HEALTH IMPACTS OF INDOOR DAMPNESS AND MOULD AND EFFECTIVE REMEDIATION AND PREVENTION STRATEGIES

Expert Review and Summary of Scientific Evidence

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About This Report

This report was commissioned by RentSafe, a multi-stakeholder collaboration of public health, medical, academic, legal, property standards, and social service organizations and individuals. RentSafe partners have worked together since 2018 to address indoor environmental health issues in residential tenancies in Ontario. www.rentsafe.ca

RentSafe research[1] demonstrated that dampness and mould (D/M) is one of the most common health and habitability concerns in rental housing. As such, it precipitates the need for response and action by multiple sectors, including tribunals and courts. In commissioning this expert report, RentSafe partners sought to make available a summary of the scientific evidence that could be used to support and expedite resolution of D/M disputes in residential tenancies, thereby reducing the strain on affected parties and judicial resources. It is hoped that the report will also be of use to public health inspectors, municipal property standards officials, and others involved in addressing D/M in rental accommodations, including ongoing efforts to update and improve inter-jurisdictional consistency in local by-laws.

The authors (see *curriculum vitae* in Annexes 2 and 3) acknowledge and confirm that the opinions expressed in this report are fair, objective, and non-partisan. The authors further acknowledge and confirm that the opinions expressed in this report relate only to matters that are within their areas of expertise.

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All photos in this report are by R.C. Summerbell.

[1] RentSafe partners conducted Ontario-wide surveys of professionals in the following sectors in 2015-2018: public health, legal aid clinics, frontline health and social services, and municipal property standards/by-law enforcement, as well as small-scale landlords. Summary reports are available at: https://rentsafe.ca/publications-videos-events/.

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Executive Summary

This report describes the scientific evidence for health effects of indoor dampness and mould (D/M) and effective response and prevention strategies. It provides a common baseline of information for tenants, landlords, and their respective legal representatives, as well as adjudicators and public health and property standards officials. It responds to the fact that D/M is a common problem creating environmental health concerns for tenants in rental housing.

Part One provides a high-level summary, in lay terms, of the scientific evidence concerning health impacts. This summary is supported by an Annex, written in more scientifically technical language, to explain mould science in more detail.

The scientific evidence about indoor D/M includes hundreds of individual investigations and the compilation and analysis of these investigations in broader, systematic reviews. **Sufficient evidence exists linking numerous respiratory health impacts with exposure to indoor dampness and mould**.

Respiratory health impacts linked to indoor D/M include:

- exacerbation/worsening of existing asthma
- asthma development
- bronchitis
- respiratory infections
- allergic rhinitis
- dyspnea (chest tightening, difficulty breathing)
- wheeze
- cough
- upper respiratory tract symptoms

Eczema is also linked with exposure to dampness and mould.

This summary of scientific information follows accepted practice in public health research. It notes the strength of evidence for associations between exposure and health effects and draws conclusions in areas where only the strongest evidence is apparent. For asthma exacerbation in children, the evidence is considered sufficient to demonstrate a causal relationship. For the other health effects listed above, there is sufficient evidence of an association.

This large body of evidence of associations between D/M and various respiratory health impacts is relied upon to support the conclusions of Health Canada, the World Health Organization, and many other authoritative health organizations, that indoor exposure to D/M can pose a health hazard that should be mitigated and prevented.

Indeed, the World Health Organization and many governmental and professional organizations, have recognized that the basic human right to healthy indoor air includes protection from the products of indoor mould infestations in structural building materials.

This report also briefly describes emerging health-related concerns that are possibly caused by D/M but are areas of active research, where evidence of causation remains suggestive and is open to question or doubt. These possible impacts include altered lung function, allergy/atopy, fatigue, and neuropsychiatric symptoms.

Dampness and mould occur most typically in older housing stock, substandard renovations, and unsuccessful attempts to adapt housing to unusually cold climates or unconventional foundations (e.g., homes built directly on irregular rock). Mould species found indoors are diverse in nature, but common types of growths may exert health effects. Some types of mould proliferation seen in dwellings are more likely than others to be associated with symptoms, and some individuals are more susceptible than others.

Part Two describes scientifically substantiated best practices for remediating indoor D/M and preventing its recurrence.

In response to the clear evidence of associations between D/M exposure and health impacts, **relevant agencies, including Health Canada, concur that the prevention and mitigation of adverse health effects associated with dampness and mould require prompt, thorough and appropriate clean-up and remediation measures**. Such measures must address both removal of mould and mouldy materials, and the elimination of dampness and its sources. These actions require an accurate determination of the extent of the mould contamination and the source of the dampness allowing for its growth.

The need to undertake these measures is unrelated to any specific species of mould present at a given time. Those exposed to mouldy conditions can presume both the potential presence of species of concern and underlying sources of dampness, particularly where there is the well-recognized odour of mould which indicates that enough moisture is present to sustain growth, and that growth is active, necessitating remediation. **Mould growth and sources of moisture in building materials require remediation in all occupied environments.** Testing for airborne fungal spores is not necessary to signal the need for remediation.

Part 1: Health Risks of Indoor Mould Exposure

Fig. 1. Cladosporium *mould on a poorly insulated wall, with moisture produced by condensation in cold outdoor weather and lack of air circulation due to furniture (bed) against the wall.*

1. International consensus on health risks and remediation strategies

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Healthy indoor air is recognized as a basic right. People spend a large part of their time each day indoors: in homes, offices, schools, health care facilities, or other private or public buildings. The quality of the air they breathe in those buildings is an important determinant of their health and well-being.

- World Health Organization, 2009

Government health departments from local to national, and major professional bodies have reviewed extensive information published in the scientific literature about dampness and mould (D/M). Over the past twenty years, they have issued statements that summarize this evidence and/or provide recommendations for addressing problems with excess indoor dampness and mould growth. These authoritative bodies include, but are not limited to, the following:

- Health Canada (Health Canada, 2014)
- National Collaborating Centre on Environmental Health (one of six National Collaborating Centres created to foster linkages within the public health community and funded by the Public Health Agency of Canada) (Palaty and Shum, 2010, 2012, and 2014)

- Canadian Committee on Indoor Air Quality and Buildings (CCIAQB, 2015)
- United States Environmental Protection Agency (USEPA, 2001)
- New York City Department of Health (NYCDoH, 2008)
- Institute of Medicine (United States) (IOM, 2014)
- American Society for Testing Materials International (ASTM, 2011)
- American Industrial Hygiene Association (AIHA, 2013; Hung et al, 2020)
- World Health Organization (WHO, 2009)

In summary, with or without observable symptoms, D/M can be harmful to building occupant health. As described and referenced below and in more detail in Annex One, ongoing or recurrent exposure to D/M can lead to multiple, often serious, respiratory health impacts. As such, prevention of dampness and mould, and prompt remediation where they occur, are paramount to ensure healthy living conditions for building occupants.

With or without observable symptoms, dampness and mould can be harmful to health. Prevention or remediation of dampness and mould is paramount to ensure healthy living conditions for building occupants.

2. Health risks of mould in the indoor environment

Dampness and mould can occur in all types of residential housing, but are most commonly associated with:

- aging housing stock that has not been adequately maintained,
- basement apartments, especially those created through do-it-yourself renovations,
- housing in northern Ontario climatic regions, and
- inadequate housing stock in Indigenous communities.

This section summarizes the range of potential effects on occupant health and well-being associated with dampness and mould in residential housing.

What is mould?
Moulds are species of fungi that commonly grow on damp building materials, foods, and other suitable substrates. Mould often causes staining of the surfaces on which it grows and often produces a characteristic "musty" odour, even when growth is not visible. Note the terms "mould" and "mouldy" as used in this report refer to viable and non-viable mould, as well as mould fragments.

2.1 Introduction and scope – moulds, microbial products, mites

In addressing mould growth indoors, a distinction must be made between airborne mould materials normally found in outdoor air and problematic mould growth or 'amplification' arising from excessive dampness and moisture in indoor environments.

This distinction relates not only to the quantity of spores and other airborne material that occupants may be exposed to, but also to the chemical nature of the types of moulds involved. Both indoor and outdoor-derived mould spores and other airborne particles may trigger allergic responses in susceptible people. Moulds, particularly those that grow in indoor situations, also produce toxins and other materials that are irritating to the body. Generally speaking, moulds in indoor environments are associated with greater health risks. Across indoor settings affected by D/M, the concentration of spores and other irritation-producing microbial products in the air will be greater in non-ventilated or poorly ventilated indoor spaces typical of older and/or improperly renovated housing. More detail about this matter and other items discussed in this section are provided in Annex 1.

Mould spores and other airborne mould particles may trigger allergic responses in susceptible people. Moulds also produce toxins that are irritating to the body.

The concentration of mould spores and other irritation-producing microbial products in the air will be greater in non-ventilated or poorly ventilated indoor spaces typical of older and/or improperly renovated housing.

Many situations where indoor mould growth occurs are also associated with excessive growth of mites (barely visible eight-legged arthropods distantly related to spiders) that eat mould. These mites, their dead parts, and their mould-laden faecal pellets may be allergenic. Small insects like springtails and sewage flies may also feed on excess mould or on the decomposing material where mould growth occurs and may also contribute to the production and dispersal of allergenic materials.

The material that occupants may be exposed to does not consist of spores alone, contrary to widespread belief. The breakdown of mould and associated mite materials into very tiny particles (nanoparticles), not recognizable under the microscope, is a highly significant factor in what people are exposed to in affected homes (Straus, 2009, Morris et al. 2016, Aleksic et al., 2017). These nanoparticles may bear fungal cell wall components that trigger immunological reactions. They can be drawn out of small fissures in and around apparently closed wall cavities by the minor air pressure differences that occur in all homes.

Mould, along with material from tiny mites that feed on mould, will break down into nanoparticles that can trigger immunological response. These nanoparticles can be drawn out of small fissures in apparently closed wall cavities by the minor pressure differences that occur in all homes.

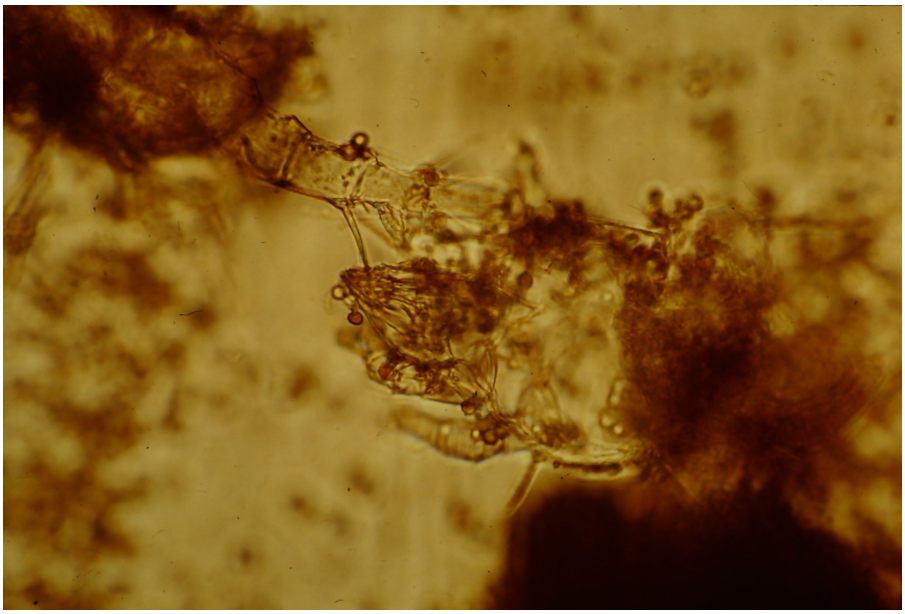

Fig. 2. Fungus-eating mite with conidia of dark coloured mould Aspergillus niger *from a wall colonization*

2.2 Population variability and mould complexity

Building occupants exposed to mould may exhibit any of a range of symptoms, or none at all. The natural variability across human populations explains why some have symptoms and others do not. Genetic predisposition, early life exposures, and epigenomics (the existence of gene-environment interactions in individuals) contribute to explaining the complexity of symptoms that can arise from mould exposure, even within a single family. Canadian epidemiological (population-based) data suggest that early life exposure to mould is of particular concern.

In sum, the people who may be affected more severely and quickly than others include:

- individuals with respiratory conditions or allergies and asthma
- those with weakened immune systems
- infants and children
- pregnant women
- elderly people, especially if they have pre-existing chronic breathing-related conditions

Added variability can occur among people who are heavy smokers. They may desensitize their airways to mould effects and may experience fewer problems than non-smokers. The state of the scientific evidence concerning these effects is discussed further below and in Annex 1.

Mould science is complex and the types of moulds growing in problem indoor situations are variable, depending on moisture conditions and the types of building materials involved (see Annex 1 for information on the types of mould growth typically associated with wallboard, wood, and other building materials).

Health Canada considers indoor mould growth to be a significant health hazard (Health Canada, 2014).

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Despite the variability across human populations and mould types, including the complexity of mould science, Health Canada considers indoor mould growth to be a significant health hazard (Health Canada, 2014).

Different people exposed to the same mould-affected environment may have quite different responses based on their pre-existing conditions, sensitivities, and age.

2.3 Moulds, dust mites, and allergy responses, including 'hay-fever' and asthma attacks

Physician-diagnosed allergies, or type 1 allergic responses, to common moulds/fungi and house dust mites include the 'hay fever' or allergic rhinitis set of responses (runny nose, watery and itchy eyes, sneezing, or in more severe reactions persistent sneezing, cough, congestion, and facial pressure) as well as asthma. Therein, a smaller proportion of people develop allergies affecting their breathing and airways. Genetic factors are involved in these responses, as are some of the individual's encounters with microbes in early life.

The most likely hay fever-like response for susceptible people when exposed to microbial material produced indoors is 'dust' allergy. This response involves both mould and mites (a specific type of mites called 'house dust mites'). It is typically an allergy to the faecal pellets and body fragments of mites that live on human skin flakes that have been colonized by moulds in the *Aspergillus glaucus* group. These moulds and mites are different from those typically colonizing wet, mouldy locations on walls. Carpets and bedding are the most common sites where the mite-mould mixture occurs that can produce the dust mite allergic response in susceptible people. Both the types of organisms in this specific community, the moulds and the mites, are drought-tolerant: they can grow in normally dry houses.[2]

[2] Note that this dust/dust mite allergy is not directly connected to the sort of mould amplification problem that is the subject of this report. It is mentioned here to note the connection to the mould colonization of human skin flakes (the mites' food source) and to prevent any confusion with the moisture-related mould problems that are primarily addressed.

Asthmatics, (i.e., those with physician-diagnosed asthma), in addition to being affected by the house dust mite-mould combination described above, may also be strongly affected by the moulds produced via moisture damage and heavy indoor mould growth. Such growths can lead to severe asthma attacks (Tischer et al., 2011). Generally, asthmatics who are allergic to mould are allergic to multiple species (Horner et al., 1995), so there is no incentive to distinguish the types of moulds that are excessively growing in the homes of these asthmatics. In addition, a developing research field has produced data suggesting that such exposures in early life may cause primary onset of asthma in children (Iossifova et al., 2009; Park & Cox-Ganser, 2011; Maheswaran et al., 2014; Caillaud et al, 2018). Hung et al. (2020), in overview, have accepted that indoor dampness and moulds show "sufficient evidence of an association" with primary development of asthma.

Asthmatics may be strongly affected by the moulds produced via moisture damage and heavy indoor mould growth. Such growths can lead to severe asthma attacks.

There is growing evidence that early-life exposures to indoor dampness and moulds may cause primary onset of asthma in children.

2.4 Other systemic or dermatological reactions to chemical components of moulds

There is sufficient evidence of an association with indoor D/M and the type of skin rash called eczema (Hung et al., 2020).

Indoor dampness and moulds are recognized as associated with eczema.

Active research continues into the potential role of mould exposure in the appearance of other symptoms, such as non-eczematous rashes, blurred vision, memory loss, headache, fatigue, cognitive dysfunction (that is, difficulty thinking properly or 'brain fog,' a term that can include impacts on short-term memory, lack of concentration or mental clarity, or inability to focus on a task), and hemorrhage (bleeding, e.g., unusually frequent nosebleeds). For example, researchers are exploring the potential association between *Stachybotrys chartarum* exposure and irritation of the eyes, sinuses and upper airways (Straus 2009; Mussalo-Rauhamaa et al. 2010).

There are also effects asserted by exploratory scientific studies in areas needing much further investigation. For example, a series of studies has shown associations between pregnancy or early childhood life in mould-affected circumstances to an increased risk of autism (Ratnaseelan et al., 2018, Kilburn et al., 2009; De Santis et al., 2017, 2019). Other neurological issues such as reduced intelligence have also been connected to early life in mould-affected environments (Jedrychowski et al., 2011). Such aspects of child development are complex and controversial, and mould effects need to be considered in the context of information on genetics and other exposures. Nonetheless,

some pathways of immune system reaction have been described that may link mould and mycotoxin (toxic substances produced by moulds) exposures to processes known to harm brain cells.

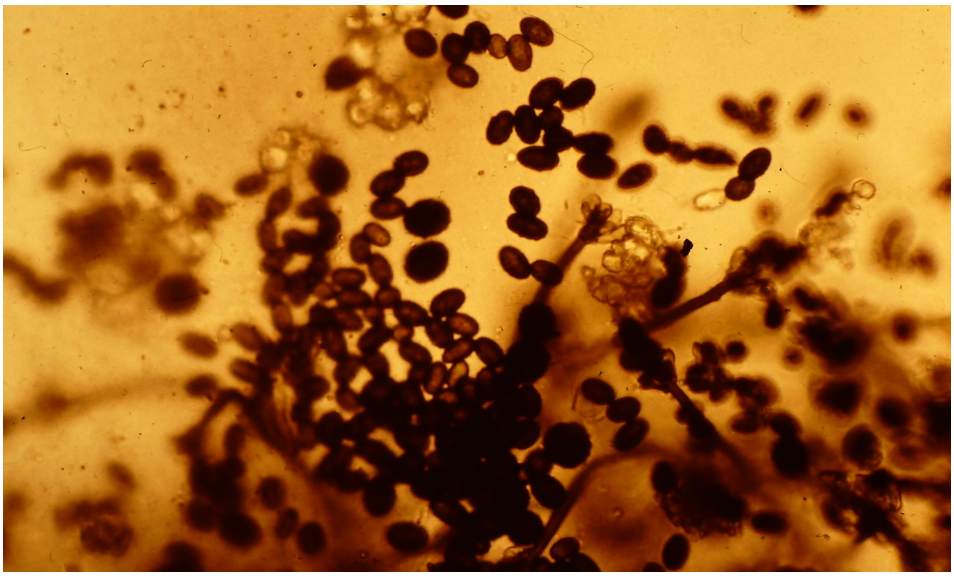

Fig. 3. Stachybotrys chartarum *from a mouldy wall.*

2.5 Mould-related infections

Certain fungi, some of which are the same as those involved in indoor mould growth, can grow on internal mucous membrane surfaces, including in the sinuses and outer ear canals (Ponikau et al., 1999). A restricted number of *Aspergillus* species, besides colonizing sinuses and ear canals, can also colonize the upper lung airways (bronchi) in severe chronic allergic conditions. Only species that can grow at human body temperature are involved in any of these conditions. This factor excludes many common indoor moulds such as *Stachybotrys* species. None of these medical conditions involves actual invasion of human flesh: the fungus instead grows on the inner surface of the body cavity involved and causes chemical and allergic irritation.

Before the development of sophisticated genetic strain identification in the early 2000s, it was not possible to test whether a person with a fungal sinusitis or ear canal infestation had been colonized by a strain coming from mould problems in their home. This test is now theoretically possible, but to our knowledge, has not been done.

Calls have been put out recently to fill some of the gaps in our knowledge of fungal invasive diseases, and connection to indoor ecology, especially in the case of persons recognized by conventional medicine as immunocompromised, is an area needing further investigation (Denning 2020).

2.6 Moulds, odour and social stigma

Mould growth in wet conditions tend to be associated with musty odours, and are often accompanied by extensive bacterial growth, which can produce additional odours suggestive of rotting vegetables or sewage. Not only do these mould-bacteria combinations contribute to the known allergenic health effects of mould exposure, these odours, like those of many moulds, are evolutionary adaptations to repel and disgust humans and other mammals that may compete for the food sources on which the moulds rely. The odours serve to protect food sources and spores. They are also highly recognizable by most people. They are made up of metabolites produced by actively growing fungal colonies and thus strongly indicate that there is both enough moisture present to sustain growth, and that growth is active, necessitating remediation. Even in situations where the volatile organic compounds (VOCs) involved are not known to cause medical harm, there is clear justification for eliminating their sources.

Mould growth in wet conditions tend to be associated with musty odours, and are often accompanied by extensive bacterial growth, which can produce additional odours suggestive of rotting vegetables or sewage. There is a notable tendency for such living conditions to cause occupants to experience social inhibition and isolation.

There is an as-yet unexplained link between perceived mouldy (or musty, mildewy) odours in a dwelling and objectively substantiated symptoms. The American Industrial Hygiene Association's authoritative handbook, Recognition, Evaluation and Control of Indoor Mold, 2nd edition (Hung et al., 2020), says:

> *Over 30 years ago, researchers first found that observed dampness and mold (D/M) in homes were associated with an increase in childhood wheeze and cough. Today, the accumulated evidence links observed D/M even more strongly to a variety of adverse respiratory health effects. In fact, a large body of research associates indicators of indoor D/M – including visible mold, moldy or musty odor, water damage and dampness/moisture – with increased risk of asthma development, asthma exacerbation, allergic rhinitis, respiratory infections, upper and lower respiratory tract symptoms, and other effects. Among these four D/M indicators, mold odor, despite its subjectivity, has shown the strongest associations with adverse respiratory effects.*

Apart from negative effects on well-being of ongoing exposure to offensive odours associated with mould, there is also a notable tendency for such living conditions to cause occupants to experience social inhibition and isolation. People may feel shame when others are present and may be reluctant to have visitors.

2.7 Strength of evidence linking indoor mould exposure with health impacts

The foregoing discussion canvasses several areas of health research organized according to allergenic and non-allergenic impacts of mould, other systemic or dermatological reactions, the social impact of mould and other areas of emerging research.

As in any complex area of scientific inquiry, the strength of evidence for associations between multiple types of exposures and multiple health outcomes will vary.

Medical and public health authorities commonly rely upon the following categories for strength of evidence:

- sufficient evidence of a causal relationship
- sufficient evidence of an association
- limited or suggestive evidence of an association
- inadequate or insufficient evidence to determine whether an association exists
- limited or suggestive evidence of no association

It is important to note that within this framework, valid, emerging high-quality evidence may be labelled “limited or suggestive” or even “inadequate or insufficient” until it has been confirmed by multiple investigators at a stringent level. These categories thus include evidence that may be well advanced on a track towards general scientific acceptance, as well as evidence that may eventually fall away as coincidentally associated. Any proposed causal link that has been even preliminarily evidenced as inaccurate, however, will likely become labelled as “limited or suggestive evidence of no association.”

For multiple health impacts of indoor D/M, strength of evidence has been categorized into either the first or second of these categories. That is, for asthma exacerbation in children, the evidence is considered sufficient to demonstrate a causal relationship. For several other health effects there is sufficient evidence of an association.

The American Industrial Hygiene Association has twice published (in 2008 and 2020) a summary of the evidence according to these internationally accepted categories (Hung et al, 2020). The AIHA evidence review is among several comprehensive reviews relied upon by health agencies around the world including in Canada.[3]

[3] Note that the most recent evidence reviews conducted by Canadian health authorities occurred in 2004 and 2012-14 (Health Canada, 2004 and Palaty and Shum, 2012 and 2014 (for the NCCEH), respectively) with both concluding that action should be taken to prevent damp conditions and mould, and to remediate mould growth in buildings. At the time of writing, Health Canada is actively reviewing the latest evidence reviewed by the AIHA in Hung et al, 2020 (personal communication with Richard Summerbell, 2021).

The AIHA provides the following summary of the evidence, (adapted from Hung et al, 2020) noting further that other reviews and large studies using different approaches to summarizing their findings reach similar conclusions.

Category for Strength of Evidence	Health Impacts of Indoor D/M
Sufficient evidence of a causal relationship with indoor dampness and mould	• Exacerbation of existing asthma in children
Sufficient evidence of an association with indoor dampness and mould	• Exacerbation of existing asthma • Asthma development • Current asthma • Ever-diagnosed asthma • Bronchitis • Respiratory infections • Allergic rhinitis • Dyspnea (chest tightening, difficulty breathing) • Wheeze • Cough • Upper respiratory tract symptoms • Eczema
Limited or suggestive evidence of an association with indoor dampness and mould	• Common cold • Allergy/atopy
Inadequate or insufficient evidence to determine whether an association exists with indoor dampness and mould	• Altered lung function • Allergy/atopy • Any other health effect not listed above
Limited or suggestive evidence of no association with dampness and mould	• No health effect identified

3. Conditions for and types of mould growth in indoor environments

Moulds can grow in many situations, but the amounts seen in well-maintained residential environments are usually small. For example, there may be a few spots on cheese kept too long in the refrigerator, a trace of darkening on a shower curtain or in shower stall grout lines between tiles, or small lines of darkening on older windowsills where traces of cold air leak around the glass in wintertime.

Problem mould growth ('amplification') situations arise where unusual levels of moisture come into contact with walls, cabinets or other structural elements (built-in parts of the dwelling).

Problem mould growth ('amplification') situations arise where unusual levels of moisture come into contact with walls, cabinets or other structural elements of a dwelling.

One regular source of major problems can be categorized as floods. This would include events affecting whole neighbourhoods, such as sewer backups caused by excessive rain, as well as events affecting single buildings or parts of buildings, such as major pipe breakages or bathtub overflows that produce enough water to wet whole rooms, or large parts of rooms.

Similar problems may be caused by leaks, which are not as high in water volume as floods, but may persistently wet some materials, such as the insides of wall cavities. Common leaks causing serious problems are roof leaks, plumbing leaks and basement foundation leaks. The moulds growing in this situation on wetted drywall usually consist of irritating, toxigenic groups like *Stachybotrys* and the *Aspergillus versicolor* complex, along with associates like *Chaetomium*. These moulds make up the indoor mould amplification scenarios that are most likely to trigger the relatively problematic non-allergic reactions noted above.

Mould amplification problems can be caused by floods (e.g., events affecting whole neighbourhoods, a pipe breakage or bathtub overflow) as well as by leaks (roof, plumbing, and basement foundation leaks) that persistently wet materials, such as the insides of wall cavities.

Persistent leaks affecting woody materials often occur around poorly sealed kitchen sinks; nearby cabinetry is also often affected. *Aspergillus versicolor* growth may occur if the affected wood is plywood or a related composite material; otherwise, various fungi can occur in differing circumstances.

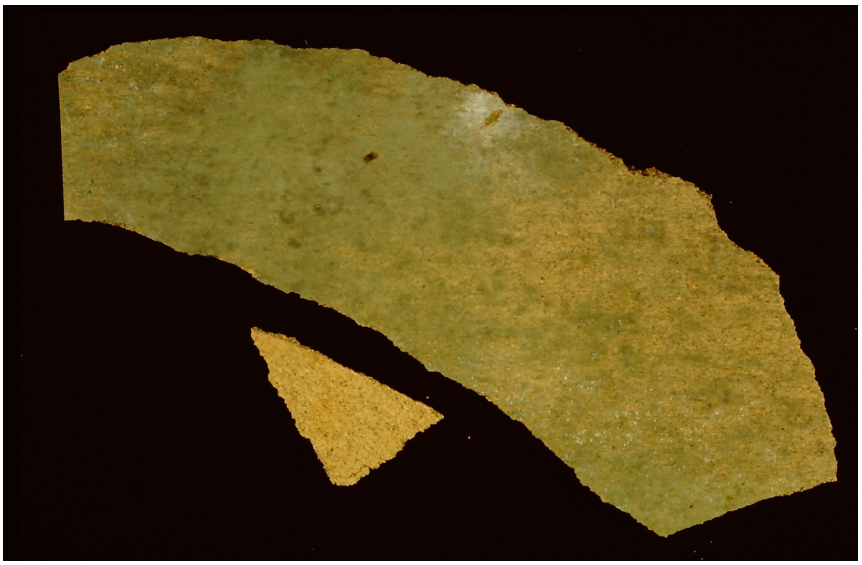

Fig. 4. A piece of particleboard backing for a school corkboard, growing a continuous lawn of Aspergillus versicolor.

Another commonly encountered source of excessive water leading to mould growth is condensation. Probably the most common type of condensation problem in Ontario is the situation where a wall is poorly insulated. In winter, it becomes cold and the normal moisture levels in the household air begin to condense on it. In extreme cases, this may lead to growth of wall-sized patches of mould. A common problem is for a room at the corner of the building to have wall insulation that doesn't go all the way into corners. This may result in mould growth in corners or, commonly, in the insides of closets built into the corners. The mould community most common in this situation tends to feature the relatively weakly irritating, but potentially allergenic *Cladosporium* as its most prominent element. More irritating elements such as *Aspergillus versicolor* and *Penicillium* species may be present.

Another commonly encountered source of excessive water leading to mould growth is condensation, a situation that can arise where a wall is poorly insulated.

In the summer, cold water pipes that have not been shielded in pipe insulation may begin to 'sweat' inside the wall cavities, especially in and near basements, sometimes causing accumulation of substantial quantities (litres) of water on the hidden surface of drywalled false ceilings. This can lead to mould growth that is dominated by *Stachybotrys* if drywall becomes saturated.

Carpets that have been flooded may become extensively mouldy if they are not dried promptly, including underlay - a very difficult process. If they have become microbially activated to the point of developing musty odours, they are likely to have ongoing growth of drought-tolerant moulds living on embedded skin scales no matter how

thoroughly they are dried, and are unsalvageable. Potentially irritating moulds not common in other indoor situations, like *Aspergillus ochraceus*, may be predominant in this situation.

The least consequential type of indoor mould proliferation is the light to moderate growth of a dark community dominated by *Aureobasidium* on inert polymer surfaces like plastic shower curtains, grout between tiles, silica sealant in showers, and windowsills painted with oil-based paints. Although this fungus is potentially allergenic, it appears to be tightly bound to the surfaces it is growing on and is seldom connected with symptoms.

The discovery of moulds amplifying indoors inevitably poses the question of what should be done about them. The two principal dimensions of this question, clean-up and prevention of recurrence, are dealt with in the next section.

Part 2: Mould Prevention and Remediation

1. Introduction

Relevant agencies, including Health Canada, concur that the prevention and mitigation of adverse health effects associated with indoor D/M requires that prompt, thorough and appropriate clean-up and remediation measures be taken. These measures encompass the following steps:

- determine the extent of mould contamination and sources of dampness
- remove mould through a combination of cleaning and material replacement
- eliminate sources of dampness
- monitor for recurrence

Note the terms “mould” and “mouldy” as used in this section refer to viable and non-viable mould, as well as mould fragments.

Actions to remediate mould must be prompt and thorough. It is essential that they address both the removal of existing mould and the elimination of the source of dampness allowing for its growth.

The need to undertake these measures is unrelated to any specific species of mould present at a given time. Mouldy conditions can presume both the potential presence of species of concern and underlying sources of dampness that must be addressed. Mould testing in relation to health exposure assessment is not recommended. Many such tests have not been certified for assessments in humans (they are more typically used by veterinarians), and they can be expensive, promote

anxiety, and are not helpful in obtaining proper medical treatment if medical treatment is necessary. Remediation must be appropriate to the situation and undertaken promptly and thoroughly. This requires an accurate determination of the extent of the mould contamination and the source of the dampness allowing for its growth.

2. Determine the extent of mould contamination and sources of dampness

The first reasonable step in this determination is to conduct a non-destructive physical inspection of the dwelling. The goals of this inspection are to

- observe for visible mould and to quantify the extent to which it exists (refer to table below)
- assess for non-visible indications of mould such as musty odours
- observe for the presence of dampness and the existence of obvious conditions within or outside the dwelling causing or contributing to its presence

Situations involving flooding must be addressed especially quickly. Mould can begin to grow in damp conditions in 48 hours.

Where possible, this inspection should be conducted with input from the occupants of the dwelling who will likely be able to provide useful information about any recent flooding or plumbing problems, the location of visible mould, where musty odours are most prevalent, observed relevant deficiencies in the condition of the dwelling, and locations that appear to be more associated with any reported adverse health effects. Note that situations involving flooding must be addressed especially quickly. Mould can begin to grow in damp conditions in 48 hours.

Reasonable expectations as to the thoroughness of this inspection encompass:

- an assessment of all rooms, closets, cupboards for signs of mould growth, staining indicative of previous mould growth or dampness entry, and musty odours. The following tools are helpful to assess moisture/dampness issues and the extent of mould:
    - a flashlight to check areas of low light such as the corners of a dark closet
    - a portable moisture meter to assess the dampness content of drywall and other building materials, especially in moderate and extensive situations
    - a portable hygrometer to measure ambient air humidity. However, the interpretation of readings can be challenging due to factors such as windows being open or closed at time of measurement, and possible activities of occupants just prior to measurement (e.g. showering)
- where applicable, a similar assessment of attic and crawlspaces [with adherence to safety precautions about confined space entry where relevant]
- an assessment of all visible plumbing fixtures and pipes for signs of leaks

- a general assessment of HVAC systems with a view to determining if
  - the heating/cooling system for the dwelling appears to be operating properly
  - system vents are unobstructed

- cooking/bathroom exhaust fans, where provided, are operative and vent to the outdoors

- a general assessment of the exterior of the building enclosing the dwelling to determine if there are obvious structural faults that could cause water entry. These include
  - roof damage
  - damaged/missing building cladding and gutters
  - basement floor and foundation cracks
  - surface water drainage issues (e.g., ground sloping towards foundation)

If the results of visual inspections reveal significant mould/dampness problems, further intrusive investigation may be needed, as well as professional guidance. Further investigation may also be required in unusual situations where D/M problems are not detected by a visual inspection, but there are plausible reasons for believing that an underlying problem may exist, for example, symptoms among dwelling occupants that are consistent with mould exposure and for which there is no other apparent cause, combined with a previous building history of dampness and mould.

Classification of Extent of Visible Mould

Small	Moderate	Extensive
3 or fewer patches and the total area is less than 1m²	If there are more than 3 patches or if the patches are greater than 1m² but less than 3m²	If a single patch is larger than 3m²

Source: Canada Mortgage and Housing/Health Canada

3. Remove mould through a combination of cleaning and material replacement

Any mould growth or materials containing remnants of previously viable mould must be removed. The effort required and the complexity involved to perform this task will relate to the extensiveness of the problem.

In some small situations, removal can be safely and effectively carried out by the landlord or the occupant with or without professional assistance. An example of a minor issue could be a small amount of mould in a bathtub or shower enclosure where removal could be performed by the landlord or occupants of the dwelling, provided they are healthy adults and do not have risk factors for mould exposure. A healthy adult

could also clean a window ledge of condensation-induced mould growth (recognizing that the source of the condensation needs to be investigated and resolved).

Mould removal in some moderate situations may likewise be carried out directly by landlords with non-professional assistance. Professional assistance can however guide the process, increasing the likelihood that the problem is successfully rectified on first attempt.

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Professional guidance is highly recommended in moderate situations where prior non-professional efforts have failed and in all extensive situations.

Professional guidance is highly recommended in moderate situations where prior non-professional efforts have failed and in all extensive situations. In all cases, mould removal must be undertaken following the general principles cited below and with the appropriate safety precautions for both occupants and workers.

a. Walls, floors, ceilings and other fixed surfaces

In general, non-porous surfaces, or porous surfaces coated with an intact non-porous coating/cladding, can be cleaned to remove mould. Such materials include metals, plastics, intact painted wood, and ceramics.

Plaster surfaces and drywall cannot be cleaned to remove mould unless the mould resides only on the painted surface of the material and has not, along with dampness, permeated the material. Where it is evident that dampness and mould have in fact permeated the material, it must be replaced unless the material can be thoroughly dried within 48 hours of initial moisture contact. The use of dehumidifiers and heaters would be required to effect such rapid drying. A moisture metre would also be essential to determine that complete drying has occurred. **Painting over mouldy material instead of replacement is not an effective alternative**.

Cleaning should occur using a mild solution of soap and water. The material should then be rinsed and dried quickly and thoroughly. **Chlorine bleach or other substances intended to "kill" mould are unnecessary and potentially expose occupants and workers to chemical hazards.**

b. Contents within the dwelling

Items made of non-porous material including metals, plastics, intact painted wood, and ceramics can be cleaned to remove mould. As above, cleaning should occur using a mild solution of soap and water, followed by rinsing and drying. **Again, the use of chlorine bleach is unnecessary and potentially hazardous.**

Clothing and bedding can, in most cases, be laundered to remove mould and musty odours. However, laundering may be ineffective where these items have been subjected to dampness and mould for prolonged periods of time. In such cases, the items must be discarded.

In most cases, mouldy rugs/carpets, cloth furniture, mattresses, stuffed toys and other similar items cannot effectively be cleaned and must be discarded.

Upon completion of the removal process, the affected areas of the dwelling must be thoroughly cleaned and HEPA vacuumed to remove remnant mould and dust associated with the process.

4. Eliminate sources of dampness

Strategies to eliminate identified sources of dampness will be largely self-evident and based on the findings of the dwelling inspection. Note that especially in moderate and excessive situations, dampness elimination will need to occur concurrently with or prior to mould removal. In relation to the example sources cited in 2) above reasonable and obvious strategies include:

- repair of leaking plumbing
- structural repairs related to roofing, exterior cladding, and the below-grade building envelope
- repair/adjustments to the HVAC system to ensure adequate air exchange
- repair/replacement of faulty existing exhaust fans or provision of same where a need is evident
- provision of dehumidifiers, recognizing **they are not an alternative to needed repairs**

5. Monitor for recurrence

Once completed, remediation work should be checked to both confirm the absence of mould and that any repairs carried out have been successful in eliminating sources of dampness.

Periodic follow-up with the occupants of the dwelling is also an important measure that can reduce the potential for recurrence. Occupants are, of course, on site and are therefore best positioned to identify the reappearance of mould or dampness early on. Follow-up with occupants also provides an opportunity to reinforce any measures they must take to reduce the potential for recurrence, such as the proper use of exhaust fans/dehumidifiers and the operation of HVAC systems.

Annex 1:
A more detailed look at indoor moulds and associations with health concerns

a. Indoor mould colonizations vs. normal background mould exposures

Anyone reading about mould-related problems in homes will soon encounter the phrase 'mould is ubiquitous,' meaning 'mould is everywhere.' Many moulds produce spores that are airborne. Thus, in fungal studies, at least some mould can be grown from any air sample that hasn't been strongly filtered. It is deceptive, though, to use this fact to suggest that mould growing indoors is therefore not a problem. Moulds are not all the same in terms of their possible effects on people.

Many of the differences among moulds arise from whether they are adapted to produce materials that irritate and repel animals, including humans. Most of the moulds found in normal outdoor air are not generally irritating. They are produced on the surfaces of living leaves and plant stems. In this habitat, there is no advantage in making anti-animal toxins and irritants. Also, our species has evolved with these leaf-surface fungi ("phylloplane fungi") as part of our normal breathing environment, and our system usually does not react to them as a microbial threat. Just a small fraction of people become allergic to some leaf-surface fungi that are common in outdoor air, like *Cladosporium* and *Alternaria*. Similarly, most fungi that colonize soil in temperate regions, like Canada, do not produce significantly irritating airborne materials.

On the other hand, some fungi have evolved to colonize decaying plant material - material that some animals could otherwise eat. Competition against animals for these materials has led to evolution of toxic secretions, off-putting odours, and chemistry that triggers strong immune reactions.

Stachybotrys, in nature, colonizes decaying grass and straw, as might be found in overly wet hay. It has evolved toxins that cause symptoms suggestive of burns on the mouth parts of grazing animals. These toxins also inhibit a basic process (protein synthesis) that is part of normal functioning inside animal and human cells. Finally, spores, cellular fragments and toxins from this fungal group are recognized by cells of the immune system, defending our lungs, as a "danger signal." (Kankkunen et al., 2009). Cells in our immune system may react by sending out chemical signals to other immune cells, leading to a strong defense reaction that can feel like a cold or a chest infection.

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Cellular fragments and toxins from Stachybotrys *moulds are recognized by cells of the immune system as a "danger signal," leading to a strong defense reaction that can feel like a cold or a chest infection.*

Some fungi are more likely to colonize plant seeds or fruits than stems or leaves. Such fruits and seeds are often used by humans as food. They are rich in nutritional value, and this energizes fungi growing on them to produce large amounts of toxic material in order to chemically 'claim' the material. *Aspergillus flavus*, which colonizes materials such as peanuts, corn kernels, and dried red peppers, produces one of the strongest natural poisons ever found, aflatoxin.[4] This toxin is surpassed only by radiation as a cause of mutations that might lead to cancer. A closely related fungus, *Aspergillus versicolor*, produces toxins that are related, though not quite as potent. It is among the most common species growing in homes with serious moisture problems.

*One of the most common species of mould growing in homes with serious moisture problems is the varying-coloured aspergillus mould (*Aspergillus versicolor*), which produces toxins that are related to, though not quite as potent as, aflatoxin.*

If studies are done of airborne mould spores in houses where there is no moisture problem, the results usually show the same species that are found in outdoor air, but at lower count levels per cubic metre of air. The largely wind-and-draft-free atmosphere inside buildings allows the normal spore levels to settle out slowly into dust, clearing the air. In Ontario, these outdoor moulds tend to form a highly recognizable pattern: *Cladosporium* and *Alternaria* are most common year-round, joined during warmer parts of the year by *Epicoccum,* some *Penicillium* types, basidiomycetes (wood-decay fungi and mushrooms), *Fusarium* species that grow on grain heads, and a few others. Yeast colonies also commonly grow in these samples, especially if there has been recent rain to knock spores off the leaf surfaces where they grow.

b. Recognition of mould; distinction from items causing confusion

Mould is one of two common growth forms of microfungus that can be found in household environments. The other - not generally a problem in homes - is yeast. Moulds can be seen under the microscope to be composed mainly of branching threads, some of which may produce spores from fertile cells at the branch tips. They have a fuzzy, wispy or cottony look in their vegetative growth. The colour is often greenish, brownish or whitish. When they start to produce spores, the spores may be dry types, which makes the mould growth look dusty or powdery. Less commonly, moulds may be types that have slimy spores, making colonies look like wet fuzz or coloured slime. Lastly, some moulds may be seen mostly as clusters of green to dark lumps looking like tiny clumps of dirt.

Items that can be confused with moulds include deposits of dirt on surfaces, especially if there are some spiderwebs added in. The common household spider in Ontario, the

[4] Note however that grain, corn, and products like peanuts, etc. are screened by the Canadian Food Inspection Agency for these mycotoxins to ensure they are not on the market in Canada.

‘long bodied cellar spider,’ makes thin, wispy webs in many little-disturbed parts of the house. When these webs become dusty over time, they can be mistaken for mould. One item that can easily be mistaken for mould, because it is powdery or clumpy and may be associated with moisture-damaged, rotting wood or paper, is insect frass, in other words, insect dung. The dung of termites or the fine chewed sawdust deposits made by carpenter ants can sometimes be found in pale yellow-brownish accumulations. These piles of frass differ from moulds in not being attached in any way to the surfaces they rest on.

Sometimes an item made of cloth or fibre, like a carpet, has been glued to a surface and then ripped away: the resulting fuzzy surface can appear mould-like. The same effect can occur when paper has been glued on and ripped away, especially if it later became dirty. Finally, especially in damp basements, the growth of wood decaying fungal species which are *not* moulds can lead to thread-like structures called ‘rhizomorphs’ criss-crossing the affected wood. The presence of these structures, however, often reflects overly damp conditions that also cause mould growth to occur nearby.

The final decision about whether something is a mould or not is made under a microscope. Many indoor moulds, however, are instantly recognized by experts because of factors like a tendency to grow as roughly circular colonies, and a tendency for moulds of particular exact colouring to associate with the same habitat over and over. For example, drywall (gypsum covered with paper as used in household wall construction), if it becomes thoroughly wetted in a flood or constant leak, regularly grows the jet-black mould *Stachybotrys*. The exact appearance this gives to the ruined drywall is unmistakable to those who have seen it multiple times.

Identifying excessive mould growth can be problematic when much or all of it may be hidden within wall cavities and connected spaces that are not generally visible, such as spaces above the visible ceilings or under the floors. Pipes that produce leaks are found in these areas, and water from floods and roof leaks tends to stream into them. Because they are enclosed spaces, they retain humidity much more than the open rooms do, and there is little chance to ventilate them or air them out. However, there is always some air flowing through them and seeping out through tiny cracks into the inhabited rooms. This means that people living in the home may inhale or otherwise come into contact with materials from mould colonies that have grown in these wall and floor/ceiling cavities. The World Health Organization (2009) has shown that a home experiences a ‘stack effect,’ that is, it is like a chimney, with warm air rising toward the roof and creating very small amounts of suction (negative air pressure) below. This suction tends to pull air out of wall cavities through very small cracks and fissures, especially when heating is on and when windows and doors are closed. When a mould

Identifying excessive mould growth can be problematic when much or all of it may be hidden within wall cavities and connected spaces that are not generally visible, such as spaces above the visible ceilings or under the floors.

problem exists in hidden locations, detection may require the cutting of small holes in the drywall or use of special cameras with flexible necks and attached lights (penetrating endoscopes) to see what is going on inside cavity spaces.

c. Indoor mould growth on various types of building materials and/or furnishings

Associations between different kinds of fungi in indoor growth have been studied in Ontario by Scott (2001). Data including a wide selection of U.S. and Canadian homes are summarized by Miller (2011). The WHO (2009) has published a list of moulds divided up by their preference for more moist or more dry environments. The ecological sketches below combine information from these and related publications with the author's long-term personal observations.

i) Moulds on wet papery material

There is a distinct group of fungi that typically grow together on papery materials indoors that have become saturated (soaking wet). The most common type of papery material available is the paper that covers drywall, used to make indoor walls. Wallpaper can similarly become involved. Flooding in wall cavities or in rooms can completely wet these papers, and the underlying clay-like gypsum, which is bone-dry at first, tends to slowly take up the water and swell, forming a water-holding sponge. This is the habitat where *Stachybotrys* typically grows. It uses the cellulose of which the paper is made as a food source, as well as the glue holding it to the gypsum. This type of mould is dependent on very wet conditions. Along with it, a fungus occurs that forms tiny green-grey lumps - the genus *Chaetomium*. In nearby parts of the drywall that have got wet but are not so fully saturated, *Aspergillus versicolor* grows, sometimes along with *Penicillium chrysogenum* and one or more *Alternaria* species. All these moulds are usually accompanied by immense numbers of barely visible mites, eight-legged creatures that are distantly related to spiders but, in many species, eat mould (Example, *Tyrophagus putrescentiae*). The mites can smell mould growth and tend to carry spores between different areas of fungal growth. In humid conditions, they can walk the distance of a kitchen table top while active. Their own body parts may cause allergy in some people, and they also produce dung (tiny 'faecal pellets') made mostly of partially digested mould spores and filament cells.

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Stachybotrys *typically grows where the paper that covers drywall has become completely wet.* Stachybotrys *uses the cellulose of which the paper is made as a food source, as well as the glue holding it to the gypsum.*

ii) Moulds on humid papery material

There is a typical thin, dark mould growth on visible surfaces of walls that have become lightly dampened by continuous humidity, generally caused by poor insulation making them cold in the winter, early spring and late fall. This growth usually consists of a dark

mould called *Cladosporium*. This mould would generally be classed as 'black' by most people looking at it, but in contrast to *Stachybotrys*, it is not pure, intense jet black, and instead is a less intense, grey-greenish black that experts call 'fuscous.' *Cladosporium* grows on drywall-based walls painted with water-based paint and on humid wallpaper; it may also grow on other damp painted surfaces that are visibly dark with mould growth, like windowsills.

To the naked eye and even under the microscope, the broad lawns of *Cladosporium* on humid walls may seem homogeneous. Any attempt to culture them, however, reveals extensive growth of bluish and greenish *Penicillium* species that grow inconspicuously in the darker *Cladosporium*. These fungi produce dry spores that are smaller than most *Cladosporium* spores and easily become airborne; moreover, many *Penicillium* species are toxigenic and some are known to be capable of causing respiratory irritation (Straus 2009).

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Toxin-producing Penicillium *mould species often grow within patches of* Cladosporium *mould that are commonly found on moist drywall-based walls painted with water-based paint, on humid wallpaper and other damp painted surfaces, like windowsills.* Penicillium *moulds produce tiny dry spores that easily become airborne. Many* Penicillium *species are toxigenic and some are known to be capable of causing respiratory irritation.*

iii) Moulds on humid, porous materials other than paper, including wood composite

Sometimes mould growths occur on porous materials that are less likely to absorb humidity than wall-covering papers. Among these materials are the rough, unfinished side of particle board panels, mineral fibre composite ceiling tiles, and densely pressed particle wood baseboards. Excess humidity may stimulate growth of *Aspergillus versicolor* on rough wood panelling, as well as on ceiling tiles. In situations where humidity is very high but most materials present are resistant to becoming wetted, drought-loving moulds in the *Aspergillus glaucus* group tend to become prominent (the name 'glaucus' means 'greyish blue-green'). They can grow abundantly on presswood baseboards, even if these boards are painted, and will also lightly cover furniture, including polished wood, as well as fabrics and shoes. Entire closets full of clothes lightly but completely covered in a grey-green sheen of *A. glaucus* may be seen. Matting around paintings is often affected; this is a well-known problem in art galleries where some humidity must be maintained, but the breath of constant visitors may add a slight excess that

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In situations where humidity is very high but materials present are resistant to becoming wetted, drought-loving moulds in the Aspergillus glaucus *group tend to become prominent. They can grow abundantly on press wood baseboards, and will also lightly cover furniture, including polished wood, as well as fabrics and shoes. Entire closets full of clothes lightly but completely covered in a grey-green sheen of* A. glaucus *may be seen.*

causes problems. These moulds change from glaucous to brownish as they age. In very high humidity, tiny bright yellow or red fluff-balls may be seen that are the sexual fruiting bodies.

Ceiling tiles, because of their low content of organic matter and chemical treatment to make them inert in case of fire, tend, when partially flooded by leaks from above, to grow noticeable dark or beige patches of moderately drought-tolerant moulds like *Ulocladium* and *Aspergillus versicolor* rather than wetness-and-cellulose-loving moulds like *Stachybotrys* and *Chaetomium*.

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Ceiling tiles, because of their low organic content and chemical treatment for fire resistence, tend to grow moderately drought-tolerant moulds like Ulocladium *and* Aspergillus versicolor *rather than wetness-and-cellulose-loving moulds like* Stachybotrys *and* Chaetomium.

Fig. 5. Suitcase from a humid closet, showing grey-brown Aspergillus glaucus *complex as well as more conspicuous dark* Cladosporium.

Fig. 6. Typical ceiling tile leak colonization by Alternaria (Ulocladium *type*) *and* Penicillium.

iv) Moulds on damp wood

Indoor wood that has been wetted is relatively resistant to mould growth, but long-term wetness, e.g., caused by an unfixed leak wetting cabinet wood under a sink, can lead to growth of 'soft rot' fungi. These moulds are diverse and often hard to identify; little is known about their health impacts. In long-wetted or extremely humid structural wood such as beams and joists, specialized wood-decaying fungi may become established. They are typically seen as white, fluffy or ropy growths, sometimes with darker webwork (rhizomorphs) in very humid environments. If the environment has ceased to be humid, these species may be hard to see on the outside of the wood but can carry on growing by chemically making their own water as they grow hidden inside the wood. In these cases, wood that has started to develop areas where the substance has turned into brown cubes with a nougat-like texture are being decayed by 'brown-rot' fungi. This is a building structural problem that doesn't, in itself, have any known health effects, apart from potential safety concerns related to building integrity

Indoor wood that has been wetted is relatively resistant to mould growth, but long-term wetness, e.g., caused by an unfixed leak wetting cabinet wood under a sink, can lead to growth of 'soft rot' fungi.

v) Moulds on plastic and on painted surfaces

Aureobasidium, a moisture loving, dark fungus that is classed as a mould but has some yeast-like properties, is often seen growing in very moist areas that seem to offer no food substance for mould growth. Plastic shower curtains can be turned hazy black by

this fungus; it also colonizes inorganic grout between tiles and the outer and inner surfaces of old silica gel sealant. The sills of older-type windows may be heavily painted with oil-based paint, but if moisture leaks in from outside, or if they are single-pane glass and have condensation running off them onto the sills in winter, these sills may grow *Aureobasidium*. Other groups like *Cladosporium* may move in after some cracking has occurred in the paint.

vi) Moulds on heated surfaces

A relatively uncommon, but nonetheless repeatedly occurring situation is to have mould growth connected to high humidity in, on or around something that is regularly heated well above room temperature. In these cases, particularly heat-loving moulds like *Aspergillus fumigatus* and *Scedosporium* may grow. These moulds are well known in medical literature as causes of infections in patients with damaged immune systems or chronic health conditions but remain unable to cause infection in most people. They may cause allergic reactions and other immune system responses even when no exposed person is vulnerable to infection. They are common causes of fungal sinus infection in people who have been chronically allergic for many years, but the direct connection of this condition to household mould sources has never been established. The un-submerged parts of the inner walls of uncleaned furnace humidifiers are notorious sites producing this sort of mould, but wet wood around heating ducts may also grow them. *Scedosporium* may grow in stagnant water such as vessels left out to catch drips from heating or cooling equipment.

A relatively uncommon, but nonetheless repeatedly occurring situation is to have mould growth connected to high humidity in, on or around something that is regularly heated well above room temperature. These heat-loving moulds like Aspergillus fumigatus *and* Scedosporium *may cause infections in patients with damaged immune systems or chronic health conditions but remain unable to cause infection in most people.*

d. Potentially problematic molecules produced by mould growth

Mould colonies start off as a spreading network of microscopic threads growing across and into the material they are decaying. They are somewhat like microscopic vine plants, with viny stems just one cell wide. The walls of these cells are made of a mixture of chitin - which is also the main component of shrimp shells - and glucans, which are related to chemicals making up plant cell walls and bacterial cell walls. The mould filaments produce enzymes that start to digest the substrate, whether it be paper, wood, cheese, bread, etc. When the food supply starts to decline because it has been mostly used up, the moulds do two switches. Firstly, they start making spores, which are designed to travel to new places that can serve as food sources. Secondly, they

produce chemicals that keep other microbes out of their domains, and that, in many cases, protect the spores by making them or nearby colony material toxic to would-be eaters.

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When their food supply has been mostly used up, the moulds do two switches. Firstly, they start making spores, which are designed to travel to new places that can serve as food sources. Secondly, they produce chemicals that keep other microbes out of their domains, and that, in many cases, protect the spores by making them or nearby colony material toxic to would-be eaters.

i) Cell wall molecules causing irritation and cell sap (cytoplasm) molecules causing allergic reactions

One of the two main components of fungal cell walls can trigger respiratory symptoms and can also worsen the symptoms caused by other irritants. This component is glucan - a specific chemical type called ß (1,3) glucan (pronounced bay-ta one three glue can). It is closely chemically related to a more potent irritant from bacteria called endotoxin, or lipopolysaccharide (abbreviated LPS). Mould growth indoors in relatively wet sites is often accompanied by growth of bacteria that, when materials dry out, may become sources of LPS in the air. Air influenced by materials from mould proliferation thus contains a mix of fungal glucan and LPS, making difficult the attempt to distinguish the effects of one of these from the other. (Direct experimentation on humans could soon clarify this point, but such experiments done with materials that are expected to cause only harmful effects are generally considered unethical.) Rylander (1999), a top researcher on this matter, said, “A general conclusion ... is that there was a relation between exposure to (1->3)-ß-D-glucan as an indicator of mould biomass (bulk growth - RCS) and the extent of symptoms of airway inflammation, fatigue, and headache.” Sorting out exactly what fungal glucan does by itself is an ongoing research question. We do know, though, that fungal glucan is specifically reacted to by human cells that control the body’s responses to foreign substances, and it triggers potentially disease-like responses (Kankkunen et al., 2010). LPS is known to increase the body’s reaction to fungal toxins (Kankkunen et al., 2009).

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Mould growth indoors in relatively wet sites is often accompanied by growth of bacteria that, when materials dry out, may become sources of LPS (lipopolysaccharide, also known as endotoxin) in the air. Air influenced by materials from mould proliferation thus contains a mix of fungal glucan and LPS, making difficult the attempt to distinguish the effects of one of these from the other. LPS is known to increase the body’s reaction to fungal toxins.

Reaction to fungal glucan probably affects everyone, but the same is not true of fungal molecules that cause allergy. With typical allergy ('hay fever' like, 'Type 1' allergy), some people become 'sensitized' and develop allergic responses, while others do not. The best known fungal allergen molecules from commonly airborne mould types are from *Alternaria* and *Aspergillus* species. 'Alt a 1' is the main trigger of allergy to *Alternaria*, and 'Asp f 1' is the principal allergen from *Aspergillus fumigatus* (Horner et al., 1995). These molecules, unlike glucan, are found in the liquid matrix of the cell sap (cytoplasm) rather than the cell wall. They have been classed as glycoproteins, that is, molecules that are part protein and part carbohydrate. Molecules similar to 'Asp f 1' are also found as triggers of allergy in *Cladosporium* species.

ii) Fungal toxins

The toxins secreted by mature and aging fungal colonies are an extremely diverse group of chemicals. Many are poisons for humans and animals, but some, like penicillin, act against bacteria, while others act against insects. The chemicals harming humans and animals in some way are generally labelled 'mycotoxins.' Some well known mycotoxins relevant to indoor air include the satratoxins made by most genetic types of the black toxic mould *Stachybotrys*, ochratoxin A made by several *Aspergillus* and *Penicillium* species, and sterigmatocystin made by the varying-coloured aspergillus mould, *Aspergillus versicolor*. Satratoxins are able to stop human cells from producing the protein molecules they need to continue living and can also trigger strong non-allergic immune reactions in the human airways (Kankkunen et al., 2009). Ochratoxin A is most famous as a kidney toxin in animals that have eaten contaminated grain, but is also able, in smaller quantities, to trigger responses in the human immune system (Sandström von Tobel et al., 2014). Included are responses that may affect brain function or development. Sterigmatocystin is less well understood than many other toxins but appears to have cancer-causing potential as well as the ability to disrupt immune signalling and to harm liver and nerve cells (Díaz Nieto et al., 2018; Zingales et al., 2020). The combination of *Stachybotrys* and *Aspergillus versicolor* toxins in the air of a courthouse complex was considered the most likely cause of an outbreak of non-allergic asthma-like symptoms, as well as more severe lung symptoms, affecting multiple employees (Hodgson et al., 1998).

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Satratoxins made by most genetic types of the black toxic mould Stachybotrys*, are able to stop human cells from producing the protein molecules they need to continue living and can also trigger strong non-allergic immune reactions in the human airways.*

iii) Fungal odour molecules

Problematic indoor mould colonizations, especially the ones associated with very wet materials, are often noted as smelling musty. Many fungi, including moulds, produce distinctive odour compounds. These are small molecules that immediately enter the air around colonies; in general, they are grouped as 'volatile organic compounds,'

nicknamed VOCs. One of the most common VOCs, produced by multiple moulds as well as some mushrooms, is a small alcohol molecule called 1-octen-3-ol. Its aroma has been described as basically earthy with notes of 'mushroom' 'green' 'oily' 'fungal' and 'raw chicken.' Another common VOC from mould colonies is geosmin, which sharply smells like 'earth.' Some bacteria in the mould-like *Streptomyces* group also produce geosmin and can grow along with indoor mould colonizations. 1-octen-3-ol produced in indoor environments has been associated with irritation of nasal passages and the rims of the eyes (nasal and ocular mucosae) (Araki et al. 2012). It has also been suggested, based on experiments on animal systems, to cause harm to the nervous system and to possibly be a factor in the development of Parkinson's Disease (Inamdar et al. 2013, 2020).

Annex 2:
Richard Summerbell *Curriculum Vitae*

June 2021

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ACADEMIC BACKGROUND

1985 Ph.D., University of Toronto. David Malloch, advisor. Thesis title: Microfungal populations and interactions in the mycorrhizosphere of black spruce.
1981 M. Sc., University of British Columbia. Robert Bandoni, advisor. Thesis title: The genus *Leucosporidium* in southern British Columbia, an area of temperate climate.
1979 B. Sc., Botany, University of British Columbia

Languages: (spoken and written) – English (native), Dutch (fluent), French (near-fluent but spoken is out of practice), Cantonese (intermediate, spoken only); languages not spoken but easily read with some dictionary support: Romance languages (Spanish, Italian, Catalan, etc.), German, Lëtzebuergesch, Russian, Ukrainian, Secwépemc (indigenous British Columbian language).

EMPLOYMENT HISTORY

2009-present *Associate Professor*, Dalla Lana School of Public Health, University of Toronto (status-only appointment)
2007-present *Research Director*, Sporometrics Inc., Toronto.

2000-2006 *Centraalbureau voor Schimmelcultures Representative*, Biodiversity Research School, University of Amsterdam
2000-2006 *Senior Researcher and group leader*, CBS Fungal Biodiversity Centre/Centraalbureau voor Schimmelcultures, Institute of the Royal Netherlands Academy of Sciences, Utrecht
1995-1998 *Chief Parasitologist* (acting), Ontario Ministry of Health, Toronto.
1991-2000 *Chief Mycologist*, Ontario Ministry of Health, Toronto.
1988-2000 *Assistant Professor*, Dept. of Laboratory Medicine and Pathobiology, (previously Dept. of Microbiology), University of Toronto
1998-1991 *Research Scientist*, Ontario Ministry of Health, Toronto
1988 *Postdoctoral Research Fellow*, University of Toronto, Erindale Campus
1986-1988 *Postdoctoral Research Fellow*, University of Toronto Department of Medicine (in cooperation with Ont. Min. of Health)

RESEARCH AREAS

Molecular biosystematics, ecology, evolution and health impact of selected fungal groups.

SCIENTIFIC GRANTS

Sloan Foundation. Savory, **R.C. Summerbell,** J. Pogacar. Microbiology of the built environment: To design improved testing methods for common building materials. USD 250,000. Fall 2012 – Fall 2014

Royal Netherlands Academy of Sciences Renewal Funds (Vernieuwingsfonds). **R.C. Summerbell**, P. Crous, Co-PIs. 2006-2010. DNA barcoding of medical fungi including *Pneumocystis*, food- and airborne fungi, and phylogenetically important type strains of the CBS collection. € 750,000 (CDN 1,059,635.96).

SYNTHESYS fellowship for Dr. M. Arabatzis. Development of real-time PCR for dermatophyte diagnostics. **R.C. Summerbell**, G.S. de Hoog. € 9,500. (CDN 13,422) July-Sept. 2005.

SYNTHESYS fellowship for Dr. H.J. Schroers. Molecular phylogeny, new species, phylogeography and patterns of opportunistic human pathogenicity within the *Fusarium dimerum* species complex. **R.C. Summerbell**. € 6,000. (CDN 8,477) March 2005.

NUFFIC Ph. D. fellowship for student Hesti Tata. Co-supervision **R.C. Summerbell**, CBS, and Prof. M. Werger, Univ. Utrecht. € 74,000. (CDN 104,550) Mycorrhizal and endophyte fungi in various land use types in dipterocarp-containing forests in eastern Sumatra, Indonesia. 2005-2009.

International Society for Human and Animal Mycology (ISHAM). **R.C. Summerbell**. Molecular medical mycology research project/training for Dr. S. Deng (China) and Dr. A. Moharram (Egypt). Molecular epidemiology of tinea capitis agents in western China; Phylogeny of *Sporothrix* species; € 10,000 (CDN 14,128), 2004-2005.

NWO-WOTRO (Netherlands Foundation for the Advancement of Tropical Research). T. Boekhout, **R.C. Summerbell**, A.M. Cleef. Function and biodiversity of root associated microorganisms in tropical lowland forest ecosystems in Colombian Amazonia (Colombia). €45,370 (CDN 64,100), 2003-2007.

Stichting het Kronendak (Forest Canopy Foundation); Studienstiftung Mykologie. **R.C. Summerbell**, G. Verkley, T. Boekhout, D, J. Wolf, D. Hooftman. The role of the microbial phyllosphere community in shade coffee plantations, Costa Rica – a study on community composition. € 9,110 (CDN 12,871). 2003-2004.

Royal Netherlands Academy of Sciences Renewal Funds (Vernieuwingsfonds) W. de Boer, **R.C. Summerbell**, G. Kowalchuk (co-P.I.'s). Fungal-bacterial interactions in soils. NLG 1,080,000 = CAD 687,630.00. 2001 – 2004. Later consumables supplement € 8000 (CDN 11,303) for each of 3 postdocs/students.

(Note: application for competitive external research grant funding was considered inappropriate in Ontario Ministry of Health position held prior to 2000. Some corporate and other collaborations were possible.)

SCIENTIFIC GRANTS (cont.)

Mediprobe Laboratories, London, Ont.

1) **R.C. Summerbell**. New techniques for molecular recognition of fungi from skin and nails. 1998-9. $40,000.

2) **R.C. Summerbell**. Molecular and physiological identification of *Malassezia* species from human skin, 1998-9. $60,000.

3) **R.C. Summerbell**. Antifungal drug susceptibilities of *Malassezia* species, 1997-9, $25,000.
4) **R.C. Summerbell**. Detection of dermatophyte mycotoxins in human tissue, 1998 -9, $45,000.
5) **R.C. Summerbell**. Disinfection of dermatophyte and other fungal inoculum, 1998-9, $40,000.

Ontario Health Research Grant, "When should intravenous administration sets be changed in children receiving lipid infusion?", A.G. Matlow (P.I.), L. Ford-Jones, I. Kitai, M. Perlman, P. Pencharz, **R. Summerbell**, H. Kirpalani, Apr. 1, 1993- Oct. 31, 1994, $59,825.00.

Pharmaceutical clinical trials, moneys provided in support of interconnected research in **R.C. Summerbell**'s laboratory, 1992 – 1995: ITR-CAN 14 (Janssen Canada), $12,744; SFF 304 (Novartis US [updated name, formerly Sandoz US]) $2,730; SF-5 (Novartis) $ 35,173; SFD 301 (Novartis) $ 18,146; SFD 302 (Novartis) $10,416.

SCHOLARSHIPS AND AWARDS

1998	Labontario Award for excellence in scientific research, awarded by Analytical Laboratories Council, Ontario Ministry of Health
1985	Medical Research Council of Canada fellowship (postdoctoral) award.
1982	Natural Sciences and Engineering Council of Canada Graduate Scholarship
1981	University Fellowship, University of Toronto.

REFEREED PAPERS

Published/In Press (index number in ***red***: > 50 ISI citations; number in ***blue***: > 100 ISI citations; number in ***green***: > 200 ISI citations; number in ***purple***: > 300 ISI citations; number in orange: > 500 ISI citations)

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186. Gupta AK, **Summerbell RC**, Venkataraman M, Quinlan EM. Nondermatophyte mould onychomycosis. J Eur Acad Dermatol Venereol. 2021 Mar 24. doi: 10.1111/jdv.17240 Online ahead of print.
185. Gupta AK, Venkataraman M, Renaud HJ, **Summerbell R**, Shear NH, Piguet V. The increasing problem of treatment-resistant fungal infections: a call for antifungal stewardship programs. Int J Dermatol. 2021 Mar 17. doi: 10.1111/ijd.15495. Online ahead of print.
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183. Braga A, Knaap W, **Summerbell R**. Examining growth rates of *Scopulariopsis brevicaulis* on decomposing porcine remains. Can Soc Forensic Sci J 2020; 53, 130-148.
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181. Gupta AK, Stec N, **Summerbell RC**, Shear NH, Piguet V, Tosti A, Piraccini BM. Onychomycosis: a review. J Eur Acad Dermatol Venereol. 2020 Apr 1. doi: 10.1111/jdv.16394 Online ahead of print.
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H-M, Glassman SI, Hirooka Y, Irinyi L, Iršėnaitė R, Martin-Sanchez PM, Meyer W, Oh S-Y, Sampaio JP, Seifert KA, Sklenář F, Stubbe D, Suh SO, **Summerbell R**, Svantesson S, Unterseher M, Visagie CM, Weiss M, Woudenberg JH, Wurzbacher C, den Wyngaert SV, Yilmaz N, Yurkov A, Kõljalg U, Abarenkov K. Taxonomic annotation of public fungal ITS sequences from the built environment - a report from an April 10-11, 2017 workshop (Aberdeen, UK). MycoKeys. 2018 Jan 8;(28):65-82.

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166. Perdomo H, Sutton DA, García D, Fothergill AW, Gené J, Cano J, **Summerbell RC**, Rinaldi MG, Guarro J. 2011 Molecular and phenotypic characterization of *Phialemonium* and *Lecythophora* isolates from clinical samples. J Clin Microbiol. 49: 1209-1216.

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Padhye AA, **Summerbell RC**. 2005. The dermatophytes. In: *Topley & Wilson's Microbiology and Microbial Infections,* 10th ed. *Medical Mycology* vol. Edited by W.G. Merz and R. J. Hay. Hodder Arnold, London, p. 220 – 243.

Summerbell, R.C. 2003. *Trichophyton, Microsporum, Epidermophyton*, and agents of superficial mycosis. In: *Manual of Clinical Microbiology*, 8th ed. Edited by P.R. Murray, E.J. Baron, J.H. Jorgensen, M. A. Pfaller and R.H. Yolken. ASM Press, Washington DC, ASM Press, Washington DC., p. 1798-1819.

Kane, J. and **R.C. Summerbell**. 1999. *Trichophyton, Microsporum, Epidermophyton*, and agents of superficial mycosis. In *Manual of Clinical Microbiology*, 7th ed. Edited by P.R. Murray, F.C. Tenover, E.J. Baron, and M. A. Pfaller. ASM Press, Washington DC, p. 1275-1294.

Davies, R., **R.C. Summerbell**, D. Haldane, A. Dufour, K. Yu, I. Broder, R. Dales, J. Kirkbride, T. Kauri, W. Robertson. 1995. Fungal contamination in public buildings: A guide to recognition and management. Environmental Health Directorate, Health Canada, Ottawa, 76 pp.

St.-Germain, G. and **R.C. Summerbell**. 1996. Identifying filamentous fungi. A clinical laboratory handbook. Star Publishers, Belmont, CA. (Co-authored and translated from French by **R.C. Summerbell**), 314 pp.

St.-Germain, G. and **R.C. Summerbell**. 1996. Champignons filamenteux d'interêt medical. Star Publishers, Belmont, CA. (French version of book cited above).

Weitzman, I., J. Kane and **R.C. Summerbell**. 1995. *Trichophyton, Microsporum, Epidermophyton* and agents of superficial mycoses. p. 791- 808. In *Manual of Clinical Microbiology*, 6th ed. Edited by P.R Murray, E.J. Baron, M.A. Pfaller, F.C. Tenover and R.H. Yolken. ASM Press, Washington DC.

Summerbell, R. C., S. Krajden, J. Kane and E. E. Duke. 1993. Medically important members of the Ophiostomatales/*Sporothrix* spp. pp. 185-192 In *Ceratocystis* and *Ophiostoma*. Taxonomy, ecology and pathogenicity. Edited by M.J. Wingfield, K.A. Seifert, and J.F. Webber. APS Press, St. Paul, Minn., USA.

Semiperiodical volume editorships

Summerbell RC, Currah RS, Sigler L. The missing lineages: phylogeny and ecology of endophytic and enigmatic root-associated fungi. Stud Mycol 2005; vol. 53.

Crous PW, Samson RA, Gams W, **Summerbell RC**, Boekhout T, de Hoog GS, Stalpers JA. CBS Centenary: 100 Years of Fungal Biodiversity and Ecology. Stud Mycol 2004; vol. 50

Guarro J, **Summerbell RC**, Samson RA. Onygenales: the dermatophytes, dimorphics and keratin degraders in their evolutionary context. Stud Mycol 2002; vol. 47

Papers published in symposia (unrefereed; first author name in ***red*** = over 50 ISI citations)

Scott J, Motavaze K, Summerbell RC, Lin W, Spiler KF, Dooreleyers M, Savory E, Pogacar J. Enhanced biodeterioration resistance tests for common construction materials. Proceedings of the Conference on the Microbiology of Built Environment, Healthy Buildings 2015 in Boulder, Colorado, USA.

Coleman, D.C., M. Rinaldi, K.A. Haynes, J.H. Rex, **R.C. Summerbell,** E.J. Anaissie, A. Li, and D.J. Sullivan DJ . 1998. Importance of *Candida* species other than *Candida albicans* as opportunistic pathogens . Med. Mycol. 36 (Suppl. 1): 156-165.

Ogawa, H., **R.C. Summerbell**, K.V. Clemons, P.G. Sohnle, T. Koga, R. Tsuboi, A. Rashid, D.A. Stevens, and Y.-P. Ran. 1998. Dermatophytes and host defense in cutaneous mycoses. Med. Mycol. 36 (Suppl. 1): 166-173.

Summerbell, R.C. 1997. Epidemiology and ecology of onychomycosis. Dermatology 194 (Suppl. 1): 32-36.

Summerbell, R.C., A. Li, and R. Haugland. 1996. The changing spectrum of dermatophyte species. In *Culture collections to improve the quality of life.* Edited by R.A. Samson, J.A. Stalpers, D. van der Mei, and A.H. Stouthamer. Centraalbureau voor Schimmelcultures, Baarn, Netherlands, pp. 383-386.

Summerbell, R.C., F. Staib, D.G. Ahearn, M. Ando, L. Ajello, S.A. Crow, D. Fung, T. Gregor, J. Noble, D.L. Price, R.B. Simmons, S.M. Tarlo, and W. Woychuk. 1994. Household Hyphomycetes and other indoor fungi. J. Med. Vet. Mycol. 32, Suppl. 1: 277-286.

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Tanaka, S., **R.C. Summerbell**, R. Tsuboi, T. Kaaman, and T. Matsumoto and T.L. Ray. 1992. Advances in dermatophytes and dermatophytosis. J. Med. Vet. Mycol. 30 Suppl. 1: 29-39.

Books and book chapters (unrefereed or reviewed for comments only)

Summerbell RC, Scott JA. 2016. Conidiogenesis: its evolutionary aspects in the context of a philosophy of opportunity (lectics). In Biology of Microfungi, edited by DW Li, Springer Science, pp. 169-195.

Scott JA, **Summerbell RC**. 2016. Biology of the whiskey fungus. In Biology of Microfungi, edited by DW Li, Springer Science, pp. 413-428.

Summerbell, R.C. 2005. Fungi associated with vertebrates. pp. 451-465 In: Mueller, G., Foster, M., & Bills, G. Biodiversity of Fungi - Inventory and Monitoring Methods. Academic Press, New York.

Summerbell, R.C. and A.K. Gupta. 2005. Superficial fungal diseases. In *Infectious diseases*, 2nd ed. Vol. 2. Edited by J. Cohen and W. G. Powderly, Mosby Press, London. Online publication, no page numbers.

Summerbell, R.C. Mould identification. *In* Clinical Microbiology Procedures Handbook, 2nd ed. Edited by H. Isenberg. ASM Press, Washington, DC. 2004. Vol. 2: 8.9.1- 8.9.59.

Summerbell, R.C. 2003. *Aspergillus, Fusarium, Sporothrix, Piedraia* and their relatives. Pathogenic and opportunistic members of the *Eurotiales, Hypocreales, Ophiostomatales* and *Pseudeurotiaceae ss. str*. pp. 237-498 *In* Pathogenic fungi in humans and animals, 2nd ed. Edited by D. H. Howard. Marcel Dekker Press, New York.

van der Aa, H.A. and S. Vanev. 2002. A revision of the species described in *Phyllosticta*. Edited by A. Aptroot, **R. C. Summerbell** and G.J. Verkley. Centraalbureau voor Schimmelcultures, Utrecht, the Netherlands.

Gupta AK, **Summerbell RC**. 2002. Mycology. p. 150-164 In Review Notes for Dermatology. Edited by P. Robins. Physicians Continuing Education Corp., New York, NY, 2002:255-273.

Samson, R. A., J. Houbraken, **R. C. Summerbell**, B. Flannigan, and J. D. Miller. 2001. Common and important species of fungi and actinomycetes in indoor environments. p. 287 – 473. In Microorganisms in home and work environments. Edited by B. Flannigan, R. Samson and J. D. Miller. Harwood Academic Publishers, Amsterdam.

Summerbell, R.C. 2001. Respiratory tract infections caused by indoor fungi. p. 195 – 215. In Microorganisms in home and work environments. Edited by B. Flannigan, R. Samson and J. D. Miller. Harwood Academic Publishers, Amsterdam.

Hoekstra, E.S., R.A. Samson and **R.C. Summerbell**. 2001. Methods for the detection and isolation of fungi in the indoor environments. p. 298 – 305. In *Introduction to food- and airborne fungi*. 6th ed. Edited by R.A. Samson, E.S. Hoekstra, J.C. Frisvad, and O. Filtenborg. Centraalbureau voor Schimmelcultures, Utrecht, the Netherlands.

Summerbell, R.C. 2000. Form and function in the evolution of dermatophytes. p. 30 – 43. In *Biology of dermatophytes and other keratinophilic fungi*. Edited by R.K.S. Kushwaha and J. Guarro. Revista Iberoamericana de Micologia supplement, Bilbao, Spain.

Summerbell, R.C. and A.K. Gupta. 1999. Superficial fungal diseases. p. 8.29.1- 8.29.8. In *Infectious diseases*. Vol. 2. Edited by D. Armstrong and J. Cohen, Mosby Press, London.

Summerbell, R.C. 1998. Taxonomy and ecology of *Aspergillus* species associated with colonizing infections of the respiratory tract. In Kurup, V.P., and A.J. Apter, *Allergic bronchopulmonary aspergillosis*. Immunology and Allergy Clinics of North America 18 (3): 549-573.

Summerbell, R.C. and J. Kane. 1997. The genera *Trichophyton* and *Epidermophyton*. p. 131-191 *In* Kane, J., **R.C. Summerbell**, L. Sigler, S. Krajden, G. Land, *Laboratory handbook of dermatophytes. A clinical guide and laboratory manual of dermatophytes and other filamentous fungi from skin, hair and nails*. Star Publishers, Belmont, CA.

Summerbell, R.C. and J. Kane. 1997. Physiological and other special tests for the identification of dermatophytes. p. 45-79, Op. cit. (above)

Summerbell, R.C. 1997. Non-dermatophytic fungi causing onychomycosis and tinea. p. 213-259, Op. cit. (above).

Kane, J. and **R.C. Summerbell**. 1997. Dermatological mycology: examination of skin, hair, and nails. p. 33-44, Op. cit. (above)

Summerbell, R. C. and D. W. Malloch. 1988. The recognition of non-mycorrhizal fungi associated with mycorrhizal roots. In *Canadian Workshop on Mycorrhizae in Forestry*. Edited by M. Lalonde and Y. Piché. Fac. de Foresterie et de Géodésie, Univ. Laval, Québec. pp. 145-148.

Other unrefereed publications

Seifert KA, Zare R, **Summerbell RC**. 2019. In memoriam: Walter Gams (1934-2017). Mycologia 13:1-8. doi: 10.1080/00275514.2019.1619058.

Agerer R, Ammirati J, Baroni TJ, Blanz P, Courtecuisse R, Desjardin DE, Gams W, Hallenberg N, Halling R, Hawksworth DL, Horak E, Korf RP, Mueller GM, Oberwinkler F, Rambold G, **Summerbell RC**, Triebel D, Watling R (2000) Always deposit vouchers. Applied Soil Ecology 15: 295-298, Can J Bot 787: 981-983, Mycol Res 104: 642-644, Mycorrhiza 10: 95-97, Mycotaxon 76: 489-493, Newsl Myc Soc America 51: 2-4, Nord J Bot 20: 221-234, Nova Hedwigia 71: 539-543 (Position paper).

Summerbell, R.C. 1994. Unnecessary yeast identifications. PHLO 2(1): 7-8. (PHLO: a clinical microbiology newsletter widely distributed in Ontario by the Ontario Ministry of Health).

Kane, J., **R. C. Summerbell**, and S. Krajden. 1992. Physiological tests for the accurate identification of common dermatophytes: theory and laboratory diagnosis. Can. Soc. Med. Mycol. Newsletter 1992 (#9): 1-2.

Summerbell, R. C. 1986. Mycorrhiza: a fungal infection that promotes life and good health. Biofeedback 7 (1): 8-9.

Major consultant reports

(Consultant reports sealed under confidentiality agreements are listed in parentheses with permitted information only).

(Evaluation of antifungal susceptibility testing results for inoculum and reisolated strains of a dermatophyte species. Client not disclosed, Mar. 18, 2016)

(Factors diminishing the need to replicate a European pharmaceutical indication clinical trial in the U.S. Client not disclosed, Nov. 14, 2014.)

Testing methods for *Legionella* bacteria. Prepared for Public Works and Government Services Canada, March 26, 2013. With James Scott.

Expert report on *Baudoinia*. Prepared for Solar Haven Farms, Shoreham VT, Feb 27, 2013.

(Expert opinion on fungal problems associated with wall condensation around cooling systems, Client not disclosed, Nov. 15, 2012. Follow-up to an earlier report on similar topic for same client.)

Report on investigation of invasion of skin of a murder victim by *Mucor hiemalis*. Prepared for Saunders Law Ltd., London, UK, April 5, 2011; followed up by 'Response to a supplementary report on fungus found on victim at the deposition site' Dec. 8, 2011.

(Contamination in a factory leading to fungal growth in incorrectly sealed consumable products, Client not disclosed, Jan 29, 2010.)

(Identity of fungi used to produce a pharmaceutical product, Client not disclosed. Nov. 10, 2009)

A Microbiological Study of Reusable Bags and `First or single-use' Plastic Bags. Prepared for Environment and Plastics Industry Council on behalf of Sporometrics, Inc., May 20, 2009.

Published on website:
http://www.plastics.ca/_files/file.php?fileid=itemXwjsKddvYz&filename=file_A_Microbiological_Study_of_Reusable_Grocery_Bags_May20_09.pdf

Investigation of the feasibility of using Polymerase Chain Reaction (PCR) and MALDI-MS for source tracking of aerosols. Scott, J., Summerbell, R.C., Green, B., Corr, D. Prepared for Ontario Ministry of the Environment Best in Science RFS 7821, Mar. 21, 2009, 150 pp.

(Investigation of *Baudoinia* in the vicinity of a distillery and maturation facility, Client not disclosed, July 2008)

Histoplasmosis, blastomycosis and cryptococcosis in Canada. CR File No. 6725-47. Prepared for Canada Mortgage and Housing Corporation, Sept. 5., 2007, 56 pp.

National Centres for Secure Biological Resources. Final report. Solicitation No. 01B68-060084/B. Prepared for Agriculture and Agri-Food Canada, March 31, 2007, 83 pp.

Laboratory analysis and interpretation of results of onychomycosis mixed infections trial. Prepared for Novartis Pharmaceuticals Corp., East Hanover, NJ, Jan. 1997. 15 pp.

Suggested Health Canada research priorities. Analysis based on Health and Housing Workshop, Ottawa, March 3, 1995. Prepared for Health Canada, April, 1995. 3 pp.

A priority list of fungi for investigation as indoor air hazards. Prepared for Health and Welfare Canada, March, 1990. 65 pp.

Biodeterioration of starch-loaded plastics by soil fungi and bacteria. Prepared for Diversified Research Inc., Toronto. Feb. 1988. 20 pp.

Invited Peer Review reports

Belgian Coordinated Collections of Microorganisms (BCCM). Peer review of the scientific environment of the collections. Prepared for BCCM, July 1998, 3 pp.

Peer review critical issues: Emerging Bacterial and Mycotic Diseases Branch, Mycology Units, Centers for Disease Control, Atlanta. Prepared for Centers for Disease Control, US Dept. of Health and Social Services, March 7, 1996, 17 pp.

Peer review of National Reference Centre for Human Mycotic Diseases, Edmonton, Alta., Canada. Prepared for Laboratory Centre for Disease Control, Health Canada, Ottawa. With Dr. P. Philips, 10 pp., April, 1995.

Legal Expert reports and Expert Testimony (partial list)

James Finney and Natalie Finney vs. Clark Realty Capital, L.L.C., c/o Clark Enterprises, Inc., et al. Expert testimony, Toronto (video link), Apr. 7, 2021.

James Finney and Natalie Finney vs. Clark Realty Capital, L.L.C., c/o Clark Enterprises, Inc., et al. Expert report, prepared for Patriots Law Group, Fort Belvoir, VA, Feb. 7, 2021.

Jeremiah Elizalde -v- Aimco Maple Bay LLC et al. Expert testimony, Toronto (video link), Sept. 30, 2020. (Re: effects of indoor molds on child health and development)

Batts -v- S.L. Nusbaum Realty Company, et al. Expert testimony, Newport News, VA, USA, March 7, 2018.

Batts -v- S.L. Nusbaum Realty Company, et al. Expert deposition, New York City, January 30, 2018 (Re: general health effects of mold contamination in dwellings)

Explanation of the use of direct microscopy in sampling *Baudoinia* in St. Croix, 2017. Prepared for Colianni and Colianni, Christiansted, St. Croix, U.S. Virgin Islands. Jan 2, 2018

Baudoinia colonization in St. Croix. Prepared for Colianni and Colianni, Christiansted, St. Croix, U.S. Virgin Islands. Sept. 27, 2017

Ryan Alleyne et al. vs Diageo USVI, Inc. and Cruzan Viril, Ltd. Declaration on *Baudoinia* distribution on St. Croix. Prepared for McMurry and Associates, Louisville, KY. May 12, 2017.

Expert report of Dr. James Scott and Dr. Richard Summerbell on *Baudoinia*. Prepared for McMurry and Associates, Louisville, KY. Aug. 19, 2016. Supplementary report on ethanol air dispersion modeling prepared 15 March, 2017.

Coleman, et al. v. Lincoln Military Housing, LLC, et al. Rebuttal of plaintiff's experts' opinions. Sept. 20, 2015. Prepared for Wise & Donahue PLC, Fairfax, Virginia.

Federico et al. v. Lincoln Military Housing LLC and Coleman et al. vs. Lincoln Military Housing LLC. Eastern District of Virginia, linked reports, Jun 2015 – Oct. 2015. (Re: mold contamination in houses).

Klepper v. Pernod, *Baudoinia* growth around aging facilities in the areas of Lawrenceburg, Indiana. Expert deposition Dec. 9, 2008.

VISITING SCHOLARS

Michael Medical School, University of Athens medical researcher Dr. M. Arabatzis. Development of real-time PCR for dermatophyte diagnostics. July-Sept. 2005

Agricultural Institute of Slovenia researcher Dr. H.J. Schroers. Molecular phylogeny, new species, phylogeography and patterns of opportunistic human pathogenicity within the *Fusarium dimerum* species complex. March 2005.

University of Toronto Microbiology program resident Dr. Peter Pieroni, research project on hydrophobicity of nocardioforms, July 1996.

POST-DOCTORAL FELLOWS

Dalla Lana School of Public Health, postdoctoral fellow Kamiyar Motavaze. Microbiology of the built environment: To design improved testing methods for common building materials. Co-supervised with primary supervisor James Scott.

Centraalbureau voor Schimmelcultures (CBS), postdoctoral fellow Francesc Prenafeta. Fungal-bacterial interactions in soil: community and *in vitro* interactions analysed by molecular and non-molecular techniques. March 2002-2005.

Centraalbureau voor Schimmelcultures (CBS), postdoctoral fellow Hans-Josef Schroers, research projects on taxonomy of Hypocreales and similar fungi, especially the *Fusarium dimerum* complex, the *Gliocladium vermoesenii* complex, and the *Phialemonium curvatum* complex. Jun 2000 – Sept. 2002.

GRADUATE STUDENTS

Utrecht University. Ph.D. Student Hesti Lestari Tata (co-supervised by Prof.. M. Werger) Diversity of Ectomycorrhizal Fungi and Root Endophytes at Different Land Use Type Sites in Jambi and Lampung (Sumatra, Indonesia): Options for Forest Restoration via Agroforestry**.** Jan 2004 – 2008.

University of Antioquia (Colombia) Ph.D. student Carlos Lopez (Co-supervised by Dr. T. Boekhout). Function and biodiversity of root associated microorganisms in tropical lowland forest ecosystems in Colombian Amazonia (Colombia). Jun 2003-2012.

Centraalbureau voor Schimmelcultures (CBS), M.Sc. student Massimiliano Silvestri, co-supervised with Prof. J. Wolf, Univ. of Amsterdam on project " Phyllosphere interactions of fungi from shade-grown and full-sun coffee in Costa Rica." Sept. 2002 - Oct. 2003.

UNDERGRADUATE STUDENTS IN PROJECTS

Allana Braga, Forensic Science Program, University of Toronto Mississauga, advised in project "Examining fungal growth on decomposing porcine remains," in invitation from supervisor Wade Knaap.

Centraalbureau voor Schimmelcultures (CBS) cooperative students on 6-9-month projects on molecular systematics in 2005-2006: Miriem Abdallaoui (*Sporothrix pallida* complex systematics), Erik Tolen (*Cladophialophora* mating type loci and pop. genetics)

CBS technical cooperative students (stagiaires) Salvatore Lopes (2001) Sagal Suleiyman (2002), Arwin van der Rhee (2003), Nienke Lancee (2003), ongoing research project on phylogeny of the genus *Acremonium*.

Visiting student (Canada/Netherlands fund, CBS) Jonathan Shapero, research on temperature relations of *Acremonium* species, Jul – Aug 2000.

Special mycology training given to undergraduates: Mandi Marcinkowski, Mt. Sinai Hosp., instructed on *Aspergillus* identification/isolation, March 1998.

Ontario Ministry of Health Ontario/Quebec exchange student Julie Gauvreau, Indoor air mycology of mines. July/August, 1994.

Ontario Ministry of Health Futures program students Janice Grey and Michelle Cottle, July/August 1993.

Ontario Ministry of Health summer student researcher Sevan Hopyan, supervised July/August 1989.

Ontario Ministry of Health summer student researcher Andrew Kazdan, July 11 - August 26, 1988. Directed research project on *Nocardia* and *Rhodococcus* differentiation.

Other training

Co-supervision given to Masters of Public Health student Waleed Shahid, Dalla Lana School of Public Health, University of Toronto, on project on the phylogeny of Canadian isolates in the *Trichophyton mentagrophytes* complex. 2107-2018.

Mycological training given to Univ. of Toronto Faculty of Medicine microbiology and pathology specialist residents on 1-2-week rotation: Dr. M. Krajden and Dr. B. Medersky (1987) Dr. Jean Boulanger (Sept. 1988), Dr. J. Sirbovan (Jan. 1989), Dr. S. King (Jan. 1989), Dr. S. Walmsley (April 1989), Dr. S. Deodhare (Jan. 1990), Dr. B. Toye (Apr. 1990), Dr. R. Tellier (Dec. 1991), Dr. J. Duffy (Dec. 1992), Dr. S. Aijumah and Dr. J. Downey (Feb. 1993), Dr. B. Demers (Apr. 1993), Dr. Y. Yau (May, 1993), Dr. M. Leob (Oct. 1993), Dr. J. Kellner and Dr. G. Tyrrell (Nov. 1993), Dr. S. Tai (Dec. 1993) Dr. J. Devenish and Dr. K. MacDonald (Apr. 1994), Dr. A. Opavsky (Feb. 1995), Dr. S. Guindy-Wasfy (June 1995), Dr. M. Salvadori (Jan. 1996), Dr. P. Pieroni (July 1996); Dr. E. Choi (April 1997); Dr. H. Gupta (Feb. 1998); Dr. A. Bitman (July 1998); Dr. D. Ruijs (Oct. 1998).

TEACHING EXPERIENCE

Courses and Major Workshops

CHL 5950F – Special Topic in Occupational and Environmental Health – Climate Change and Health. Two lectures and participating as co-instructor. Dalla Lana School of Public Health, University of Toronto, Sept-Nov 2020.

Westerdijk Institute 2-week course on biodiversity of fungi. (several different lectures and lab sessions – Anamorph-teleomorph connections; conidiogenesis; isolation from nature; ecology; *Fusarium*; *Trichoderma*; Overview of Fungal Kingdom). Westerdijk Institute, Royal Netherlands Academy of Sciences, Utrecht, Netherlands. Feb 5-, 2018.

HMB436H - Human Fungal Interaction course, University of Toronto. Served as Course Director and lecturer for half-term course, Sept. – Dec. 2012. Currently co-instructor, Sept. 2013, 2014, 2015, 2016, 2017, 2018, 2019.

Contributed lectures in courses CHL5918H Biological Hazards, CHL5413H, Public Health Sanitation, CHL5902H, Advanced Occupational Hygiene, Dalla Lana School of Public Health, 2007-2013 (ongoing)

Introduction to mould. Interpreting Lab Results. With Michael Saleh and Kristine White. Paired one-day courses held at Sporometrics, Toronto, Feb. 15-16, 2012. Interpreting Lab Results also presented Oct. 25, 2012.

HMB436H - Human Fungal Interaction course, University of Toronto – 4-lecture series on medical mycology, Nov. 2011.

CBS 2-week course on biodiversity of fungi. (several different lectures and lab sessions – Anamorph-teleomorph connections; conidiogenesis; isolation from nature; ecology; *Fusarium*; *Trichoderma*; Dematiaceae [until 2007], Overview of Fungal Kingdom [2009 ff.]). Centraalbureau voor Schimmelcultures, Royal Netherlands Academy of Sciences, Utrecht, Netherlands, Feb. 2002. *Updated versions, same course again 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013*, *2014, 2015, 2016, 2017*.

CBS 3-week course on medical mycology. (lectures and lab sessions on conidiogenesis, Hypocreales, *Sporothrix,* Dematiaceae). Centraalbureau voor Schimmelcultures, Royal Netherlands Academy of Sciences, Utrecht, Netherlands, Feb-March 2001. *Updated versions, same course again 2002, 2003, 2004, 2005*, *2006*.

Seventh International Workshop, entitled 'Medical Mycology.' Principal invited instructor for 4-day workshop, March 19-24, 2005, University of Assiut, Assiut, Egypt.

Fifth International Workshop, entitled '*Fusarium*.' Principal invited instructor for 4-day workshop, March 16-19, 2003, University of Assiut, Assiut, Egypt.

Pathogenic fungi in humans and animals. With Lynne Sigler. One-day workshop for National Laboratory Training Network, San Antonio, TX, May 30, 2003.

Laboratory identification of Hypocrealean fungi: *Fusarium, Acremonium* and their relatives. 2-day lecture/lab workshop sponsored by National Laboratory Training Network, Orlando, FL. May 2001.

CBS 3-week course on medical mycology. (lectures and lab sessions on conidiogenesis, Hypocreales, *Sporothrix*). Utrecht, Netherlands, Feb-March 2001.

CBS 3-week course on systematics of fungi. (several different lectures and lab sessions). Baarn, Netherlands, March 2000.

Medically important mycotoxigenic fungi. With J. Pitt. 2-day lecture/lab workshop sponsored by National Laboratory Training Network, Atlanta, GA, May 14-15, 1998.

Medical mycology: the clinical and technical aspects. With L. Sigler and S.K. Mohan, with smaller contributions from I. Campbell, S. Richardson, and H. Richardson. Three-day lecture/lab course presented at the Michener Institute for Applied Health Sciences, June 25-27, 1997.

Dermatophytes and other cutaneous fungi you're itching to know. With Lynne Sigler. 2-day lecture/lab workshop sponsored by National Laboratory Training Network, Miami, May 1-2, 1997.

Keys to success in medical mycology. With Guy St.-Germain. Two-day lecture/lab course. Presented 1) as a preconference workshop sponsored by US National Lab. Training Network (NLTN) in conjunction with American Society for Microbiology meeting, New Orleans, May 16- 17, 1996; 2) for NLTN Pacific office in Berkeley, California Oct 28- 29, 1996, and 3) Santa Ana, California Oct. 31-Nov. 1, 1996.

Medical Mycology: Practical approach seminars and laboratory experience. With Dr. Julius Kane and Dr. S. Krajden. Three-day lecture/lab course presented at Mohawk College, Hamilton, Ontario, June 6-8, 1994.

Dermatophytes and non-dermatophytes from skin and nails. Workshop at XII Congress of the International Society for Human and Animal Mycology, Adelaide, Australia, March 12, 1994. With Lynne Sigler.

Actinomyces, Nocardia, and other filamentous bacteria. With B. Black, A. McNabb and R. Shuttleworth. 2-day course presented at the Michener Institute for Applied Sciences, Oct. 23-24, 1992.

Dermatophytes and unusual Hyphomycetes found on the skin. With L. Sigler. 2-day workshop presented for American Society for Microbiology, Northern California Region, San Francisco, CA, Aug. 19-20, 1992.

Fundamentals of wild mushroom identification. Six-lecture mini-course presented through the Mycological Society of Toronto, Sept./Oct. 1990.

Dermatologic mycology. Six-lecture series presented to Dermatology Residents, Women's College Hospital,

Toronto. With Dr. Julius Kane. Sponsored by Univ. of Toronto Dept. of Medicine. Feb./Mar. 1990; also Feb./Mar. 1989, 1987.

Introductory Course Workshop on Fungi of Medical Importance. Five-day lecture/lab course for laboratory workers from across Ontario. With Dr. Julius Kane. Ontario Ministry of Health, Toronto. Oct. 27-31, 1986.

Invited lectures and one-day workshop presentations (selected, 1995-present)

Mold fungus, health and grow-ops. Is the situation out of control? Invited lecture at Occupational Hygiene Association of Ontario Spring Symposium. Toronto Congress Centre, March 22, 2012.

Infectious fungi. Two-hour lecture in week-long HIP IAQ (Healthy Indoors Partnership Indoor Air Quality) Investigator Certification Course, Toronto Construction Association Hall, Richmond Hill, Ont. Jan 24, 2012.

Habitat indicators for indoor fungi. Lecture in one-day course "Sampling Methods and Interpretation of Lab Results for Fungi and Bacteria." Feb. 23, 2010. Accredited (ABIH, CBROH, BCRSSP) professional course at Sporometrics, Inc., Toronto, Canada.

"Microbes in Industrial Processes" and "Fungal pathogens of humans" – two guest lectures in CHL5918H, Biological Hazards in the Workplace and Community course, Dalla Lana School of Public Health, University of Toronto, Dec 3, 2009 and Oct. 15, 2009.

Mycology of Indoor Environments. CLIMOA (Canadian Life Insurance Medical Officers Association) 2009 annual meeting, Nov. 6, 2009, Toronto, Canada.

Medically important fungi. Lecture to Human Biology course HMB436H - Human Fungal Interaction, University of Toronto. Nov. 26, 2008; also Dec. 2, 2009.

"Advanced diagnostic technology in systemic and opportunistic fungal infection" and "Environmental fungi associated with hospital infection." Commission training for Medical Laboratory Professions, Hong Kong Hospital Authority, Nov. 7, 2008.

Occupational mycotic diseases. Guest lecture for Occupational and Environmental Health, Department of Public Health Sciences, University of Toronto, Oct. 23, 2008.

Fungal ecology of homes and other indoor spaces. With J. Scott. Ontario Industrial Accident Prevention Association (IAPA) 2008 Professional Development Conference, Toronto, Apr. 23, 2008.

Rapidly Changing Mycology: New Facts & Ideas. With Lynne Sigler. Workshop sponsored by the U.S. National Laboratory Training Network, Toronto, May 17, 2007.

Filamentous fungi in the clinical laboratory. One-day pre-conference workshop for the 8th International Mycological Congress, Aug. 18, 2006, James Cook University, Cairns, Australia; with guest lecture by Montarop Sudhadham.

Medically important fungi: an overview. Lecture Master Course Eijkman Graduate School for Infectious Disease and Immunology. Utrecht University, December 11, 2003, Utrecht, the Netherlands. Also March 2004, Sept. 2005, Sept. 2006.

Dermatophytes and other fungi in laboratory dermatology. With L. Sigler, D. Parr. 1-day lecture/lab workshop presented in conjunction with the International Union of Microbiological Sciences congress, 15 Aug. 1999, Sydney, Australia.

Structure of the fungal cell wall. Presented to Microbiology Residency seminar series, Dept. of Laboratory Medicine and Pathobiology, University of Toronto, Mt. Sinai Hosp., Jan 7, 1999.

Update on opportunistic mycoses: hyalohyphomycosis. Presented on the Telemedicine audio network, sponsored by the Faculty of Medicine, University of Toronto, and Toronto Hospital, Mar. 3, 1998. (Nationwide audio broadcast)

Fungal families and orders: the secret way to make sense of morphology, molecular testing, susceptibility and more. Presented on the Telemedicine audio network, sponsored by the Faculty of Medicine, University of Toronto, and Toronto Hospital, Feb. 25, 1997. (Nationwide audio broadcast)

Dermatophytes biology and pathogenesis. Presented to Infectious disease/Microbiology seminar series, Dept. of Microbiology, Mt. Sinai Hosp., Oct 17, 1996.

Medical mycology as a mycological opportunity. Invited keynote address to 16th Great Lakes-St. Lawrence Mycology Workshop, University of Toronto, March 2-3, 1996.

Common contaminants and opportunistic fungi. Presented to listeners of the Telemedicine audio network, sponsored by the Faculty of Medicine, University of Toronto, and Toronto Hospital, Jan. 30, 1996. (Nationwide audio broadcast)

Effect of intermittent or pulse antifungal therapy on fungi. Seminar to Canadian Council on Dermatomycoses meeting, Toronto, Jan. 19, 1996.

Toxic and infectious risks associated with fungi in buildings. Invited lecture to Dept. of Microbiology and Immunology, Universite de Montreal, Dec. 5, 1995.

Medical mycology. 3-lecture series to 2nd year Medical Microbiology (MPL 210) students, University of Toronto, Nov. 7, 8, 10, 1995.

Biological aspects of medically important fungi. Guest lecture to 3d year Mycology students, Dept. of Biology, York University, North York, Oct. 2, 1995.

New techniques and emerging agents in clinical mycology. Presented to the Canadian Society for Laboratory Technology Congress, Ottawa, June 20, 1995.

Fungi associated with indoor air health hazards. Presented to the US Environmental Protection Agency (EPA), Cincinnati, Ohio, June 27, 1995

Mycology for Today's Laboratory. Teleconference presentation for Laboratory Proficiency Testing Program, June 7, 1995. (Ontario-wide audio broadcast with some additional out-of-province connections)

Laboratory Identification of Poisonous Mushrooms from Cooked Samples. Workshop presentation given in conjunction with American Society for Microbiology for National Laboratory Training Network, Washington, DC, May 19, 1995.

Onychomycosis: medical mycology's most difficult diagnosis. Presented to University of Alberta Hospital/Northern Alberta Public Health Laboratory, Edmonton, Alta., March 24, 1995.

Selected cases in Mycology II. Presented to listeners of the Telemedicine audio network, sponsored by the Toronto Hospital, March 7, 1995. (Nationwide audio broadcast)

Prospective epidemiology of dermatophytes in clinical trial. Seminar to Canadian Council on Dermatomycoses meeting, held in conjunction with American Academy of Dermatology meeting, New Orleans, La., Feb. 4, 1995.

Medical mycology. 2-lecture series to 4th year Microbiology students, University of Toronto, Toronto, Ont. Jan. 9 and 11, 1995.

EDITORSHIPS AND OTHER SERVICE ACTIVITIES

Associate Editor, *Studies in Mycology*, 2002-present.

Editor-in-chief, *Medical Mycology*, 1999- 2003

Ex-officio member, ISHAM Council (International Society for Human and Animal Mycology), 1999-2003.

Editor, Environmental mycology section, *Mycopathologia*, 1997- 2001.

Editorial board member, *Journal of Clinical Microbiology*, July 1988- Dec 2000.

Associate Editor, *Journal of Medical and Veterinary Mycology* (currently titled *Medical Mycology*), Jan. 1995 - May 1997.

Reviewer, *Mycological Research, Nova Hedwigia, FEMS Microbiological Journal, Clinical Microbiology Reviews, Canadian Medical Association Journal, Vaccine, European Journal of Clinical Microbiology, Mycopathologia, Canadian Journal of Botany, Canadian Journal of Microbiology, Canadian Journal of Forest Research, Medical Mycology*, *J Dermatol Treatment*, *Heredity, FEMS Microbiology Reviews, British Journal of Dermatology*, *FEMS Microbiol Lett, Mycoscience* and many others.

RESEARCH PAPERS AND POSTERS PRESENTED AT MEETINGS
(Most recent; full list available on request – excludes most student or collaborator presentations).

Summerbell, R.C. Whiskey fungus and its stoner cohabitants (*Lithophila*, etc.). Presented at 32nd Great Lakes-St. Lawrence Mycology Meeting, Apr. 30, 2016.

Summerbell, R.C. The future taxonomy of the taxonomically cryptic. Invited lecture at Special Symposium 1, International Mycological Congress 10, Bangkok, Thailand, Aug. 3-8, 2014.

Scott JA, Motavaze K, Summerbell RC, Savory E, Pogacar J. Improved biodeterioration resistance tests for building materials. Oral presentation at Indoor Air 2014, Hong Kong, July 7-12, 2014.

Summerbell, R.C. Airborne fungi in hospitals. Presented at Pan American Aerobiology Association, Toronto, July 29-30, 2013.

Summerbell, R.C., Scott, J. Significance of a *Legionella* testing outbreak. Presented at American Industrial Hygiene Conference & Exposition (AIHce), Montreal, May 18-23, 2013.

Summerbell, R.C., Scott, J. Unlocking the *Acremonium* powerhouse with molecular phylogeny. BIT's 2nd Annual World Congress of Microbes-2012, 2nd Annual International Symposium of Mycology, July 30 – Aug 1, 2012, Guangzhou, China.

Scott, J., Summerbell, R.C. Initial validation report for opportunistic fungal pathogen screen – a rapid clearance test for healthcare facilities. CHICA (Community and Hospital Infection Control Association) Canada 2012 National Education Conference. Jun 19, 2012, Saskatoon, Sask.

Summerbell, R.C., J. Scott, B. Green. Putting black fungus on the map. 2010 Great Lakes – St. Lawrence Spring Workshop in Mycology. Apr. 24-25, 2010, Queen's Univ. Biological Stn, Chaffey's Locks, Ont.

Summerbell, R.C., J. Scott. Guidelines for the prevention of exposure to airborne *Histoplasma*, *Blastomyces*, and sylvan *Cryptococcus* around Canadian (and similarly situated northern U.S.) homes. Pan American Aerobiology Association Annual Symposium, Amherst, Mass., U.S.A., June 16-19, 2008.

Summerbell, R.C. Blastomycosis, histoplasmosis and tropical cryptococcosis: management around the Canadian home. 2008 Great Lakes – St. Lawrence Spring Workshop in Mycology. Apr. 26-27, 2008, Toronto.

Summerbell, R.C. DNA barcoding, 'accelerated ecology' and the acremonioid fungi. Presented at the 8th International Mycological Congress, Cairns, Australia, Aug. 21-25, 2006.

Summerbell, R.C., G.S. de Hoog, M. Arabatzis. DNA barcode identification table d' hôte: will that be sequence spaghetti, oligo risotto or a nice fluorescent bowl of realtime soup? Presented at the International Society for Human and Animal Mycology meeting, Paris, France, Jun 25-29 2006.

Summerbell, R.C. The international "DNA barcoding " tsunami and its entry into the bay of medical mycology. Presented at the British Society for Medical Mycology, Dublin, Ireland, March 26-28, 2006.

Summerbell, R.C., Lévesque A., Bovers M., Seifert, KA., Boekhout, T., Fell, J., Stalpers, J., Crous, P. DNA barcoding in fungi: moving from the culture collection into the field and the medical lab First International Barcode Conference, The Natural History Museum, London, Feb. 7-9 2005

Summerbell, R C., M. Starink-Willemse, A. van Iperen. What to do about complex and simplified morphologies in the *Acremonium* coenosis? Presented at Mycological Society of America/Mycological Society of Japan joint meeting, Hilo, Hawaii, 30 Jul – 5 Aug. 2005.

Summerbell, R.C. *Fusarium* and *Acremonium* infections in Africa: what do we know and what should we expect? Invited lecture at Medical Mycology, the African Perspective. Inaugural meeting, Pan-African Medical Mycology Society, Hartenbosch, South Africa, 25 Jan 2005.

Summerbell RC. Molecular resolution of the true relationships of morphologically simplified, medically important members of the genera *Fusarium* and *Acremonium*. Invited lecture at the Japanese Society for Medical Mycology 47th Annual Meeting, Tokyo, Oct. 16-17, 2003.

Summerbell, R.C. *Acremonium:* the Wild West of fungal identification. Invited lecture at the International Society for Human and Animal Mycology (ISHAM), San Antonio, May 25-29, 2003.

Summerbell, R.C. Problematic and unusual fungal pathogens. Invited lecture at the American Society for Microbiology 103d General Meeting, Washington, DC, May 18-22, 2003.

Annex 3:
Robert Hart *Curriculum Vitae*

Summary of Qualifications

Public health professional with 23 years experience in environmental health management. Highly skilled at developing lean and effective programs with tangible outcomes. Proven record of successful policy development and change management. Strong content knowledge in all areas of environmental health. Excellent communication and media relations skills. Adept in the use of both standard computer platforms/software and custom databases. Committed to quality management principles, continuous lifelong learning and mentoring.

Education/Credentials

- Bachelor of Science, University of Toronto, 1982
- Certificate in Public Health Inspection (Canada), 1981
- Certified Manager of Quality and Organizational Excellence (American Society for Quality), 2006; re-certified, 2014

Employment History

2019 – present
Casual part-time public health inspector, Niagara Region Public Health

Duties: inspection of food premises, public swimming pools, personals service settings, long term care and child care facilities for compliance with relevant regulations under the Ontario Health Protection and Promotion Act

2010 – 2018
Public Health Manager, Grey Bruce Health Unit, Owen Sound ON

Duties: management of programs related to infectious disease and environmental health

Key Accomplishments:

- Introduced simple, but effective quality assurance practices for auditing inspection program performance
- Developed and implemented a comprehensive mosquito and tick surveillance program to monitor for West Nile Virus and Lyme Disease in the area
- Worked with local housing authorities to develop best practice procedures for bedbug control

2002 – 2010
Environmental Health Manager, Hamilton Public Health Services, Hamilton, ON

Duties: management of the City's food safety inspection program

Key Accomplishments:

- Successfully managed high profile media scrutiny of the food premises inspection program resulting in increased public confidence and Board of Health support for enhanced program funding

- Restructured the inspection services program resulting in improved program performance and increased compliance with food safety regulation

2000-2002
Director of Environmental Health, Brant County Health Unit, Brantford, ON

Duties: executive management responsibility for the development, implementation and performance of public health programs related to food safety, water quality, health hazard abatement and tobacco control

Key Accomplishments:

- Successfully advocated for and implemented Ontario's first Mandatory Food Handler Training by-law

1995 – 2000
Manager of Food Safety and Infection Control, Waterloo Region Health Department, Waterloo, ON

Duties: management of the Region's food safety and infectious disease programs

Key Accomplishments:

- Established effective liaison between environmental health and nursing programs responsible for infection control

Recent Committees/Work Groups

- RentSafe Advisory Committee (current)
- OPHA Healthy Environments Committee (current)
- Canadian Institute of Public Health Inspectors (CIPHI) Built Environment working group (2016-18)

Presentations/Seminars

- Podcast – *Mould in Rental Housing: Health Effects and Intersectoral Approaches,* College of Family Physicians of Canada, 2019
- *Healthy Housing: Exploring the Interface between Public Health and Municipal Property Standards* (CIPHI Conference, Hamilton, ON 2019)
- *Housing and Health*, Owen Sound, ON 2017
- *Exposure to Lead in an Indoor Recreational Firearms Range*, Toronto, ON 2013
- *Safe Produce Handling at Point of Use*, Hamilton, ON 2009
- *Basic Quality Control Metrics for Environmental Health Programs*, Oakville, ON, 2008
- *Norovirus and Food: Implications for Long Term Care Facilities,* Hamilton, ON, 2007
- *The Effect of Inspection Frequency on Food Safety Compliance*,
  CIPHI Ontario Branch Conference, Niagara Falls, ON, 2006
- *Microbial Water Quality and Pedicure Foot Baths*
  National Environmental Health Association Conference, San Antonio TX, 2006

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De Santis B, Brera C, Mezzelani A, Soricelli S, Ciceri F, Moretti G, Debegnach F, Bonaglia MC, Villa L, Molteni M, Raggi ME. Role of mycotoxins in the pathobiology of autism: A first evidence. *Nutr Neurosci*. 2019; 22:132-144

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Inamdar AA, Morath S, Bennett JW. Fungal Volatile Organic Compounds: More Than Just a Funky Smell? *Annu Rev Microbiol*. 2020; 74:101-116.

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Kankkunen P, Teirilä L, Rintahaka J, Alenius H, Wolff H, Matikainen S. (1,3)-beta-glucans activate both dectin-1 and NLRP3 inflammasome in human macrophages. *J Immunol*. 2010; 184:6335-42.

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Mould Abatement Guidelines, 2nd Edition, 2010

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Mould Assessment Recommendations, October, 2010 version

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