Gegenwart. Vol. I., pp. 250—258, Hannover: Schaper, 1976.
PACHER, J.: GEORG LUDWIG HARTIG 1764—1837. Persönlichkeit und Wirken im Lichte seiner Zeit, gemessen an der heutigen Situation der Forstwirtschaft. Allg. Forst-Jagdzeit. **135,** 241—247 (1964).

THEODOR HARTIG:

MANTEL, K., und J. PACHER: Forstliche Biographie vom 14. Jahrhundert bis zur Gegenwart. Vol. I., pp. 222—228, Hannover: Schaper, 1976.
PACHER, J.: Die Auswirkungen der Naturwissenschaften auf die Forstwissenschaft im 19. Jahrhundert anhand bedeutender Vertreter der deutschen Forstwissenschaft. Allg. Forst-Jagdzeit. **142,** 265—274 (1971).
GREUEL, WALTER: THEODOR HARTIG, eine Biographie. 104 p. Dipl. Arbeit, Forstliche Fakultät, Göttingen 1979.
PAES, R.: Das Collegium Carolinum als forstliche Alma Mater und seine Beziehungen zum braunschweigischen Staatsforstdienst. Forstrath Prof. Dr. HARTIGS Schicksal zwischen Collegium und Cammer. 14 pp. Braunschweig: Universitäts Bibliothek, 1970.

ROBERT HARTIG:

Forst-Jagdzeitung, 129—131 (1902) (E. P. MEINECKE).
Z. Forst-Jagdwesen **34,** 3—4 (1902) (anonymous editorial).
Forstwiss. Centralbl. 1—5 (1902) (DINGLER).
Ber. Deutsch. Bot. Ges. **20,** 8—28 (1902) (C. VON TUBEUF).
Jagdwesen **28,** 42—46 (1902) (CIESLAR).
SCHWARZENTRAUB, H.: Biographie des Forstpathologen ROBERT HARTIG. 79 p. Dipl. Arbeit, Forstliche Fakultät, Göttingen 1979.

ERNST MÜNCH:

Ber. Deutsch. Bot. Ges. **68a,** 135—140 (1955) (HUBER).

Bibliography of RICHARD FALCK:

(Since there is no bibliography of RICHARD FALCK available in the literature, we have tried to give as complete information as possible on his publications.)

Die Cultur der Oidien und ihre Rückführung in die höhere Fruchtform bei den Basidiomyceten. Diss. philos. Fakultät, Breslau, 36 pp. J. U. Kerns Verlag (1902).
Die Bedingungen und die Bedeutung der Zygotenbildung bei *Sporodinia grandis*. In: COHN, F. (Herausg.), Beiträge zur Biologie der Pflanzen Vol. VIII, pp. 213—307. Breslau: J. U. Kerns Verlag (1902).
Darstellung und Anwendung consistenter Spiritusseife zur rationellen Reinigung und Desinfektion der Haut, besonders von anklebenden Schimmelpilzsporen. Archiv klin. Chirurgie. **73,** 407—437 (1904).
BREFELD, O., und R. FALCK: Die Blüteninfektion bei den Brandpilzen und die natürliche Verbreitung der Brandkrankheiten. In: BREFELD, O. (Herausg.), Untersuchungen aus dem Gesamtgebiete der Mykologie. Heft XIII, Brandpilze (Hemibasidii) IV. pp. 1—77, Münster: Schöningh (1905).
Über den Hausschwamm. Z. Hygiene Infektionskrankheiten **55,** 478—505 (1906).
Der echte Hausschwamm und die holzzerstörenden Pilze. Technische Rundschau, Berliner Tageblatt **13,** 473—474 (1907).
Denkschrift, die Ergebnisse der bisherigen Hausschwammforschung und ihre zukünftigen Ziele betreffend. Hausschwammforschungen **1,** 5—22 (1907).

Wachstumsgesetze, Wachstumsfaktoren und Temperaturwerte holzzerstörender Mycelien. Hausschwammforschungen **1**, 53—159 (1907).
Denkschrift die düngerbewohnenden Fadenpilze und die Entstehung der Kohlensäure und Salpetersäure dessimilierenden Humussubstanzen betreffend. Dem preuss. Kultusministerium im Jahre 1906 überreicht, gedruckt in: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 11—72 Jena: Fischer (1923).
Die Flugbrandarten des Getreide, ihre Verbreitung und Bekämpfung. J. Landwirtsch. 173—182 (1908).
Die Lenzitesfäule des Coniferenholzes. Hausschwammforschungen **3**, 1—241 (1909).
Die Sporenverbreitung bei den Basidiomyceten und der biologische Wert der Basidie. In: COHN, F. (Herausg.), Beiträge zur Biologie der Pflanzen. Vol. IX, pp. 1—82. Breslau: J. U. Kerns Verlag (1909).
Über die Luftinfektion des Mutterkorns (*Claviceps purpurea* Tul.) und die Verbreitung pflanzlicher Infektionskrankheiten durch Temperaturströmungen. Z. Forst-Jagdwesen **43**, 202—227 (1911).
Die Meruliusfäule des Bauholzes. Hausschwammforschungen **6**, 1—422 (1912).
Örtliche Krankheitsbilder des echten Hausschwamms. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte I., Jena: Fischer (1913).
Die Fruchtkörperbildung der im Hause vorkommenden holzzerstörenden Pilze in Reinkulturen und ihre Bildungsbedingungen. Mykologische Untersuchungen und Berichte I. (1913).
Kritische Bemerkungen zu den Hausschwammstudien WEHMERs. Mykologische Untersuchungen und Berichte I. (1913).
Anweisung zur Edelpilzkultur (*Psalliota campestris* L.). Z. Forst-Jagdwesen **46**, 639—645 (1915).
Über die Sporenverbreitung bei Morcheln und verwandten Pilzen. Z. Forst-Jagdwesen **47**, 407—421 (1915).
Über die Kultur, den Extraktgehalt und die Konservierung eßbarer Pilze. Z. Forst-Jagdwesen **47**, 38—56 (1915).
Zerstörung des Holzes durch Pilze. In: TRÖSCHEL, E. (Herausg.), Handbuch der Holzkonservierung. pp. 16—147, Berlin: Springer (1916).
Über die Sporenverbreitung bei den Askomyceten. I. Die radiosensiblen Diskomyceten. Mykologische Untersuchungen und Berichte I. 75—144 (1916).
Über die Waldkultur des Austernpilzes (*Agaricus ostreatus*) auf frischen Laubholzstubben. Z. Forst-Jagdwesen **49**, 159—165 (1917).
Massensterben jüngerer Fichten im Solling 1913 und 1914. Z. Forst-Jagdwesen **49**, 506—526 (1917).
Eichenerkrankung in der Oberförsterei Lödderitz und in Westfalen. Z. Forst-Jagdwesen **50**, 123—132 (1918).
Über die Bewertung von Holz- und Pflanzenschutzmitteln im Laboratorium und über ein neues Spritzmittel für den Pflanzenschutz. Z. angew. Botanik **1**, 177—249 (1919).
Kultur, Diagnose und Entwicklung des echten Hausschwamms sowie die Kultur eßbarer Pilze (Ausstellung). Ber. Deutsch. Bot. Ges. **37**, 8—14 (1919).
Die Resinolbrühe als Spritzmittel zur Bekämpfung tierischer Schädlinge. Z. angew. Entomologie **1**, 37—47 (1920).
Wege zur Kultur der Morchel-Arten. Z. Forst-Jagdwesen **52**, 312—323 (1920).
Merkblatt zur Hausschwammfrage. Hausschwammforschungen **7**, 1—14 (1921).
Über die Sporenverbreitung bei den Askomyceten. II. Die taktosensiblen Diskomyceten. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. III. pp. 370—403, Jena: Fischer (1923).
VON HÖHNELS mykologische Arbeiten. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. I. pp. I—VI, Jena: Fischer (1923).
Über ein krystallisiertes Stoffwechselprodukt von *Sparassis ramosa* Schäff. Ber. Deutsch. Chem. Ges. **56**, 2555—2556 (1923).
Nachruf für ALFRED MOELLER. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 1—10, Jena: Fischer (1923).
Denkschrift die Dünger bewohnenden Fadenpilze und die Entstehung der Kohlensäure und Salpetersäure dissimilierenden Humus-Substanzen betreffend. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 11—23, Jena: Fischer (1923).
Die Analyse der Umsetzungen bei der salpetersauren Huminifikation in einem größeren Stroh-Dünger-Verrottungsversuch. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 24—37, Jena: Fischer (1923).

Erweiterte Denkschrift über die Bedeutung der Fadenpilze für die Nutzbarmachung der Abfallstoffe der Baumernährung im Walde und über die Möglichkeit einer nachträglichen pilzlichen Aufschließung des Trockentorfs. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 38—63, Jena: Fischer (1923).

FALCK, R., und O. FALCK: Über die Sporenkeimung des Champignons. Neuere Untersuchungen zu ihrer Morphologie, Physiologie und Ökologie. In: FALCK, R. (Herausg.), Mykologische Untersuchungen und Berichte, Vol. II. pp. 64—127, Jena: Fischer (1924).

ALFRED MÖLLER. Bot. Archiv **6**, 1—7 (1924).

Über das Eichensterben im Regierungsbezirk Stralsund nebst Beiträgen zur Biologie des Hallimaschs und Eichenmehltaues. Algem. Forst-Jagdzeitg. **100**, 298—317 (1924).

Zur Frage der Holzimprägnierung mit arsenhaltigen Mitteln. Forstarchiv **1**, 129—131 (1925).

Aufgaben und Ergebnisse mykologischer Forschung. Forstarchiv **1**, 49—54 (1925).

Über korrosive und destruktive Holzzersetzung und ihre biologische Bedeutung. Ber. Deutsch. Bot. Ges. **44**, 652—664 (1926).

Der Lignin- und der Zellulose-Abbau des Holzes. Zwei verschiedene Zersetzungsprozesse durch holzbewohnende Fadenpilze. Ber. Deutsch. Chem. Ges. **60**, 225—332 (1927).

Über die Größen, Fallgeschwindigkeiten und Schwebewerte der Pilzsporen und ihre Gruppierung mit Bezug auf die zu ihrer Temperaturströmungs-Geschwindigkeiten. Ber. Deutsch. Bot. Ges. **45**, 262—281 (1927).

Sechs Merkblätter zur Holzschutzfrage. Hausschwammforschungen **8**, 1—71 (1927).

Nachruf auf ALFRED MÖLLER. Hausschwammforschungen **9**, 54—64 (1927).

FALCK, R., und W. COORDT: Der Methoxyl-Gehalt beim Lignin- und Cellulose Abbau des Holzes. Ber. Deutsch. Chem. Ges. **B 61**, 2101—2106 (1928).

Hausschwamm und Holzschutz aufgrund eigener Forschungen. Silva **40/41**, 1—18 (1928).

Die Gruppierung der Zersetzungsprozesse der verholzten Membran auf chemischer Grundlage und die Bedeutung derselben für die Bodenzersetzung im Walde. Verh. Intern. Kongreß Forstl. Versuchsanstalten (IUFRO), Stockholm, pp. 528—534 (1929).

Der Schutz des geschlagenen Eichenholzes durch Immunisation und Vergasung. Der Holzmarkt, Nr. 165, 1. Beilage, 1, (1929).

Lärchensterben und Theorie der Krebsbildung. I. Lärchensterben und Stammkrebsbildung. Die Gartenbauwissenschaft **1**, 53—70 (1929).

FALCK, R., und H. LUTZ: Vorschlag zur Verbesserung und Vereinfachung der Holztrocknungsmethoden. Forstarchiv **5**, 267—275 (1929).

FALCK, R., und H. LUTZ: Einfluß des Dämpfens und Druckdämpfens auf Laubhölzer, speziell auf Buchenholz. Forstarchiv **5**, 419—452 (1929).

Nachweise der Humusbildung und Humuszehrung durch bestimmte Arten höherer Fadenpilze im Waldboden. Forstarchiv **6**, 366—377 (1930).

Neue Mitteilungen über die Rotfäule. Mitt. Forstwirtsch. Forstwiss. **1**, 525—570 (1930).

Die Scheindestruktion des Koniferenholzes durch die Larven des Hausbockes (*Hylotrupes bajalus* L.). Cellulosechemie **9**, 89—91 (1930).

Über den Einfluß des Flößens auf die Widerstandsfähigkeit des Bauholzes gegen Trockenfäule und über den Holzschutz durch Schimmelbefall und Diffusionstränkung. Mitt. Forstwirtsch. Forstwiss. **2**, 480—485 (1931).

FALCK, R., und S. KAMESAM: Verfahren zur unlöslichen Fixierung des Arsens an die Holzfaser durch Zusatz von Chromaten. Chemiker Ztg. **55**, (1931).

FALCK, R., und H. LUTZ: Einfluß der Scharftrocknung auf die Quellungsvergütung beim Buchenholz. Mitt. Forstwirtsch. Forstwiss. **2**, 485 (1931).

FALCK, R., und S. KAMESAM: Ein neues, allgemein verwendbares Holzschutzmittel. Chemiker-Ztg. **55**, 837—838 (1931).

Die chemische Schutzbehandlung des Bauholzes und die für die Abgabe in der Apotheke in Betracht kommenden Holzschutzmittel. Pharmaz. Ztg. **77**, 1072—1074 (1932).

FALCK, R., und H. LUTZ: Wirkung physikalischer Methoden der Vorbehandlung des Buchenholzes. Die Einflüsse des Dämpfens, der Lagerung, des periodischen Dämpfens und der Scharftrocknung auf die Vergütung des Quellens und Schwindens. Quantitative Untersuchungen über Quellung und Schwund. Hausschwammforschungen **10**, 1—62 (1934).

FALCK, R., und V. KETKAR: Prüfung und Schutzwertbestimmung der Feuerschutzmittel des Holzes. Hausschwammforschungen **11**, 1—46 (1934).

The application of respiratory poisons in the cure and prophylactic treatment of the living tree. Palestine J. Botany Horticult. Sci. **1**, 70—92 (1935).

Die Ptychogasterfäule des Koniferenholzes. Hausschwammforschungen **12**, 1—61 (1938).

Das Schwammserum und die Schwammheilmethode der Firma X & Y. Hausschwammforschungen **12**, 62—100 (1938).

Der chemische Holzschutz und seine handwerkliche Anwendung im Hochbau, bei ländlichen Bauten und für allgemeine Nutzung im Freien. Hausschwammforschungen **12**, 101—124 (1938).

OLGA FALCK (obituary). Pal. J. Botany **5**, 263—266 (1946).

FALCK, R., and O. FALCK: A new class of Ascomycetales. A contribution to the orbis vitae system of fungi. Pal. J. Botany **6**, 89—106 (1947).

Grundlinien eines Orbis-vitalen Systems der Fadenpilze. Eine Untersuchung über die Bedeutung des Lebenskreises (orbis vitae) für die Gestaltungslehre, die Entwicklungsgeschichte und die Systematik der Fadenpilze. I. Teil. Die Haerangiomyceten und Ventangiomyceten im orbisvitalen System der Fadenpilze. II. Teil. Die gymnocarpen Ascomyceten und die Ableitung der Vescokarpiomyceten und der Sccharomyceten auf orbis-vitaler Grundlage. 85 pp. Amsterdam: de Bussy (1948).

Die Disto-Schutzstoffe und Proxi-Schutzstoffe des technisch verwerteten Holzes. Holz, Nr. **12**, 244—245 (1949).

LYSENKO's theory of variable gene viewed in relation to the life-sphere system of fungus taxonomy. Pal. J. Botany **7**, 126—134 (1949).

The types of symbiotic linkage and their significance for the formation of highly organized forms, functions and life-spheres in the phylogenetic process of development. Pal. J. Botany **7**, 1—16 (1949).

Podstawy fiziologiczne rozowoju grzybni *Vasomella maeandrata* oraz innych gatunkow z rodziny Ceratostomelleaceae. (Fundaments of the physiological development of mycelium *Vasomella maeandrata* and of other kinds of the Ceratostomelleaceae family. Inst. Polonais des Recherches Forestières. Travaux et Comptes Rendus. Ser. A. Nr. **59**, 3—24 (1949).

Podstawy zabezpieczenia drewna uzytkowego w zwiazku z fizjologicznym charakterem rozwoju grzybni i przeznaczeniem drewna. (Fundaments of the timber protection accordingly to the physiological character of the growth and the timber employment). Inst. Polonais des Recherches Forestières. Travaux et Comptes Rendus. Ser. A. Nr. **59**, 25—53 (1949).

Grundlinien eines Orbis-vitalen Systems der Fadenpilze. Eine Untersuchung über die Bedeutung des Lebenskreises (orbis vitae) für die Gestaltungslehre, die Entwicklungsgeschichte und die Systematik der Fadenpilze. III. Teil. Der karyologische Entwicklungs-Gang und seine Bedeutung im orbisvitalen System der Fadenpilze. 97 pp. Göttingen: Dietrich'sche Universitätsdruckerei (1950).

Die Degobasidie und die Degobasidiales. Ein Beitrag zum orbisvitalen System. Proc. 7th Int. Congr. Stockholm 1950, pp. 402—403. Stockholm (1953).

FALCK, R., und M. FALCK: Die Bedeutung der Fadenpilze als Symbionten der Pflanze für die Waldkultur. Frankfurt: Sauerländers Verlag, 1954.

Prof. Dr. ALOYS HÜTTERMANN
Forstbotanisches Institut
der Universität Göttingen
Büsgenweg 2
D-3400 Göttingen