

The CBS Fungal Biodiversity Centre (CBS-KNAW)

Research assessment 2008-2013

2014

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## 1 Introduction

### **The Netherlands system of research quality assessment**

An external committee of peers evaluated the research quality of the CBS Fungal Biodiversity Centre (CBS-KNAW) during a visit in June 2014 and reports its findings in the present document.

This quality assessment (peer review) is part of the assessment system for all publicly funded Dutch research, as organized by the Association of Universities in the Netherlands (VSNU), the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Netherlands Organisation for Scientific Research (NWO).

The aims of this assessment system are:

- Improvement of research quality
- Accountability to the board of the research organisation, and towards funding agencies, government and society at large

The assessment takes place at the level of research institutes and research programmes within the institutes.

The site visit to each institute by an external committee, once every six years, is an essential part of the assessment system. A committee of peers is appointed and asked to review the research. Important elements of the site visit are the interviews which the evaluation committee conducts with the management (university board, faculty board), the institute's director and the programme directors, as well as with PhD students, post docs and technicians.

Before the site visit, the research institute submits a self-evaluation report, containing a short outline of the mission of the institute, the objective of each of its research programmes, a description of the results that have been achieved in the programmes during the previous six years (including quantitative data about staff input, PhD's, publications, financial resources), and developments anticipated in the future.

Guidelines for the research quality assessment are provided in the Standard Evaluation Protocol (SEP) for public scientific research in the Netherlands, published by KNAW, VSNU and NWO.

### **Scope of assessment**

The assessment was commissioned by the KNAW, as the CBS is one of its institutes. The CBS Fungal Biodiversity Centre was established in 1904 to house a collection of fungal cultures and became an institute of KNAW in 1968. Currently, the institute aims to study all aspects of fungal biodiversity in three themes: agricultural, industrial and medical mycology (for a short description of the institute, see Appendix 1).

The previous peer review took place in 2008; the CBS and its research programmes then were rated as 'very good to excellent'. The current assessment covers the period 2008-2013; recent developments have been taken into account as much as possible.

The committee was asked to operate according to the Standard Evaluation Protocol (SEP) 2009-2015, and all members received a copy of this document. The protocol specifies the information that must be provided to the committee and the criteria for the research

assessment. The committee was asked to assess the institute as a whole, its six research programmes and the collection, and to pay specific attention to:

1. Cooperation with other academic institutes and/or companies and governmental institutions
2. The relationship between research and collection policy and the organization of the collection department

### **The evaluation committee**

The evaluation committee consisted of:

- Prof. dr Stanley Brul (chairman) – University of Amsterdam, the Netherlands
- Prof. dr Kevin McCluskey – University of Missouri, Kansas City, USA
- Prof. dr Marc Stadler – Helmholtz-Centre for Infection Research and Technical University of Braunschweig, Germany
- Prof. dr Lene Lange – Aalborg University, Denmark
- Prof. dr Francine Govers - Wageningen University, the Netherlands

Mrs. Willy van Strien (science journalist, Leiden, The Netherlands) was appointed secretary to the evaluation committee.

A short curriculum vitae of each of the members is included in Appendix 2.

All members of the committee signed a statement of independence to ensure that they would judge without bias, personal preference or personal interest, and that their judgment is made without undue influence from persons or parties committed to the institute or programmes under review, or from other stakeholders.

### **Proceedings**

In April, the committee members received the self-evaluation report of CBS, the SEP and the Terms of Reference. The self-evaluation report included a bibliometric analysis. During the preparatory meeting, one or two research programmes were assigned to each committee member to focus on and to take the lead during preparation, interview, discussion and reporting on the assigned programme(s).

During the site visit (for the programme, see Appendix 3), the committee met with CBS director, programme leaders, members of the Scientific Advisory Board, a delegation of post docs and PhD's, and the Staff Representation ('*Ondernemingsraad*'). The committee viewed the labs and the collection. At the end of the visit, the Chair presented the main recommendations of the committee to the CBS Management Team and representatives of KNAW.

After the visit, the evaluation report was written and when all committee members had added their additions and comments, a final version was drawn up and sent to the CBS for a check on factual errors. Finally, the report was delivered to the KNAW.

### **Criteria and assessment scale**

The Standard Evaluation Protocol requires the evaluation committee to assess the research on four main criteria:

- Quality (the level of the research conducted)

- Productivity (relationship between input and output)
- Societal relevance (social, economic and cultural relevance of the research)
- Vitality and feasibility (flexibility, possibilities for improvement)

The ratings used are on a five-point scale that is described in the Standard Evaluation Protocol as follows:

- Excellent (5) – Research is world leading. Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field.
- Very Good (4) – Research is internationally competitive and makes a significant contribution to the field. Research is considered nationally leading.
- Good (3) – Work is competitive at the national level and will probably make a valuable contribution in the international field. Research is considered internationally visible.
- Satisfactory (2) – Work adds to our understanding and is solid, but not exciting. Research is nationally visible.
- Unsatisfactory (1) – Work that is neither solid nor exciting, flawed in the scientific and or technical approach, repetitions of other work, etc.

## 2 The CBS Fungal Biodiversity Centre (CBS-KNAW)

In our report on the situation at the institute level, we first discuss our overall impression of the CBS Fungal Biodiversity Centre. Next the assessments are given and the scores are commented upon. Both areas of specific attention are covered, i.e. cooperation with other academic institutes, companies and governmental institutions and relationship between research and collection policy and the organization of the collection department.

In the text we indicate at appropriate places where an observation cross-references with recommendations that we have for the institute. These recommendations are listed at the end of the chapter and grouped in four categories: *Resources and funding policy*, *Mission and strategy*, *Management structure* and *Next generation researchers*.

The CBS Fungal Biodiversity Centre is a vibrant institute where many PhD students, coming from all over the world, get their research education in a highly active and inspiring international state of the art research environment. The institute has at its heart a treasure, i.e. a culture collection of near to 80.000 fungal strains, the largest in the world and representing the vast fungal biodiversity. The CBS constitutes a really unique selling point in the research portfolio of KNAW, as it outmatches all its global competitors among the mycological and microbiological strain collections in terms of scientific expertise and productivity.

The committee has taken good notice of the fact that the institute has as its core-mission to collect, study and preserve fungal biodiversity. The CBS Fungal Biodiversity Centre makes an excellent impression, but must make sure that:

- the strategy that it has set itself is widely supported in the organization (**recommendation 11,16**);
- it remains financially sustainable to ensure a continued growth or even maintenance of the current status quo;
- it incorporates at an appropriate level in its strategy the richness of the collection and the overall value generated for the users of the collection to ensure similar quality in the future.

CBS has formulated its AIMs around three pillars representing three research programmes: Agriculture, Industry and Medical Mycology. In addition, it holds a culture collection and has a Bioinformatics Programme.

It is not evident that the institute should organize its collection and database maintenance as stand-alone groups, similar to the other (fully research oriented) programmes, as their main focus should be across programmes.

A current cross-programme aim is to exploit the culture collection to the benefit of natural product discovery and obviously to maintain the high standards of the collection itself (**recommendation 8**). The anticipated establishment of a Natural Product (including proteins) Discovery Unit is an interesting next development, but CBS must think through carefully both the research strategy and the business-case that will best suit the future programme including the external collaborative effort needed to ensure sufficient experience to avoid pit falls of redundancy and toxicity (**recommendation 6**).

After the previous site visit, CBS has set up a separate Bioinformatics programme. Research-wise the Bioinformatics programme is small. Resources to extend it beyond the provision of community services have not been available. Hence it is questionable whether Bioinformatics at CBS is currently most efficiently organized (**recommendation 10**).

The funding structure of the institute is such that it gets over half of its 7 million Euros from external partners. Academy funds have not increased since Pedro Crous took over as director in 2002 and ought to be renegotiated considering the increased output in terms of scientific publications and the great value of the collection for the European and global research communities (**recommendation 1**). CBS often hosts foreign guest researchers from the developing world linked to its status as **the** expertise centre for fungi on a global level. To ensure the provision of strains to third parties as well as to be able to provide expert advice, a financial system has to be put in place that has a well proven 'accounts receivable' capability. From our interviews it seems that this is currently a hurdle (**recommendation 2**).

At CBS research and collection are and should be intimately linked. The research is highly relevant for fundamental science including prominently the assessment of global fungal biodiversity and the 'One Fungus, One Name' challenge in fungal nomenclature. Even more value could be generated if the research results generated had an even stronger feed-back loop to ensure inbuilt benefit to the end users of the collection, e.g. in relation to new knowledge about applied aspects such as food spoilage, medical mycology, and/or new resource efficiency through innovative bio-based products, produced by fungal biomass conversion.

The CBS does well in choosing - based on its solid past - for the future a strategy of focusing on the application areas Agricultural, Industrial and Medical Fungi. Cross programme bridges are in need to ensure leverage of knowledge and breadth of expertise whilst maintaining the chosen focus (**recommendation 3**). Such a focus will be the key to ensure a continued stream of external funding sufficient to match the large and appropriate technology investments done with sufficient personnel to sustain critical mass for CBS's performance (**recommendation 9**).

CBS should aim at expanding its position gained in the field of Trichocomaceae, Dothideomycetes, yeasts, and medically important fungi and become an even more central hub in strain provision and supplier of state of the art strain knowledge. In this way the institute can facilitate the identification of information for fungal strains of interest to the benefit of the Bio-Based Economy and sustainable agriculture (**recommendation 7**). To structure its collection activities and expertise maintenance, CBS should keep track of active use of its collection by the international scientific community and by public and private organizations (**recommendation 4**).

As indicated, the Dutch Royal Academy of Arts and Sciences asked the committee to pay specific attention to the following two areas:

*1 CBS's cooperation with other academic institutes and/or companies and governmental organisations*

In the report we mention at the various sections on the individual groups, where appropriate, the links that the institute's principal investigators have with academics, companies and or governmental bodies. In general, the CBS is well linked-in through its programme and project leaders. The new developments in bioactive natural compound identification offers opportunities to intensify industrial contacts.

It is crucial that all PhD students at CBS are affiliated to Dutch research schools and that their training is captured in a CBS-wide policy (**recommendation 13-15**). The links with companies are evidently present, albeit that care should be taken to maintain confidential links with companies where issues of e.g. food spoilage are concerned.

## *2 The relationship between research and collection policy and the organisation of the collection department*

We mention at specific points the major challenges that exist. Noticeably, we suggest that the CBS reconsiders the efficiency of organisation of its collection and Bioinformatics groups in the same manner as the fully research oriented groups (**recommendation 3, 10**). Taking one step back, the management of CBS should make a clear organogram of the reporting lines in the organization (**recommendation 12**), as the organogram reported in the self-evaluation does not show reporting lines and hence is unclear on hierarchy within the organisation.

### **Assessment**

Quality	5
Productivity	5
Societal relevance	5
Vitality and feasibility	4

### **Quality**

CBS is outstanding in being both a highly esteemed culture collection and a very active research institute. In fact, CBS is an integrated and highly respected part of the global research community, not just a well-run culture collection. CBS is internationally highly regarded and recognized for its quality in terms of biological material provided, i.e. the fungal strains, and scientific data reported in peer reviewed literature, monographs and other books. What is more, through the high external funding input that the institute managed to obtain in the period of review, a major impulse was given to the exploitation of more potential strengths of the institute, hidden in its culture collection.

To unlock bioactive compounds and novel secreted proteins that potentially can be biologically produced by the fungi, physiological knowledge at the highest level is essential. By having a VICI winner amongst its midst (R.P. de Vries) as well as coupling him to a world renowned specialist in food (and air)borne fungi, a 'winning team' has been formulated. The Trichocomaceae on which R.A. Samson is a leading expert and J. Houbraken has a lot of expertise, are also the most prolific fungal secondary metabolite producers known. Progress on the chemical characterisation of these organisms - in collaboration with J.C. Frisvad (Lyngby, Denmark) - has been substantial.

The team now needs to be glued together, which is the major challenge.

A second major challenge is the recruitment of a new Medical Mycologist who can fill in the position that is now vacant in that area because of the official retirement of the (still very active) project leader 'Origins of Pathogenicity in Clinical Fungi'. The new appointee will have to be able to interact seamlessly with the current project leader 'Yeast Research' as well as get the space to develop his/her research interest.

The institute is well positioned to continue to play a leading role in the collection, preservation and study of fungal species originating from all over the world. However, focus, providing basis for achieving the highest level of expertise must be balanced with maintaining expertise to handle all major parts of the Fungal Kingdom.

### **Productivity**

The institute has had an extremely productive period with a near to doubling of its total scientific output between 2008 and 2013. The number of just over 160 publications per year is impressive, especially considering that it has been accomplished during a period stagnating funding from KNAW. Next to publications in international peer-reviewed journals, monographs and books are important deliverables that are highly valued by the research community. The group has also taken the initiative to establish various open access databases that have impact for mycology, plant pathology, industrial and, albeit to a slightly lesser extent, medical mycology.

In addition to leading in the field of comparative genomics, as demonstrated by targeted genome sequence analysis of 12 key species in the genus *Aspergillus*, CBS researchers have been engaged in many key fungal genome programmes. Among these are in house sequencing and collaborative genome sequencing with key international partners such as the US Department of Energy Joint Genome Institute (DOE-JGI) (1000 Fungal Genome Program) and the Beijing Genomics Institute (BGI).

Furthermore, the CBS collection has been brought in active use also beyond *Aspergillus*: a broad spectrum of Ascomyceteous model species (a plant pathogen, a thermophile, a dung fungus and an industrial cellulose producer) have been studied next to basidiomycetes (white rot fungus and commercially grown mushrooms).

### **Societal relevance**

Because fungi are increasingly understood by society as being useful for industry, medicine, and agriculture, the work at CBS supports public understanding and acceptance of fungal biotechnology. In fact, fungi are often misunderstood or neglected, and because information available in the public domain can be presented without supporting information, the CBS is an acknowledged source of **accurate** and **authoritative** information.

The focus is on industrially, medically and agriculturally relevant species. In the context of the Bio-Based Economy, the institute aims at exploiting its source of natural biodiversity in natural products, including both smaller molecules and secreted proteins, which is contained in the strains of the collection. The institute collaborates with industry to the benefit of Plant Protection Organisations, food manufacturing companies and public agencies in charge of monitoring bioterrorism activities. In this context the CBS focuses amongst others on advanced tools for rapid species identification. The institute is pro-active in promoting the public awareness of fungal biodiversity.

### **Vitality and feasibility**

The CBS Fungal Biodiversity Centre has put itself ambitious but realistic goals. The foundation of the institute, the collection and related activities, can be maintained with the base funding from the Royal Netherlands Academy of Arts and Sciences (KNAW). It should be of major concern to the institute management that this funding is far below what is required to truly deploy the collection's richness in fungal biodiversity to the benefit of society. Collaborations and collaborative funding are and will be in future even more important to allow the CBS to reach its goals (**recommendation 5, 9**).

Research and collection are intimately linked at CBS. CBS should pay close attention to the appropriateness of organization of its collection and database maintenance as stand-alone groups with a similar status as the (fully research oriented) other programmes. Especially the organization of the Bioinformatics support should be reassessed for efficiency of the chosen set up (**recommendation 10**).

## **Recommendations**

From the previous considerations on the institute, its quality, productivity, societal relevance, vitality and feasibility, the following sixteen recommendations emerge. We have grouped these under the headings *Resources and funding policy*, *Mission and strategy*, *Management structure* and *Next generation researchers*.

### *Resources and funding policy*

Recommendation 1: The committee recommends that the institute renegotiates with the KNAW its direct funding to match the steep increase in research grant based funding and research contributions, with regard to both quality of research and number of publications.

Recommendation 2: The institute should urgently agree with the KNAW on how to make its financial management system fit for purpose, i.e. to facilitate one of the core activities of the institute, namely product sales, in particular strains and books.

### *Mission and strategy*

Recommendation 3: While focusing its main research on certain fungal groups, CBS should also secure, at an appropriate level, the knowledge base to handle the broad diversity of fungi from all parts of the Fungal Kingdom maintained in its collection.

Recommendation 4: CBS should report on the use of its collection and include which strains are used and which are not requested by the international scientific community and by public and private organizations. The report should include a ratio of specific taxonomic groupings on the total number of strains.

Recommendation 5: CBS is advised to broaden its visibility to stakeholders and society and to further improve the marketing of its activities, for example via internet and flyers in which its activities are promoted and that are fit for congresses and similar occasions.

Recommendation 6: With respect to the envisioned establishment of a Natural Product (including proteins) Discovery Unit, CBS is advised (i) to think through carefully the expertise and infrastructure that is needed and (ii) to develop an appropriate business model that considers both intellectual property rights (IPR) and other ways of more open knowledge sharing to serve society at large and to provide a basis for the necessary collaborations and partnerships.

Recommendation 7: CBS is advised (i) to create an 'Open Access Biology' environment that includes relevant and searchable information for fungal strains of interest to the Bio-Based Economy and (ii) to aim at acquiring a position as central hub providing state of the art knowledge on the strains that can be used in sustainable production of valuable biotechnological products.

Recommendation 8: CBS must continue its active participation in the boards of the Microbial Resource Research Infrastructure (MIRRI), the European Culture Collection Organization

(ECCO), the International Union of Microbiological Sciences (IUMS), and the International Mycological Association (IMA).

Recommendation 9: CBS is advised to pursue activities aimed at generating funding through global philanthropic organizations, by emphasizing the documented importance of the culture collection for food, nutrition, resource efficiency and health research.

Recommendation 10: CBS is advised to avoid insourcing and outsourcing of IT tools and assistance to the company Bio-Aware if it could be done cheaper by strengthening the in-house resources. The BioloMICS Software that is used must be bench-marked against peer programmes such as 'BioDiversity' and 'Specify' (for natural history non-living collections), that are operated on an open source basis, widely adopted and well supported.

#### *Management structure*

Recommendation 11: The management of CBS should make clear time lines for the implementation of its strategy beyond 2015.

Recommendation 12: The management of CBS should make a clear organogram of the reporting lines in the organization.

#### *Next generation researchers*

Recommendation 13: Make internal guidelines for PhD training, especially for students from abroad.

Recommendation 14: Appoint 3<sup>rd</sup> or 4<sup>th</sup> year PhD students or post-doctoral fellows as mentors for new PhD students, not only for those enrolled at Dutch Universities, but also for those visiting as guests and/or pursuing a PhD degree at a university abroad.

Recommendation 15: CBS should make sure that all PhD students affiliated with Dutch Universities are enrolled in appropriate graduate schools.

Recommendation 16: CBS management should provide information about new strategies in a timely manner to its personnel, PhD students, researchers and technicians alike.

### 3 Research programmes

Evolutionary Phytopathology  
Prof. dr P.W. Crous

The programme investigates the speciation and host adaptation of various important phytopathogenetic fungi (fungi that cause plant disease), with a focus on Dothideomycetes.

#### **Assessment**

Quality	5
Productivity	5
Societal relevance	5
Vitality and feasibility	4.5

#### **Quality**

This research group is one of the leading groups worldwide, if not the leading group worldwide, focusing at the taxonomy of fungal plant pathogens. Their species discovery approach is not solely based on molecular identification, but includes extensive culturing of the fungi, detailed morphological studies and analysis of host specificity. This polyphasic taxonomy approach makes the research of the Crous group state of the art. The research is sustainable because all important data are easily accessible to the users, either through publication in peer-reviewed (mostly open access) journals and/or deposits in public domain databases.

#### **Productivity**

The group has an excellent publication track record and is certainly among the most productive mycological research groups world-wide! Besides publications in international peer-reviewed journals, the monographs and books are important deliverables that are highly valued by the research community and the plant pathology community at large. In collaboration with the CBS Bioinformatics group and the International Mycological Association (IMA), the group has also taken the initiative to establish various open access databases that have impact for mycology and plant pathology.

#### **Societal relevance**

The research is highly relevant for global plant health issues as, for example, demonstrated by the Q-bank initiative. In this comprehensive database of quarantine plant pests and diseases the 'Evolutionary Phytopathology' group plays a major role regarding the knowledge base on fungal pathogens. The group collaborates with industry to address the needs of for example Plant Protection Organisations or agencies in charge of monitoring bioterrorism activities, for advanced tools for rapid species identification. The group is pro-active in promoting the public awareness of fungal biodiversity.

#### **Vitality and feasibility**

The group has an extensive international collaboration network with the best research groups world-wide. They coordinate important projects related to Plant Health (FES Plant Health, QBOL, etc.) and are pro-active in finding grants for continuation. The group has a prominent role in the 'One Fungus, One Name' process. They display high quality of teaching, especially with regard to training of experts from around the world. PhD students are enrolled in the graduate school Experimental Plant Sciences (accredited by the Dutch Research School Accreditation Committee (ECOS) and rated 'excellent').

Finally, this group has excellent valorisation of human capital; many of the PhD students and the postdocs have acquired positions in academia, or with government agencies or companies in need of mycological and/or phytopathological expertise.

## **Recommendations**

- The focus on the Dothideomycetes is easily explained by the scientific history of the group leader and the utmost importance of these fungi in plant pathology, and should by all means continue. However, there are many other important plant pathogens that currently receive little attention at CBS, and it should be considered to extend the research activities to those in the future. In that respect, the collaboration with groups in Wageningen on *Fusarium* causing Panama disease on banana is a positive development and offers opportunities to exploit synergies to concurrent projects on *Fusarium* in the medical mycology group at CBS. The envisaged project on the 'Genera of Fungi' could constitute a starting point for further activities in this field.
- The research group is now heavily involved in genomic studies, which should give rise to further high impact publications dealing with the molecular basis of host specificity and/or functional studies on the mechanisms of host colonisation.
- Broadening the focus from 'bad bugs' (plant pathogens) to 'good guys' is recommended. Many species in the Ascomycete genera that are being studied by the Crous group (and beyond) may be good candidates for biocontrol/biofertilisers, may have an interesting secondary metabolism or, most importantly, may have potentials for strengthening the robustness of plant growth, e.g. by providing for increased nutrient efficiency or increased water efficiency, contributing to feeding the soon 9 billion people. Plant breeding must go hand in hand with microbial products to feed the world in future. Therefore, also other parts of the collection should in future be used and studied more intensively for their beneficial potential in agriculture and biotechnology.

### 3 Research programmes

#### Origins of Pathogenicity in Clinical Fungi Prof. dr G.S. de Hoog

The research concerns the diversity, identification, ecology, transmission and pathology of clinical relevant fungi, with a focus on less-common species.

#### **Assessment**

Quality	4
Productivity	4.5
Societal relevance	4
Vitality and feasibility	3.5

#### **Quality**

The main goal of this programme appears to be the understanding of factors, including virulence, natural ecology, or routes of transmission, which predispose some fungi to be pathogens. The group is elucidating the phylogeny of the fungi relevant to their inquiries to or below the species level and developing tools for rapid diagnosis.

By its nature a focus on less-current species means that there is a relatively large amount of species that might be studied. This is exactly what happens in the group. While it is commendable that such attention exists, it is key to not lose sight of medical fungi of prime interest given the positioning of the group.

The programme is very international and diverse and enjoys support from a variety of entities ranging from the legacies to the CBS, the Centre for Scientific Research of the Tropics, various governmental bodies of developing countries to industry (Thermo Fischer) and the University of Amsterdam.

The projects under this programme are very diverse and seem to lack a unique focus. This is emphasized for instance by the taxonomic presentation of target genera. Exclusion of basidiomycete yeasts is a significant weakness when considered in the context of a CBS Yeast Research programme. Hence the unification of the two fungal programmes as planned should receive prime attention and should be pursued with vigour. Actually, the PI of the Yeast program (Boekhout) is working on both the basidiomyceteous and the ascomyceteous yeasts and has recently delivered a very well received lecture about this at the IUMS meeting. He is also the leader of the ascomycete yeasts nomenclature committee.

The mentioning of topics like bioremediation of oil contaminated soil in the self-evaluation is gratuitous. The abundance of future tense statements suggests that results are not in hand. In section 3.6 of the self-evaluation report they refer to a programme for Medical and Extremophilic Fungi. This is a much wider scope than that stated in their mission statement. While this research programme is internationally competitive, it suffers somewhat from assuming that technology will provide data to answer 'big questions', and from overlooking potential collaborative opportunities with the Yeast Research programme (as relates to basidiomycete pathogens). Given the highly competitive international arena this creates a concern for the future.

#### **Productivity**

This group has institute average, i.e. high, productivity. There is a large cadre of visiting scientists and it seems to the committee important to differentiate between work done at CBS and work done in collaboration, but at the home institute of the collaborators. The programme is recognized internationally for its contribution to annual and other courses and to the *Atlas of Clinical Fungi*. The *Atlas of Clinical Fungi* is a world class product.

### **Societal relevance**

The societal relevance of research on pathogenic fungi is very high. Methods that are now under development for characterisation, especially the Liquid Chromatography-Mass Spectrometry, are highly innovative and very important for the medical mycologists to facilitate rapid identification of newly emerging pathogens. The committee does not well understand the rationale for constructing correlations between pathogens and extremophiles. The idea that some general theory of pathogenicity will be discovered, or that some key evolutionary feature would predispose some taxa to being pathogenic, is not well supported. Rather than stating these somewhat extreme ambitions, a strong focus on the pursued development of diagnostic tools or a stronger focus on understanding the biology of the fungal pathogenesis seem appropriate. The latter is an area for creating synergy to the new Natural Product effort. Being knowledgeable in a wide area of fungal species is here a strong point that ought to be deployed.

### **Vitality and feasibility**

This programme attracts investment from collaborators and from industry. It makes important contributions, but needs to remain mindful that more data does not always translate into more answers. The situation with additional students is precarious as it may interfere with the establishment of a new Medical Mycology group. Moreover, it should be acknowledged that the financial impact of hosting many students is not necessarily in the best interest of the CBS. The strategy of merging this group with the yeast group of Boekhout can generate significant synergy provided that group leaders collaborate productively and sufficient (financial and physical) space is available to generate critical mass.

### **Recommendations**

- The group should focus given its size of permanent staff to remain at the forefront in this field and be in line with current and near future CBS strategy.
- Any negative impact of interpersonal dynamics on collegiality, productivity, and the integration process of the medical mycology groups needs to be addressed, dealt with as soon as possible and redirected.
- The group leader should from here on not accept any additional CBS students as doing so is an impediment to the mission and strategy of the CBS Centre as a whole. The CBS is advised to consider for all recently started PhD students options of nominating a co-supervisor to guarantee the continuity of supervision under all circumstances.

### 3 Research programmes

Yeast Research  
Dr T. Boekhout

The research programme focuses on the relationship between evolution (biodiversity, phylogeography, speciation, taxonomy) and pathogen traits (virulence, susceptibility to antifungals) of yeast species. Primarily pathogenic basidiomycetes are studied with *Cryptococcus neoformans*, *C. gattii*, as well as commensal *Malassezia* spp. as the most prominent examples.

#### Assessment

Quality	5
Productivity	4.5
Societal relevance	4
Vitality and feasibility	4.5

#### Quality

Clearly the group has a key role in the study of one of the most important fungal pathogens i.e. *C. neoformans*, an organism that is ubiquitous in the environment and causes over half a million deaths a year, the greatest burden of disease occurring generally in sub-Saharan Africa where mortality peaks up to 70 %. Generally, the immunocompromised are at major risk of infection including those undergoing immunosuppressive medication, cancer patients, transplantation patients but also sometimes otherwise seemingly healthy people might occasionally be struck by the disease.

A good choice of specialization, which is complemented by research on the medically relevant skin pathogens of the *Malassezia* spp., noticeably *M. furfur*. *Malassezia* spp. cause important skin diseases such as Pityriasis versicolor and may lead to dangerous infections in the very young. In addition they are regarded as problem organisms because they cause dandruff.

Finally, as the group is expert in yeasts per se, they are also heavily involved in more taxonomic studies on yeasts. The group is frequently consulted for advice on novel species and is invited in collaborative projects.

Citations of the group in the *Cryptococcus* field are prominent and they have established a good link with immunologist Teunis Geijtenbeek at the Academic Hospital of the University of Amsterdam, resulting in a co-authorship on a *Nature Immunology* paper and numerous senior authorships in other well rated journals. In the area of their *Cryptococcus* work, there is more to be done provided that sufficient funding is obtained. In that regard the VENI by PhD student Hagen is an important application. If not successful other funding opportunities in this direction should be exploited.

The work on *Malassezia* is important and a second area of good funding opportunity given the excellent reputation of the group.

It is not advisable to extend the scope further as its suggested in the context of the collaboration with Geijtenbeek in Amsterdam. The group is small and needs to build on its strong points to maintain its excellent status. The merger with the 'Origins of Pathogenicity' group should give an important boost and lead to synergy of Medical Mycology at CBS. In

the area of yeast taxonomy the expertise of the group is leveraged with the input by the curator of the Yeast Collection (M. Groenewald). This is an area to keep active input in given the mission of the CBS, hence arguing even more against diversification of the medical fungi studies.

### **Productivity**

The group has a good productivity at institute average. *The Yeasts, a Taxonomic Study 5<sup>th</sup> edition 2011* sets the world-wide standard for yeast classification and study. The group should be aware of the need to maintain a good balance between collaborative projects in which its yeast expertise is requested as well as its medically oriented study which is at the core of the future three pillar strategy of the institute. The critical mass of the programme should benefit from a new Medical Mycology PI and a merger of the ‘Yeast’ and ‘Origins of Pathogenicity’ groups.

### **Societal relevance**

The work has been relatively descriptive albeit with leads where future further physiological analysis is now well possible. Such analyses might be done on *Cryptococcus gatii* as well as *Malassezia* yeasts in the medical area.

In terms of classifying yeasts of use to society, the group was spotted by funders in Qatar who provided support for studies of the microbial ecology of the waters around Qatar. The group is expert in the basidiomycetes which is a valuable expertise and should be maintained. Its broad recognition and knowledge is valorised in many such collaborative projects. Other than taxonomic study the work could also provide more mechanistic physiological understanding and would thus widen the impact on society.

### **Vitality and feasibility**

This programme is able to attract funding from outside as well as within the Royal Netherlands Academy of Science. Though the group is with the current composition quite modest in size, it has been successful in leveraging its expertise in many collaborations on yeast taxonomy due to its collaboration with the Yeast Collection Curator (Groenewald). The other work received EU and other dedicated funds.

In order to capitalize on the investment in *Cryptococcus* and *Malassezia* research, it is important to obtain new funds that allow medical mycology work to be done with the same intensity as before. The merger with the group on ‘Origins of Pathogenicity in Clinical Fungi’ should improve the critical mass of the group. This is necessary for continued performance at the highest level.

### **Recommendations**

- The group should keep to a clear focus whilst modalities should be identified to maintain the profile of the group as ‘world-wide yeast expertise centre’.
- The merger of the group with the ‘Origins of Pathogenicity in Clinical Fungi’ group needs to be pursued with determination and has to have a clear planning with aimed completion upon completion of the new CBS wing in 2015.

- The group should capitalize on and expand its collaboration with the Amsterdam Immunology group at the AMC to enlarge visibility in the medical field and leverage the very good to excellent *Cryptococcus* and *Malassezia* work that the group has done.

### 3 Research programmes

Applied and Industrial Mycology  
Prof. dr R.A. Samson

The area of research is the biodiversity, phylogeny and cell biology of fungi related to food spoilage, indoor environments and industrial applications.

#### **Assessment**

Quality	4.5
Productivity	4.5
Societal relevance	5
Vitality and feasibility	3.5

#### **Quality**

Despite the fact that the group leader has (officially) retired and was since then only kept on staff as part-time researcher, this research group has continued to produce several excellent and valuable publications. Together with their long-term collaborator Jens Frisvad (Lyngby), they continue to be the world leaders in the taxonomy of Trichocomaceae, i.e., the most important family of fungi in terms of benefits as well as detrimental potential (*Aspergillus*, *Penicillium*, *Paecilomyces* and *Talaromyces*). The numerous previous publications, including some of the most highly cited and transparent issues of *Studies in Mycology*, have resulted in a very high reputation, as can be seen from the fact that the group constantly receives identification service requests from all over the world. Other projects that relate to applied mycology, such as the study on the mode-of-action of the food additive Natamycin, were also conducted on third party funding.

Furthermore, Samson also had a leading role in the nomenclature discussion on the fate of the Trichocomaceae taxa with regard to the implementation of an 'One Fungus, One Name' concept and continues to serve as Secretary General of the International Union of Microbiological Societies (IUMS).

#### **Productivity**

The productivity is excellent, considering the size of the group. This does not only concern the various new taxonomic studies, but even the constant updates of books and the continuous teaching activities mentioned above. Several young scientists have once again become acquainted with the Trichocomaceae under guidance of Samson and his colleagues and proved their ability to compile high quality polyphasic taxonomy studies.

The *Studies in Mycology* issue on development of *Aspergillus* and other publications mentioned above shows that the expertise of the group goes far beyond mere taxonomy and phylogeny. Notably, the publication strategy includes the efforts of Samson as Editor-in-Chief of the high impact open access journal *Studies in Mycology* (No 1 in the ranking of the mycology journals with an Impact Factor that currently is at 9.2!). Since the authors are obliged to deposit cultures with CBS, any new publication in *Studies in Mycology* will inadvertently lead to a further increase in the quality of the CBS collection.

In terms of the wider impact that the group could have in further our understanding of food spoilage physiology, it could improve in getting some more of its papers published in food spoilage oriented or more generic microbial physiology journals.

### **Societal relevance**

There can be no doubt that the work of the Samson group continues to be highly relevant, especially for non-mycologists, applied mycologists and food chemists and for food safety for society at large. This is reflected by the huge community efforts and by prestigious grants. In addition to the aforementioned publications, the substantial knowledge of the group is being spread by excellent publications that should not be missing in any laboratory, including the new colour edition of the manual *Food and Indoor Fungi*, and by the numerous training courses at CBS and elsewhere.

The IM-BOL project granted by the Sloan Foundation on the phylogenetic barcoding of indoor fungi (Indoor Mycota Barcode of Life) has resulted in highly interesting and relevant evidence, and aside from valuable publications, a highly valuable database of indoor moulds has been compiled and will be further developed as the Sloan grant has been extended. As the fungi involved (and their mycotoxins!) are important in eliciting allergic response in susceptible patients, the impact of this study is inestimable. So are, of course, the studies on mycotoxin producers and other projects related to food chemistry that continue in the department.

Highly useful polyphasic identification keys for important mycotoxin producers have been made available on the internet. Another study, revealing the recalcitrant sexual state (*Byssochlamys*) of the important spoilage organism *Paecilomyces variotii* has revealed important evidence that may in future help the food and beverage industry to avoid substantial losses.

### **Vitality and feasibility**

The group has a leadership in taxonomy/nomenclature of important taxa (Trichocomaceae) and maintains excellent teaching activities, e.g., indoor mycology course and education of PhD students and postdocs from around the world. The group also acts as highly important service provider, in particular for industry and has already started activities relating to the intended future additional focus point, i.e. novel secondary metabolite discovery. Hence, were it not for the future perspective, the grade would undoubtedly be 'excellent'.

After Samson's retirement, the know-how can probably be kept in the group, since Houbraken and Dijksterhuis are highly experienced and will continue with this work. However, they lack the high visibility that Samson has, in particular in his contacts with industry and at the IUMS. Moreover, it remains questionable how these two permanent staff members should simultaneously manage the retirement of the group leader and the start of a novel laborious project on 'novel product discovery' (above all, the Physiology group, which will merge with the current group, has even less permanent staff workers!). Considering the great impact of this research on matters that are very important to the society, it would be desirable to create an additional permanent postdoctoral position and at least one more permanent technician to keep and develop the know-how.

### **Recommendations**

(also applying to forthcoming merger with the Physiology group)

- Increase funding opportunities and create internal synergies by pursuing the merger of the current Fungal Physiology and Applied and Industrial Mycology programmes.
- Deploy the fact that the entire collection will soon be barcoded to the benefit of e.g. creating 'customised' strain collectives, which can be selected for certain purposes.
- Increase the in-house collaborations with other groups since not only the Trichocomaceae are interesting with regard to the discovery of novel products for the Life Science industry. For instance, basidiomycetes and extremophilic ascomycetes are highly interesting with respect to industrial applications, particularly enzymes. In addition, external collaborations will be essential for the implementation of a new research strategy targeting applied mycology. The Trichocomaceae could be a good starting point, since they have already been characterised extensively for secondary metabolites in collaboration with Jens Frisvad and colleagues.
- Make equipment for secondary metabolite detection such as analytical HPLC instruments and options to do bioassay-guided fractionation on a small scale available on-site. The activities should then be extended to other groups of fungi, in particular to novel phylogenetic lineages of Ascomycota discovered in-house and to the Basidiomycetes that seem to be attractive for discovery of both, novel enzymes and useful secondary metabolites, keeping in mind that also species belonging to the Zygomycetes and the Chytrids have such potentials. At this point, it is not regarded realistic to include preparative chromatography, large scale fermentation, medicinal chemistry and know-how on structure elucidation. However, this could be done through external collaboration, since contacts to some of the leading scientists in the field of natural product discovery and antimicrobial screening are already established.

### 3 Research programmes

Fungal Physiology  
Prof. dr R.P. de Vries

The research group aims to understand how fungi species use natural carbon sources, in particular plant biomass, from an evolutionary viewpoint.

#### **Assessment**

Quality	5
Productivity	4.5
Societal relevance	4.5
Vitality and feasibility	4.5

#### **Quality**

The Fungal Physiology programme was started in 2009 with a group leader, two post docs, a technician, and three PhD students. Since then it has grown significantly: in 2014 it consists of a group leader, three technicians, seven post docs, and 11 PhD students.

The research in the programme is impressively cross disciplinary, in expertise as well as in available research infrastructure, embracing beyond physiology also molecular biology, biochemistry, genetics, (comparative) genomics, transcriptomics, proteomics and phylogeny. The programme aims to undertake in-depth studies of a few carefully selected model organisms and to combine and complement it with large comparative studies across a wide selection of the Fungal Kingdom. The naming of the programme 'Fungal Physiology' is reflecting this: by increased conceptual understanding of the fungal physiology we can create a basis for unlocking the full potentials of the fungi for industry and society at large. By understanding how fungi use natural carbon sources, the group can provide relevant knowledge that adds value to the industry.

The leadership provided is of high standard and very ambitious: in just a few years a very strong research group has been built: scientifically qualified, disciplinary broad and internationally highly profiled. Very impressive indeed.

#### **Productivity**

A very wide selection of model species has been studied. First and foremost comparative genomics of 12 key species of the genus *Aspergillus* has been undertaken. This has been brought in perspective by comparing the data to all available Eurotiales genomes, efficiently implemented through collaboration in a global network of 60 different research groups. Furthermore, the CBS collection has been brought in active use also beyond *Aspergillus*: a broad spectrum of Ascomycetous model species (a plant pathogen, a thermophile, a dung fungus and an industrial cellulose producer) has been studied and put in perspective by studying also Basidiomycetes (white rot fungus and commercially grown mushrooms). The research publications are many, of impressive academic standard, and the scientific research reported is highly relevant with regard to topics, hypotheses, biological questions asked and methods used. Given the aim and name of the group, Fungal Physiology, the group should tenaciously pursue, within the strategic framework of the CBS, the capitalization of

their molecular physiology work in model organisms like *Aspergillus niger* and *A. nidulans* as well as other fungi of relevance to the bio-based economy.

### **Societal relevance**

A comprehensive experimental mycological approach has resulted in the construction of a searchable, public database illustrating fungal growth characteristics on a high number of different carbon sources. A new protein production host system has been developed, with the added benefit of being non-proteolytic, giving potentials for even higher yields and lower side activities. A new user friendly business model has been built: all (industrial) members of a 'User Committee' has been given access to the experimental databases of De Vries. The users can mirror their own results in the CBS/De Vries results, adding direct value to the users' own results, pointing out where they did some unique observations or where they have incomplete understanding and can upgrade their knowledge using De Vries' results.

### **Vitality and feasibility**

The future prospects of the Fungal Physiology seem very promising. They have already outlined directions which seem to provide a basis for a continuous flow of an impressive number of interesting papers, making the group highly attractive as funding partners both in EU and globally. The rising era of the bio economy gives high expectations for a continued successful development. Under the capable leadership of De Vries ambitious research activities have been initiated: to advance interesting basidiomyceteous model studies to allow for optimized use of basidiomycetes next to ascomyceteous species as applied work horses (production hosts and gene donors - for new types of enzymes for improved biomass conversion). Furthermore, advanced studies of e.g. interactions in nature of fungi and bacteria have been initiated; studies which may add to the future development of mixed culture fermentations also in industrial scale. It does remain of some concern to the committee that the financial sustainability of parts of the current infrastructure of CBS, which now adds to the attractiveness of the group as a research partner, is not fully clear at the time of review.

### **Recommendations**

- The Fungal Physiology group should contribute even more significantly to the 'Open Access Biology' - generating value for the users of the CBS collection by adding relevant and searchable information to fungal strains of applied interest (e.g. pH optimum and temperature tolerance for enzymes of a given fungal species; substrate decomposing capabilities of a given fungal strain; GRAS status; or relevance as expression host and toxicity of metabolites produced).
- The research focus of the Fungal Physiology group should expand beyond decomposition of carbon sources to also include how fungi and fungal products can be used for optimizing recovering, modifying and refining of selected, valuable parts of nature's plant cell wall, proteome and metabolome complexity.

### 3 Research programmes

Bioinformatics  
Dr V. Robert

The Bioinformatics group develops the software and IT infrastructure for CBS and several associated projects.

#### **Assessment**

Quality	3.5
Productivity	4
Societal relevance	4.5
Vitality and feasibility	4

#### **Quality**

A comprehensive, global and growing culture collection as CBS must be able to handle large amounts of data, including records on a large number of strains and to cover characteristics of a wide number of parameters and fields. Very early on shortcomings of available database tools were identified and a strategy for building better IT tools was developed, providing the user access to all sources and types of information on species and even strain level. A new software, called BioloMICS, was made, capable of searching, identifying, classifying and analyzing all available data in a polyphasic way. In 2004 the MycoBank concept was introduced. In 2009, a dedicated Bioinformatics programme was established, based on increased demands for data storage, developments of new and specific algorithms and multiple research projects requiring specific programming.

The scientists working in the Bioinformatics group have only 10 per cent research time allocated. If time and resources would be available, highly interesting bioinformatic-driven research on the CBS collection could be made. The current level of allocated resources of time of CBS staff does not allow for much dedicated research activities within the field of Bioinformatics. The activities are actually confined to the field of IT informatics which covers only part of the scope that is generally allocated by the scientific community to the research field of Bioinformatics. Characteristically, in the self evaluation reporting almost all of the planning for the future work programme is described under wordings as ‘maintenance’ or ‘development’; and it is very clearly stated that research activities will only be possible at any significant level if external funding is generated. However and most importantly, the Bioinformatics group of CBS is absolutely essential for keeping a robust and well-functioning institute and strain collection.

#### **Productivity**

The group is oriented more to service than to research, developing the tools needed for the daily management of the collection and helping researchers to analyze their data. The importance of the Bioinformatics programme for both CBS collection and research cannot be overestimated. It is noteworthy and should be highlighted as a very important observation that the Evaluation Committee did not hear any complaints about IT service failing to back up the activities - throughout the entire evaluation of all parts of the programme and meetings with all groups of employees.

## **Societal relevance**

CBS is a very important vehicle and vital organ for the need of the scientific mycological community within taxonomy, classification, and identification, e.g. through a well functioning MycoBank; and it provides robustness and muscle to CBS to leverage European mycological expertise, to mirror, complement and partnering in a global scale with e.g. the US and the Chinese mycological efforts in biodiversity, phylogeny, taxonomy and genomics.

## **Vitality and feasibility**

The basics of the software program of essentially all of the CBS database activities is the BioloMICS; this program is more than 20 years old; it has been modified primarily by budding and building out on the same core. While being very comprehensive it has also resulted in a very large and according to some reportings also in time rather slow execution of program functions. This could develop to a threat to the vitality of the programme.

## **Recommendations**

- The group should make a careful user analysis, including both internal and external insightful experts, in order to timely foresee if a point in time is approaching where a new software system must be developed and built. Such software should be chosen/developed to match the need of both the CBS collection and its research programmes. Substantial additional and dedicated funding including additional qualified manpower is a prerequisite for carrying out such endeavour.
- The group should make a careful cost-benefit analysis in order to avoid insourcing and outsourcing of IT tools and assistance if it could be done cheaper by strengthening the in-house resources, hereby also building staff resources to service the CBS staff and customers.
- Dedicated funding activities by the KNAW should be found to ensure that sufficient basal research within the field of Bioinformatics can be done on the rich collection of data connected to the CBS strain collection. Finding additional funding to capitalize upon these foundations should subsequently be stimulated and may well include public private partnership grants.

## 4 Collection

Dr G. Verkley

The main objective of the Collection programme is to preserve living strains of all cultivable members of the Kingdoms Fungi and Stramenopiles, and a bacterial collection as well, and to make them available to the scientific public.

### **Assessment**

Quality	5
Productivity	5
Societal relevance	5
Vitality and feasibility	4.5

### **Quality**

#### *Collection*

The CBS culture collection is among the most highly regarded such collections in the world. It is an acknowledged leader in the world and exists in a complementary manner to other collections worldwide. The collection grows by deposit, but also by the incorporation of established collections which are no longer able to maintain their holdings.

The CBS collection is open and utilizes a widely accepted model for Intellectual Property Management of maintaining patent strain deposits. The fungal collection is vastly larger than the bacterial collection, although recent characterization of endohyphal microbes within fungi suggest that more diversity is present than past technology could characterize - this new observation opens in itself for new and highly interesting studies.

The ISO certified activities are central to the operation of the collection and are above the norm for international operations. Most collections only aspire to this level of certification and only a few of the largest and most successful collections obtain certification. This is a characteristic of a fully mature culture collection: a Biological Resource Centre.

#### *Technology*

Implementation of modern technological approaches to taxonomy allow the collection to fully document, utilize, and promote the strains in the collection.

The identification of techniques to cryopreserve, desiccate, or otherwise maintain strains which presently require passage is highly desirable. The technologies for cryopreservation are of the highest calibre.

DNA banks are yet to be proven reliable and their resources are exhaustible. Distribution of DNA from pathogens is a good way collections can generate revenue. Long term storage of DNA should have a process for quality control such that there is between-sample standardization.

The use of DNA from non-cultured specimens is troubling and should be limited. Many cryopreservatives include uncharacterized components which could contribute alien fungal or non-fungal DNA to the specimen.

The technology that has been utilized to increase efficiency, including the 96-channel system and the MicroLab robotic system, are entirely appropriate and consistent with what other

collections are utilizing. Additionally, robotic manipulation of arrayed materials is inherently more robust than human manipulation of the same materials.

### *Research*

The research projects of the collection staff are high potential projects. Characterization of coelomycetes is valuable as this is an unresolved area of fungal taxonomy. The value of identifying otherwise ‘unidentified’ soil fungi in the collection cannot be underestimated. The Mass Spectrometry Protein (MSP) database is of growing importance as traditional barcode taxonomy reaches its resolving limits.

Other researchers at the collection are relatively new to this project, but integrate well with other projects. The collection is highly collaborative and provides essential reagents and resources for many projects at CBS.

### **Productivity**

The productivity of the culture collection is evaluated both for publications and also for the strains distributed. This is a key metric for the productivity of a public culture collection.

### **Societal relevance**

Because the CBS culture collection holds essential and validated microbial strains for research, industry, agriculture, and as yet un-invented applications, it makes biotech an open field where good ideas can lead to disruptive technologies.

The high quality and diversity of the CBS collection are a strong representation of Dutch science and thus constitute a major asset to the Royal Netherlands Academy of Science.

### **Vitality and feasibility**

The CBS collection is highly visible in the international arena and because of this visibility any reorganization in terms of changes in staffing and technical support of the CBS collection should be done with the utmost care and be executed such that the continuity of its operations is fully guaranteed.

A culture collection like the CBS always requires investment from public funds. Experience elsewhere shows that a self-sustaining collection can easily lead to Intellectual Property conflicts, disruptive business practices, high prices, and reduced capacity.

The CBS culture collection benefits from strong investment from a forward-thinking government, a world renowned staff, strong synergies with related research projects, and (not to be discounted) very strong brand recognition and an excellent reputation.

The staff at the collection has undergone some changes in recent years, but the programme leader and curators are established in their fields as strong contributors. Continuity in Bioinformatics is important and should be a desired goal. Integration with the informatics programme is an example of how this can be attained.

The collection, through engagement with the European Culture Collections’ Organisation (ECCO), the World Federation for Culture Collections (WFCC), and related entities, has anticipated the impact of the Nagoya Protocol to the Convention on Biological Diversity and while it is not possible to predict the changes that will occur after Nagoya, the TRUST initiative provides a robust path forward to limit the impact of Nagoya on non-profit academic research with microbes.

The collection is not a repository of reagents generated in cell biology or other biotech focused research and should consider solicitation of deposit of strains carrying transgenes or other molecular or genetic modifications. This could be a new area of emphasis and there is no other open collection in Europe that emphasizes materials from molecular or genetic research. This area is complementary and not in competition with the emphasis on taxonomy.

### **Recommendations**

- The collection should evaluate the labour input for the agar cultures in the context of whether these materials are ever requested by clients. Clearly, these cultures are removed from their original state and this cannot be discounted. Preservation in suspended animation for cultures in this category that are essential to the mission of the collection should be a priority.
- The engagement in ECCO, WFCC and CBD-relevant issues should be maintained. CBS has a lot to offer on an even wider scale than its own mandate.

## Appendix 1

### Description of the institute and its research activities

The CBS Fungal Biodiversity Institute was established in Baarn in 1904 to house a collection of fungal cultures. It became a research institute of the Royal Netherlands Academy of Arts and Sciences (KNAW) in 1968.

In 2000, it moved from Baarn to Utrecht (university campus), where the staff and collection of the Yeast Department of Delft University of Technology joined the institute. Also the Netherlands Culture Collection of Bacteria was incorporated, a merger of collections from Utrecht and Delft.

The mission of CBS currently is to collect, study and preserve as much of the world's fungal biodiversity as possible and to unlock this resource for the international research community. The institute holds 80000 strains of filamentous fungi, 9500 yeast strains and thousands of bacterial wild types, mutants, plasmids and phages. The collections keep growing at a high rate.

CBS has the intention to generate DNA barcodes of all preserved strains.

Research concerns primarily biosystematics, and is both fundamental and applied. Three focus areas are chosen to work on: agriculture (fungal plant pests), industry (indoor air and food; plant biomass use) and human health (fungal diseases). Before long, this will be mirrored in the organisation by merging a few research programmes:

- Agriculture will consist of the current programme Evolutionary Phytopathology;
- Industry will include the programmes Applied and Industrial Mycology and Fungal Physiology;
- Human health will comprise the programmes Origins of Pathogenicity in Clinical Fungi and Yeast Research.

In addition to predominantly biosystematic research, long-term preservation techniques are developed, as well as methods for data storage and processing (in the Bioinformatics programme).

CBS is one of four life sciences institutes in the KNAW. It employs 32 fte research staff (2013). Part of the support staff and technicians are shared with the neighbouring Hubrecht institute of KNAW.

The website of CBS-KNAW is accessible via <http://www.cbs.knaw.nl/>

## Appendix 2

### Curriculum vitae of committee members

#### **Prof. dr Stanley Brul** (chairman)

Prof. dr Stanley Brul is full professor of Molecular Biology & Microbial Food Safety at the Swammerdam Institute for Life Sciences at the University of Amsterdam.

Brul was trained as biochemist. In 1991 he obtained a PhD with a doctoral thesis entitled 'Biochemical and Genetic Aspects of Peroxisome Biogenesis in Mammalian Cells'. After a post doc position at Nijmegen University, a visit to the Rockefeller University New York (lab. prof. Miklos Muller, who discovered hydrogenosomes) and a stay at the International Institute for Cellular and Molecular Pathology in Brussels, he moved to Unilever Research & Development, where he was appointed as a scientist in the field of fungal physiology and molecular biology.

In 1999 Brul was appointed professor of Industrial Microbiology on an endowed chair at the Swammerdam Institute for Life Sciences of the University of Amsterdam while staying appointed at Unilever. As of 2002, he holds his current position.

Brul is editor of *Food Microbiology*, *Innovative Food Science* and *Emerging Technologies* as well as *J. of Biotechnology and Biomedicine*. He is chairman of the Dutch Institute for BioSciences, Expert Advisor of the Strategic Research Program of the IFR (UK), member of the Faculty of 1000, the Dutch BioScience Forum and the 'ad hoc' Cie. BioSciences of the Royal Academy of Science (KNAW), and co-chair of the Organising Board & Program Committee of the 6<sup>th</sup> FEMS Congress (2015 Maastricht).

<http://www.uva.nl/over-de-uva/organisatie/medewerkers/content/b/r/s.brul/s.brul.html>

#### **Prof. dr Kevin McCluskey**

Prof. dr Kevin McCluskey is Research Professor at the University of Missouri- Kansas City. McCluskey completed his bachelor and master of science degrees at Stanford University in 1985. After working in a MIT medical technology laboratory, he completed his PhD degree at the Oregon State University in 1991 working on molecular elucidation of fungal karyotypes. He spent time as a postdoctoral fellow studying the detoxification of plant secondary metabolites and then he accepted the position of curator of the Fungal Genetics Stock Center in 1995. In addition to shepherding the *Neurospora* collection into the post-genomics era, he taught medical mycology, consulted for industry and for scientific infrastructure institutions, and served as reviewer, editor, and contributor for a number of journals.

McCluskey has published over 50 papers and has served on review panels for diverse funding agencies. He has been co-investigator on the grant which supports the FGSC since 1998 and is the leader of the US Culture Collection Network grant.

[http://sbs.umkc.edu/facultydetail.cfm?Faculty\\_ID=365](http://sbs.umkc.edu/facultydetail.cfm?Faculty_ID=365)

#### **Prof. dr Marc Stadler**

Prof. dr Marc Stadler is Head of the Department Microbial Drugs at the Helmholtz Centre for Infection Research.

Marc Stadler studied biology at the University of Kaiserslautern and received his PhD in 1993; the subject of new antibiotics and nematicides from predacious fungi. After a post-doctoral stay at the University of Lund, Stadler joined the pharmaceutical industry and

worked in the natural products department of Bayer Healthcare (Pharma Division). Together with other Bayer researchers, he co-founded the company InterMed Discovery GmbH in 2006. During his industrial career (17 years in total) he was responsible for the fungal and microbial culture collections, the fermentation and biotechnological process development, as well as a natural product chemical laboratory.

Concurrently, he was teaching at University of Bayreuth, where he completed his habilitation in 2009 and received the *venia legendi* in Mycology. He took over his current position at HZI in 2012 and is teaching biology and biotechnology at the Technical University of Braunschweig. In 2013, he was also appointed as Visiting Professor at CAS Institute of Microbiology, State Key Laboratory of Mycology and Lichenology in Beijing. He also acts on the Editorial Boards of leading mycological journals such as *Studies in Mycology*, *Fungal Diversity*, *Fungal Biology* and *Mycological Progress*, and member of the Executive Board of the International Mycological Association (IMA).

[http://www.helmholtz-hzi.de/en/research/research\\_topics/anti\\_infectives/microbial\\_drugs/marc\\_stadler/](http://www.helmholtz-hzi.de/en/research/research_topics/anti_infectives/microbial_drugs/marc_stadler/)

### **Prof. dr Lene Lange**

Prof. dr Lene Lange holds a personal professorship in Biotechnology at Aalborg University, Denmark. In her research she seeks increased understanding of how fungi decompose and use natural carbon resources; and to use such insight to discover also new fungal proteins of relevance for generating increased value from agricultural and agroindustrial side streams, crop residues and organic waste. All parts of the Fungal Kingdom are included in the protein discovery projects (Chytrids, Zygomycetes, Ascomycetes and Basidiomycetes). Methods include fungal experimental molecular biotechnology, with focus on (meta-)transcriptomics and secretomics.

Lange has reached research director level positions in both academia and industry; she has hereby acquired extensive experience from all parts of the knowledge-value-chain: research, technology, development, innovation, commercialization and policy making. She has a comprehensive portfolio of past and present positions in boards and advisory groups (including several chair and vice chair positions) for both public and private R&D heavy organizations (global, European, Nordic, and Danish).

<http://personprofil.aau.dk/Profil/118165>

### **Prof. dr Francine Govers**

Prof. dr Francine Govers holds a personal professorship in Phytopathology at Wageningen University where she studies the mechanisms underlying pathogenicity in oomycetes, in particular in the potato late blight pathogen *Phytophthora infestans*. Pioneering work in the 1990s included gene silencing and functional gene analysis in *P. infestans* and the generation of the first *P. infestans* molecular-genetic linkage maps culminating in the cloning of several avirulence loci.

Govers is/was editor of *Frontiers in Plant-Microbe Interactions*, *MPMI* and *EJPP*, member of scientific evaluation committee's (NWO, DFG, NSF, USDA) and of the government advisory committee on Genetic Modification COGEM, Scientific co-chair of the 25th Fungal Genetics Conference 2009, Asilomar CA, USA and Program Director of the NGI Centre for BioSystems Genomics (2009-2014). She teaches BSc and MSc courses dealing with Phytopathology, Plant-Microbe Interactions, Mycology and Genomics.

<http://www.wageningenur.nl/nl/Personen/Francine-Govers-1.htm>

### Appendix 3

#### Programme of the site visit

#### **Tuesday June 10**

<i>Time</i>	<i>Programme</i>	<i>Present</i>
9.00-10.00	Welcome by CBS staff and general introduction by CBS director Pedro Crous	CBS staff
10.00-12.30	Meeting with programme leaders	Prof. dr Rob Samson Prof. dr Sybren de Hoog Dr Teun Boekhout Prof. dr Ronald de Vries Prof. dr Pedro Crous
12.30-13.00	Review	
13.30-14.30	Meeting with Collection and Bioinformatics	Dr Gerard Verkley & Dr. Marizeth Groenewald Dr Vincent Robert
14.30-15.00	CBS: The Future	Prof. dr Pedro Crous
15.00-15.30	Discussion with members of the Scientific Advisory Board	Prof. dr P.G.J.M. de Wit (Chair) Prof. dr E. Smets
15.30-18.00	Discussion and preparation of meetings Wednesday June 11	

**Wednesday June 11**

<i>Time</i>	<i>Programme</i>	<i>Present</i>
9.30-10.30	Discussion with postdocs and PhD students	Salvador Capeus; Anna Kolecka, Cobus Uisagie; Frank Segers; Benjamin Stefou; Sandra Videira; Lorenzo Lombard; Isabelle Benoit; Aleksandrina Patyshakuliyeva; Sarah A-Ahmed; Anne van Diepeningen
10.30-11.30	Tour of institute	Prof. dr Rob Samson (research floor) Dr Gerard Verkley (collection)
11.30-12.30	Discussion with group leaders	Prof. dr Pedro Crous Prof. dr Rob Samson Prof. dr Sybren de Hoog Prof. dr Ronald de Vries Dr Teun Boekhout Dr Gerard Verkley Dr Vincent Robert
12.30-13.00	Review	
13.30-14.00	Meeting with Staff Representation (OC)	Dr Jan Dijksterhuis (Chair) Dr Anne van Diepeningen Mrs Arien van Iperen Mr Bart Theelen Mr Ad Wiebenga
14.00-16.30	Preparation of report	
16.30-17.00	Preliminary conclusions	CBS Management Team and representatives of KNAW