

Centraalbureau voor Schimmelcultures: hundred years microbial resource centre

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Abstract: The Centraalbureau voor Schimmelcultures was established in 1904 by the Association Internationale des Botanistes. In 2004, it celebrated its 100 year anniversary. The collection was founded by F.A.F.C. Went and started with the maintenance of 78 cultures, most of which were collected in Indonesia. Presently CBS is one of the largest mycological centres in the world, with holdings of over 60 000 cultures, including many ex-type isolates of filamentous fungal and yeast species. The institute and its holdings have been at the basis of most major scientific breakthroughs in mycology.

Pure culture: a scientific revolution

At the end of 19th century, cultivation of microorganisms was no less than a scientific revolution. Without pure cultures, Louis Pasteur (1822–1895) would not have been able to carry out the experiments that had such a profound impact on today's medical practice. Robert Koch (1843–1910) laid the foundation of a new era in phytopathology by using cultures to realize his classic postulates for distinguishing phytopathogens from contaminants. In The Netherlands, the bacteriologist Martinus Willem Beijerinck (1851–1931) developed concepts in microbial ecology that are still valid today. For example, he was the first to obtain pure cultures of bacteria and he developed the enrichment culture method (Bos & Theunissen 1995).

By 1880, fungal culturing had followed the standards set in bacteriology. Yeasts and moulds gained increasing significance for many applications and they became daily tools used by a wide diversity of scientists. In institutions all over the world, fungal collections were built up. It was realized, however, that it is not so easy to keep strains alive on simple natural media without sustained maintenance and management.

Around 1900, immediate action was required to guarantee the long-term availability of reference materials. The Dutch botanist Prof. F.A.F.C. (Frits) Went (1863–1935) was the person who brought the matter onto the agenda of international scientific organizations. He was a pioneering phytopathologist in Indonesia, which at that time was a Dutch colony, and he had built up his own culture collection of fungal agents of important crop diseases. After Went received his doctoral degree in 1886, he worked in Indonesia at the famous Botanical Garden in Bogor. Soon afterwards, he became the director of the Agricultural Experimental Station in West Java, and later focussed his research on sugar cane diseases after

being appointed at the Sugar Cane Experimental Station (Peirce 1936). Besides phytopathogens, he also isolated many yeast and filamentous fungal strains that he recognized as playing an essential role in the production of Asian fermented foods.

The necessity of an international depository for fungal cultures was discussed in 1903 during a meeting of the board of the Association Internationale des Botanistes in Leiden. This organization had just been founded in 1901 and had, in compliance with its statutes, chosen Leiden as its legal domicile. It was decided that Went should initiate such an international collection in his own laboratory in Utrecht, as an experiment. Around 1903–1904, Went succeeded in creating an official status for this collection as a division of the Association. This can be concluded from a letter dated September 29, 1904 from the treasurer of the Association, Prof. J.P. Lotsy, directed to the “Manager of the Department of Fungal Cultures of the Association Internationale des Botanistes”. The letter acknowledged a report on the activities of this department, and the board allocated a small sum for the financial support of the collection. Although there must have been earlier activities, we consider this letter to be the beginning of the institute. The name Centraalbureau voor Schimmelcultures (CBS) was created shortly thereafter. Prof. Went donated his own collection to the establishment of CBS. In 1907 he published the first *List of Cultures*, documenting 78 strains, in *Botanisches Centralblatt* 105: 127, under the heading *Centralstelle für Pilzkulturen*. One of the oldest essential strains is the type of *Rhizopus oryzae*, a species Went described together with H.C. Prinsen Geerligs. After more than 100 years, this strain, CBS 112.07, is still in excellent condition. The second *List of Cultures*, published in 1908, already listed 180 strains. Some income to support the collection was generated by selling the strains for 1.50 Dutch guild-

ers to members of the botanical society, and for 3.00 guilders (equivalent to 25 € today) to non-members.

Went had a lively vision of his culture collection. In a popular article in the Dutch language, he referred to the fungus collection as “a botanical garden for moulds”. Such facilities were at that time available for vascular plants and for animals, but the equivalent for fungi, algae and bacteria had yet to be invented. Techniques for isolation and maintenance of microorganisms were still in their infancy. Went argued that the availability of fungal cultures was important not only for experimental science using model organisms, but also for storage of reference material after the experiments had been completed, so that public collections could keep this material accessible for verification studies and for future research. This concept was widely accepted, and the collection grew at a rapid pace. Very soon, problems of space availability became apparent, and both technical assistance and available managerial time appeared to be insufficient. In short: a specialized facility was needed, applying techniques that were not available in most botanical laboratories at that time, including Went’s. Prof. Went was urged to look for another solution, something better integrated with established institutional structures. During the 1913 meeting of the board of the Association Internationale des Botanistes in Copenhagen, a proposal was entertained to move the whole collection to Germany. Because of the difficult situation developing in Europe, scientists from the U.S.A. made a counterproposal to move the collection to the “new world.” In 1915, however, the Dutch Government made a timely endowment of an annual grant to the “Association” for the benefit of the CBS collection, ensuring that a move was no longer necessary.



Fig. 1. Prof. Johanna Westerdijk working in the CBS collection (around 1930).

Johanna Westerdijk: First Lady of science

The right person to manage the challenging task of providing an adequate infrastructure for the future was an ambitious young lady, appointed at the age of 23 as director of the Willie Commelin Scholten Phytopa-

thological Institute (WCS; Schipper & Roosje 1997). This was the now very famous Dr Johanna Westerdijk, the first female professor in the Netherlands. The laboratory she managed had been established in 1895 as the “Foundation Willie Commelin Scholten Phytopathological Laboratory” in Amsterdam. Its creation had been financed by Mr. C.W.R. Scholten and Mrs. H.H. Scholten (née Commelin) in commemoration of their son Willie who passed away during his botanical studies with Prof. Hugo de Vries. Prior to Westerdijk’s arrival, the WCS already had a unique record of experience with fungal cultivation.

Westerdijk promoted women's emancipation both in person and through the International Federation of University Women, of which she ultimately became president in 1932. She encouraged young female graduates to take Ph.D. studentships and to participate in research programmes or to work in the fungal collection. This policy was unique in traditional Holland. Westerdijk created a pleasant atmosphere in the institute, which many found highly motivating. As one account says, “she was famous for being hospitable, very musical, and a great lover of celebrations” (Smit 2003). Over the door of her teaching lab, she had an engraver carve the saying “*Werken en feesten vormt grote geesten*” (roughly, “Work and celebration: greatness comes from the combination”), and she often repeated the motto, “*Van een saai en eentonig leven gaat zelfs een schimmel dood*” (“When life gets dull and monotonous, even a fungus dies off”).

Under Westerdijk’s supervision, mainly fungal plant diseases were investigated, an arrangement that was beneficial for the CBS collection. The ‘marriage’ between CBS and WCS turned out to be very successful, and lasted many decades, although both institutions always maintained their independence.

The rapid expansion of the fungal collection in Amsterdam reflected the growing interest of the scientific community. Strains were sent in spontaneously from all over the world, including Japan, China, Australia and the U.S.A. Japanese senders soon discovered that they greatly preferred to receive their CBS exchange strains by the 3- or 4-month overland shipping route via Siberia rather than by the damaging 6- to 8-month maritime shipping route via the tropics. In 1913, Westerdijk travelled to Indonesia and was then unable to return because World War I had broken out. She spent some time in Japan, China and the United States, to come back to the laboratory in Amsterdam only in 1916. One year later she became the Netherlands’ first female university professor at the State University of Utrecht.

The success of the collection required a steady increase in financial support. Strains were maintained on agar slants, which had to be transferred manually every 6 mo, an extremely laborious enterprise. The income of the institute remained very modest because

most strains were made available in exchange rather than being sold. A temporary solution was found in hiring a preponderance of women, who were mostly supported by their families, in addition to bachelors, who at the time had relatively modest financial requirements. A combination of both groups was considered optimal. Among the women was Catherina Cool, one of the founders of the Netherlands Mycological Society, who in 1909 began a two-year stint as a volunteer at CBS. Later she became the curator of the National Herbarium collection in Leiden and one of the first professional researchers on macrofungi in the Netherlands. C.P. (Cato) Sluiter was appointed as the first curator of the CBS collection. She was an old school friend of Johanna Westerdijk, having studied at the same university in Zürich, Switzerland, where Westerdijk produced her Ph.D. thesis.

The financial difficulties experienced by CBS were noted in the scientific community, and the Section of Mathematics and Natural Sciences of the Royal Netherlands Academy of Arts and Sciences (Koninklijke Nederlandse Akademie van Wetenschappen, KNAW) decided to intervene. Prof. Went, at that time an influential member of the Academy, proposed that the Academy take over responsibility for CBS from the Association, which was in serious decline. A board was established under the supervision of the KNAW, consisting of three members, one appointed by the Academy itself, one from the WCS Foundation and one from the Association Internationale des Botanistes. The first designated Academy representative was Gerrit van Iterson, Jr., best known as the founder of the Delft Technical University Botanical Garden, who became the first president of the commission overseeing CBS, while Westerdijk represented WCS. Negotiations with the Ministry of Education took several years, but finally in 1920 it was decided that the CBS should become property of the KNAW. During a Feb. 1921 meeting of the KNAW's Section of Mathematics and Natural Sciences, new regulations governing the CBS were passed.

Interbellum: reorganizations and major discoveries

As a professor of phytopathology at the Amsterdam University, Westerdijk was the colleague of important Dutch botanists such as F.A.F.C. Went and August Pulle, who had, from 1920 onwards, a large botanical garden at their disposal in Baarn, a village between Utrecht and Amsterdam. Richly ornamented villas, most of them dating back to the 19th century, were surrounded by large gardens, and there were two castles owned by the Dutch Royal family. The new botanical garden, named Canton Park (Dutch *Cantonspark*) after the villa "Canton" it was initially attached to, was the 3.5 ha former private garden of the famous Dutch planter August Janssen from Indonesia, who in his time was one of the richest persons

in the Netherlands. After his death in 1918 he left his garden to the State and after some discussion it was donated to the Botany Department of Utrecht University. Westerdijk, increasingly faced with space problems in her Amsterdam laboratory and lacking room for field experiments, persuaded the boards of WCS and CBS to buy an old but rather roomy villa, Villa Java, that was situated close to Canton Park and was also provided with a large garden. In 1920, WCS and CBS both moved to Baarn. The phytopathological laboratory received a large part of Canton Park as a site for performing field experiments.



Fig. 2. Johanna Westerdijk with a technician in front of her fungal collection (around 1930).

An important event in 1929 was the receipt of a bequest from the will of Mr. Odo van Vloten, who posthumously established a special foundation for the benefit of the CBS "fungal garden." The foundation still exists today, supporting CBS in various ways.

When both WCS and CBS were accommodated in Baarn, the most creative and successful period in the career of Johanna Westerdijk and her team commenced. More than 50 theses were published between 1920 and 1950, and many of them retain their value because the fungal strains were maintained in the CBS collection for later reference.

Of a special scientific and historical value was the thesis completed by M.B. (Bea) Schwarz in April 1922. For the first time she isolated the causative agent of what came to be known as Dutch Elm Disease. Her publication was based on long-term investigation of this disease, which became a focus of research at WCS. Soon after the publication she left The Netherlands for a career in Indonesia, from whence she ultimately returned, as Dr Beatrice Schol-Schwarz, for a new episode as a taxonomist at CBS.

Another important appointment was that of A. (Abraham) van Luijk. He became one of the important workers at CBS/WCS during the interbellum. He had discovered the antibiotic activity of fungal metabolites before Nobel Prize-winner Alexander Fleming (1881–

1955) did so, but his reputation was overshadowed by Fleming's because his early discoveries concerned *Penicillium expansum*, which makes antibiotics that are toxic to humans. Only after World War II did van Luijk receive some recognition: he was nominated in 1946 as a honorary doctor at the State University of Utrecht.

An influential CBS taxonomist from the period between the two world wars was Dr Frederik H. van Beyma Thoe Kingma (1885–1966). He originated from an old noble family and had received his scientific education in Germany as one of the star students of the famous mycologist Prof. Richard Falck in Hannoversch-Münden. From 1925 onwards he worked at CBS and published a large number of papers on new fungal species, many of which had industrial significance.



Fig. 3. Albert Jan Kluyver (1888–1956).

Yeasts: a technical breakthrough

In 1921 Albert Jan Kluyver (Fig. 6) succeeded the famous microbiologist M.W. Beijerinck as professor at the Technical University of Delft (see also Robertson 2003). He asked Johanna Westerdijk's permission to take over her collection of yeasts. He was the first to adapt physiological methods for identification, developed in bacteriology, to yeast diagnostics. His Ph.D. students Nellie Margaretha Stelling-Dekker and Harmina A. Diddens included this methodology in their large taxonomic monographs, which became very influential and set the standard in yeast research for many decades. They did an incredible job in systematically clearing up the taxonomic confusion that had resulted from the application of diverse methods in the preceding decades. A "Dutch School" of yeast taxonomists developed. This laid the basis for a series of multi-authored volumes compiling monographs of all recognized yeast genera. Periodic publi-

cation of such compendia every 5–10 years still occurs.

The separation of the CBS Yeast Division in Delft from the main office for filamentous fungi in Baarn had some remarkable consequences. If it were not enough that yeasts and fungi looked different, the fact that they were being treated by two seemingly separate institutions applying totally different sets of diagnostic criteria (physiology vs. morphology), reinforced the idea that these organisms had nothing to do with each other. It was only in 1987 that the two CBS divisions together organized a symposium in Amersfoort drawing attention to the phylogenetic ties between the two groups. The reunification of the Delft and Baarn sections of CBS in a single building in Utrecht in the year 2000 seems to be symbolic of this reunified vision of the fungi.



Fig. 4. Gerda Bunschoten

Wartime: survival and revival

Staff member G. (Gerda) Bunschoten, who worked on a thesis on the nutrition of fungi in pure culture, deserves the credit for helping the CBS collection through the war. In 1944 The Netherlands suffered from a severe famine during the German occupation, which took the life of thousands of inhabitants. Today it is difficult to imagine how she managed to keep the cultures alive, when no permanent methods for storage such as lyophilization or cryo-maintenance were available. For several years she worked without a salary, and was supported by her parents. Notwithstanding her modest personality, she became one of the most important staff members of the CBS collection.

During the war, A.J. Kluyver was instrumental in the secret Dutch production of penicillin at the Yeast and Spirits factory in Delft. He recognized that CBS held the same species that had been published on by Alexander Fleming in 1928, and acquired the culture from Bunschoten for his work. The Nazi occupiers did not possess penicillin and never learned that it was

being secretly manufactured, albeit in small quantities, for the benefit of injured Netherlands.

Bunschoten continued to serve until 1967 as curator under three CBS directors. During that time, CBS developed from a subordinate department of WCS in the 1920's to a modern and independent collection in a separate building in 1964.

In 1952 Westerdijk, who had earlier retired as director of the WCS Laboratory, also gave up her responsibilities for the CBS, after a directorship of 50 years. Forced out by her health, she stopped working in 1957 and in 1961 passed away. She was succeeded at WCS by Prof. Louise C.P. Kerling. CBS appointed its own director, Dr Agathe L. van Beverwijk. One of her major tasks was to plan and oversee the construction of a new building for CBS adjacent to, but independent from, the WCS Phytopathological Institute. Van Beverwijk suddenly died shortly before the new institute was ready and was succeeded by J.A. von Arx. In 1968, CBS became a full institute of the KNAW.

Post-war: citation classics

For the independent CBS, scientific research directly linked to the collection became a prime task. The combination of maintenance and research has made CBS unique in mycology: research projects greatly benefit from the in-house culture collection, while research is vital to keep the quality of the collection up to the latest standards. CBS workers are renowned for their consistent and meticulous revisions of biologically cohesive fungal groups. CBS monographs are being used in every mycological laboratory worldwide. These publications retain their value for decades and often have become citation classics.

The Yeast Division in Delft was a place where numerous famous yeast researchers received their education. The list includes H.J. (Herman) Phaff, N. J.W. (Nel) Kreger-van Rij, Jacomina (Mia) Lodder, Willemien C. Slooff, and Johannes P. van der Walt; later, David Yarrow, Lennart Rodrigues de Miranda and Maudy Th. Smith continued to renew the tradition. All were involved in the production of the standard monographs *The Yeasts*, based on the CBS yeast collection, even after some had left the institute for careers elsewhere. David Yarrow was appointed curator of the collection in Delft in 1972, and he also became strongly involved in a second monograph series by J.A. Barnett and co-workers. Physiological yeast identification rests 100 percent on the knowledge built up in the CBS collection and its databases, and modern molecular identification is also strongly rooted in strains with CBS culture numbers.

At the filamentous fungal division of CBS, a number of well-known researchers joined the staff in the decade following the war. Gerard A. de Vries came from the University of Utrecht. He monographed the genus *Cladosporium* for his Ph.D. thesis,

which was published in 1952. This proved to be an important milestone in fungal taxonomy. Additionally, he worked on medically important fungi and, in the 1950's, initiated the CBS Course on Medical Mycology, which is still held annually today. De Vries retired in 1972.

Amelia (Melie) C. Stolk started at CBS in the same year as de Vries and was involved in industrial and food mycology. Her taxonomic work focussed on *Penicillium* and *Aspergillus*, which are among the main spoilage organisms. She continued the taxonomic work started by van Beyma, who left CBS after World War II. Stolk had intensive contacts with Charles Thom, Kenneth B. Raper and Dorothy I. Fennell, who prepared their famous monographs on *Penicillium* and *Aspergillus* using numerous CBS cultures.



Fig. 5. Josef Adolf von Arx (1922–1988).

An important period for CBS started when Josef Adolf (Dolf) von Arx was appointed as director, succeeding Agathe van Beverwijk. Von Arx had worked as a phytopathologist and mycologist at the WCS since 1949. His tenure at WCS was the start of a career that made him one of the most important fungal taxonomists of the last century. His monographs of ascomycete genera with 1- or 2-celled ascospores, published together with Emil Müller (from Switzerland), are still standard works. During the directorship of Von Arx, CBS not only built up the collection, but also expanded its scientific power by means of the strategic appointment of young mycologists. The institute became one of the major mycological expertise centres in the world. Although von Arx, with his background in plant diseases, examined numerous fungi *in vivo*, he recognized the importance of taxonomic work based on pure cultures. His book *Genera of Fungi*

Sporulating in Pure Culture was a direct result of his concept. This publication, which appeared in three successive editions (1973, 1978, 1981), has guided many mycologists into the realm of fungi. In the last part of his career, von Arx became interested in yeast-like fungi. His approach of using morphological and chemical characters in addition to physiology was unique and resulted in completely new taxonomic schemes that have withstood examination in later years.

Among the staff members appointed in the early 1960's were Dr A.J. (Annie) van der Plaats-Niterink and E.J. (Els) Hermanides-Nijhof. Van der Plaats-Niterink gave up a career as teacher at a secondary school for the study of the genus *Pythium*. Hermanides-Nijhof was responsible for *Mortierella* and *Fusarium*, and published on black yeasts. M.A.A. (Riet) Schipper was responsible for the Zygomycetes and has published taxonomic overviews of *Mucor* and some other genera of the *Mucoraceae*. Riet was also the curator of filamentous fungi for many years.

H.A. (Huub) van der Aa was appointed in 1965 to cover the taxonomy of coelomycetes. He was an important driving force behind the CBS General Mycology Course and played also an important role in the Dutch Mycological Society. At the time of his retirement in 2002 his assiduous work was crowned with the publication of a revision of all taxa published in *Phyllosticta*. It was co-authored by a Bulgarian colleague, Dr Simon Vanev.

In the late 1960's K.W. (Walter) Gams (from Innsbruck, Austria) was a regular guest at the institute. This led to his appointment in 1967 as a permanent staff member. Gams focussed on soil fungi, and early in his career discovered, and later described, one of the most economically important of all fungi, *Tolypocladium inflatum*, the producer of the immune-suppressive drug cyclosporin. His monograph of *Acremonium* (cephalosporium-like hyphomycetes) in 1971 was an adventurous approach to these morphologically poorly differentiated and heterogeneous fungi. Some of these fungi, particularly those with verticillium-like conidiophores, were revised in 2001–2004 in collaboration with Rasoul Zare (Tehran), while others are in process of being critically reassessed with molecular methods by R.C. Summerbell. Gams, as coauthor of the authoritative *Compendium of Soil Fungi* (Domsch *et al.* 1980), one of the most frequently cited books in mycology, wrote the taxonomic portions and contributed to the other sections. His wide knowledge of the fungal Kingdom and his experience in many fields have made him one of the best known mycologists at CBS.

The success of the *Compendium* spurred the production of other general handbooks on important ecological groups of fungi. Recent handbooks that have already acquired many hundreds of citations are the *Introduction to Food-borne Fungi* (called *Introduction to Food- and Airborne Fungi* in recent editions) by Rob Samson and co-workers, and the *Atlas of Clinical Fungi* by Sybren de Hoog and colleagues.



Fig. 6. The CBS staff in Baarn in 1979: A. van der Plaats-Niterink, Connie van Oorschot, Els Hermanides, Dolf von Arx, Bert van Eijk, Co Weyman (first row), Walter Gams, Grietje De Bruin, Joost Stalpers (second row), Sybren de Hoog, Huub van der Aa, Riet Schipper, Rob Samson and Gerard de Vries (third row).



Fig 7. CBS staff of the yeast department in Delft. Lennart Rodriques de Miranda, Torsten Wikén, Maudy Smith and David Yarrow (1979).

From 1960 onwards lyophilization has become firmly established in CBS as a permanent preservation method for cultures, at least for sporulating fungi. Since the 1980s, deep-frozen preservation at -135°C or in liquid nitrogen containers has also been employed, and most strains are now permanently preserved by means of these techniques. A metabolically inactive culture can now officially be recognized as valid type material for fungal taxa. This provision is particularly applicable to yeasts, which scarcely show significant features as dried cultures.

The *CBS List of Cultures*, increasing in size with each new edition, was printed for the first time from a computerized file in 1980. After two editions produced by means of a primitive computerization of a 'minimal data set', this text file was converted into a complex database in 1983 according to an internationally agreed format. The amount and range of information included was expanded to the greatest extent reasonably possible in subsequent years.



Fig. 8. JA von Arx with his wife Riekje and Herman Pfaff, Nico van Uden and Johannes van der Walt (1986).

Modern times: frontline research

In their research, CBS workers have consistently taken up modern technologies as soon as these became available. The Dutch School of yeast taxonomy remained a leading force until the 1970's, when first comparative molecular techniques were developed in bacteriology. David Yarrow and Maudy Smith were among the first to apply these techniques to yeasts. Von Arx recognized that chemotaxonomy could enhance taxonomic concepts previously based on morphology alone, and he therefore appointed G.W. (Bert) van Eijk and later A.C.M. (Co) Weijman to set up a biochemical laboratory. Secondary metabolites, fatty acid contents and carbohydrate profiles were successfully studied and applied to the taxonomy of yeasts and yeast-like fungi. The identification of hyphomycetes had been rather esoteric until mycologists took up the 1953 proposal of Canadian mycologist S.J. (Stan) Hughes to apply conidiogenesis as a consistent marker. Rob Samson, during his postdoc at Garry Cole's lab in Texas, used electron microscopy to make a standard overview of conidiogenous processes. A definitive book, *Patterns of Development in Conidial Fungi*, was published by Cole and Samson in 1979.

J.M.J. (Jaap) Uijthof was among the first to introduce molecular techniques for filamentous fungi. More recently, the entire CBS staff has added a wealth of molecular parameters to the available set of classical techniques. The study of sequences of various genes to determine phylogenetic relationships has not only opened possibilities for more reliable classification at the supraspecific level, but also enabled more precise population-genetic studies at the infraspecific level. Fascinating questions in population dynamics and ecology can now meaningfully be addressed. Initial steps towards integrating functional genomics and phylogenomics into fungal systematics are currently being taken. CBS is involved in several microarray projects using state-of-the-art technology. The CBS collection possesses one of the most advanced data banks in comparative biology. Fungal preservation techniques developed at CBS have been shown to be useful for other organisms as well, and they have been widely adopted by other institutions, for example, by manufacturers of vaccines against whooping cough and other diseases.

Many comparative studies have seamlessly integrated old and new techniques as parts of a polyphasic taxonomy involving increasingly large sets of isolates. In contrast to classical morphological revisions, such studies are based on a multitude of independent data sets, enabling detection of homoplasy. Questions can now be raised in the form of hypotheses that can be verified or falsified in a well-designed experiment. Taxonomy has become a mature science.

The current CBS features researchers working on a wide spectrum of fungi. R.A. (Rob) Samson, who worked with Melie Stolk beginning in 1970, has continued the theme of her *Penicillium* and *Aspergillus* research with many key publications, including a series of three highly influential symposium books. For many years he has been supported in these studies by Jens C. Frisvad (from Lyngby, Denmark) and E.S. (Ellen) Hoekstra. G.S. (Sybren) de Hoog has concentrated in recent years on extremophilic and medically important fungi, and has put the previously little known but medically relevant group of the black yeasts on the map. J.A. (Joost) Stalpers worked for his Ph.D. thesis on wood-decaying Aphyllophorales in pure culture, producing the most-cited volume of the CBS *Studies in Mycology* series; he has remained a leader in the study of cultured basidiomycetes. Currently, he is the curator of the integrated CBS collection. C.S. (Shu-hui) Tan, currently the collection's assistant curator, has developed a variety of preservation techniques that can be adapted for optimal maintenance of various groups of fungi. C.A.N. (Connie) van Oorschot wrote her Ph.D. Thesis on *Onygenales*, a group recently taken over by R.C. (Richard) Summerbell, who brought wide expertise on medical fungi from his previous position in Canada. A.W.A.M. (Arthur) de Cock is responsible for the Oomycota. Though he wrote numerous papers on phytopathogenic Oomycetes, he has become most heavily cited for key work on the human pathogen *Pythium insidiosum*. Teun Boekhout began as a specialist on basidiomycetous yeasts at the CBS Yeast Division, and currently focuses on *Cryptococcus*, which is studied with a multitude of genomic approaches. G.J. (Gerard) Verkleij and André Aptroot are involved in the taxonomy of ascomycetes, with the former focused on coelomycetous anamorphs and the latter on teleomorphs. Data banking at Baarn prior to 2000 was done by G.J. (Gerrit) Stegehuis, while at Delft it was done by Vincent Robert. Both are now working together in the more bioinformatics-focused environment of the modern CBS. Robert has developed BioloMICS, a multi-functional data management system which is now being adopted for the entire CBS and can currently be used online in connection with the CBS yeast collection.

The CBS directorship: New perspectives

In 1979, when CBS celebrated its 75th anniversary (de Hoog 1979), von Arx became seriously ill and the institute was temporarily directed by M.A.A. Schipper. Von Arx left CBS in 1980 and died in 1988 after a long illness (see accounts by Müller 1989, and van der Walt 1989). The institute experienced several years of instability. In 1987, Dr Robert Kokke was appointed as the new director. He was a Dutch microbiologist who had worked several years in Japan for UNESCO. He stayed only for three years at the CBS

and was succeeded in 1990 by Dr Dirk van der Mei. Van der Mei re-introduced stable conditions and implemented new strategies for the collection and for research. One of his major tasks was to move the institute to Utrecht, where it could benefit from the facilities and academic environment of the University, in a so-called "Academy cluster" together with the Hubrecht Laboratory for Developmental Biology directed by Prof. Dr Ronald Plasterk. The move to the Uithof university campus in Utrecht took place in November 2000. Since 2002, the institute has been directed by Prof. P.W. (Pedro) Crous, who has reintroduced plant pathology as a major line of research. The combined culture collection of yeasts, filamentous fungi and bacteria now comprises about 60 000 strains and is growing by more than 2 500 accessions per year. The sheer size of the collection, combined with its quality and its enormous proportion of the world's stock of essential type and model strains, has made the CBS the uncontested global centre for comparative mycology.

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