Court File No.: T-2030-13

FEDERAL COURT

BETWEEN:

NEIL ALLARD
TANYA BEEMISH
DAVID HEBERT
SHAWN DAVEY

Plaintiffs

and

HER MAJESTY THE QUEEN IN RIGHT OF CANADA

Defendant

AFFIDAVIT OF JOHN DAVID MILLER

I, John David Miller, Professor, of the City of Ottawa, in the Province of Ontario, SWEAR THAT:

1. I am a Professor, employed by the Department of Chemistry, Carleton University, in the Province of Ontario and as such have personal knowledge of the matters hereinafter deposed to by me, except where same are stated to be based on information and belief and where so stated I verily believe them to be true.

2. I have been retained by the Attorney General of Canada in the above proceeding to provide an expert report for the Court. Attached at **Exhibit "A"** is my expert report.

3. On June 3, 2014, the Attorney General of Canada provided me with an instruction letter to complete my expert report. Attached as **Exhibit "B"** is a copy of the instruction letter.

4. Further, on June 3, 2014, I was provided with a copy of the Code of Conduct for Expert Witnesses. Attached as **Exhibit "C"** is a signed copy of the Certificate Concerning Code of Conduct for Expert Witnesses.

5. Attached as **Exhibit "D"** is a copy of my current Curriculum Vitae.

6. Attached as **Exhibit "E"** is a copy of an article that I co-authored with Luke Johnson entitled, "Consequences of Large-scale Production of Marijuana in Residential Buildings."

SWORN before me at the City of Ottawa, in the Province of Ontario, this 3rd day of October, 2014.

Caroline Dawn Seguin

Commissioner for taking Affidavits in and for the Province of Ontario

Dr. John David Miller

Caroline Dawn Seguin, a Commissioner, etc.,
Province of Ontario, for the Government of Canada,
Department of Justice.
Expires November 27, 2016.

This is Exhibit " A " referred to in the affidavit of:
Ceci est la pièce mentionnée à l'affidavit de:
JOHN DAVID MILLER
Sworn before me this 3RD day of OCTOBER, 20 14
Assermenté(e) devant moi ce jour de
A Commr. & etc. / Commissaire à l'assermentation
Caroline Dawn Seguin, a Commissioner, etc.,
Province of Ontario, for the Government of Canada,
Department of Justice.
Expires November 27, 2016.

Federal Court of Canada

Re: Allard et al. v. Her Majesty the Queen in Right of Canada

I - John David Miller - am a Professor in the Department of Chemistry, Carleton University, Ottawa.

QUALIFICATIONS

I have a PhD from the University of New Brunswick in fungal physiology. I have a specialized MSc degree from the University of Portsmouth (England) in Biodeterioration of Materials, that is, the study of fungi and bacteria that degrade structures, materials, objects and plant materials.

I was hired by Agriculture Canada in 1982 and, in 1984 was instructed to begin a series of studies on mold and other exposures additional to my work on mycotoxins. I joined Carleton University as Professor & NSERC Industrial Research Chair in Fungal Toxins & Allergens in 1999. From 1999-2008, I held a partial appointment in the Air Health Effects section of Health Canada until I have published > 300 papers on the impact of fungi and fungal toxins on population health, circa 30% of which relate to indoor environmental quality. I have co-written/edited 8 books, including on medical mycology and on mold and dampness in the built environment. I have been involved in and/or co-managed the large Health Canada studies on dampness in the built environment from 1985 to 2007.

Since 1987, I have served on many expert panels addressing indoor environmental quality at the national and international level. At present, I serve on a panel of the American Academy of

Allergy Asthma and Immunology that has so far published four medical practice parameters on allergens in the built environment. At Health Canada, I was a drafting author of the 2004 guideline in mold in buildings and assisted in the guidelines on mold (Health Canada 2007) and formaldehyde. As a member of the American Industrial Hygiene Association Biosafety and Environmental Microbiology committee, I have been active in developing the best practice guidelines for investigations of damp buildings used in the USA and Canada starting with the so-called New York Guidelines" in 1993. In particular, I was the senior editor of the current practice guideline "Recognition, evaluation and control of indoor mold" (2008).

I have considerable experience in toxicology, having serving on key committees of the World Health Organization and the US Food & Drug Commission that address man made and fungal toxins. More detail can be found in my CV.

I note that while at Health Canada, the issue of marijuana cultivation in the built environment was one of the files I addressed with respect to both the residential built environment and occupational exposures for first responders, including the RCMP who are covered by the Canada Labour Code. I spoke at the National Grow op conference in Ottawa in 2004 on occupational health issues for the RCMP, Fire Fighters and other first responders. I helped with the development of the protocols that are used by this community when entering a grow operation.

Under the Constitution Act, housing is a Provincial jurisdiction. However, the Government of Canada has an important impact on housing in three ways: the development of the National Building Code (first released in 1941), the facilitation of mortgage insurance and home design by Canada Mortgage & Housing Corporation (Acts from 1938-1954) and in energy conservation (1970s-; NRCan and predecessor agencies). The purpose of the National Housing Act is "to promote the construction of new houses, the repair and modernization of existing houses, and *the improvement of housing and living conditions*". Albeit by varying procedures, Provincial and Municipal governments adopt provisions of the National Building Code that suit their conditions. As noted by Commissioner Barrett in "The renewal of trust in residential construction: Commission of inquiry into the quality of condominium construction in British Columbia" (1998; chapter 2, section II) building codes are "*intended to represent minimum standards regarding life safety, health, and structural sufficiency of buildings*".

Part of my interest, therefore, was and is also to consider how the design and operation of housing affects the safety and durability of the housing stock.

In 2009, Carleton University accepted a contract from Health Canada to prepare a report on the consequences of growing marijuana in residential housing written and managed by me which resulted in a report and later a publication (Johnson & Miller 2012). This did not involve any personal remuneration i.e. the money was used to hire research assistants and other costs. The final report documented that in a high percentage of Canadian homes, the cultivation of marijuana on any scale would lead to serious moisture and mold problems, the risk of unusual

exposures to *A. fumigatus* and other contaminants which would pose health risks to occupants and visitors and in the case of multi-unit residential buildings, neighbours. Further, marijuana cultivation and drying, among other actions, would be predicted to result in damage to the buildings, some of which would not be easily seen by subsequent purchasers. The important findings were subsequently condensed and submitted to a peer reviewed journal Indoor Built Environment that was accepted in May 2011 and went on line in November.

ASSIGNMENT

Ms. BJ Wray asked me to address four questions:

- The consequences of locating marijuana growing operations in residential dwellings, including single family dwellings, condominiums and apartments.

- What would be required in order to deal with the consequences of growing marijuana in residential dwellings?

- The consequences of using marijuana that is contaminated by mold.

- What is required to prevent mold growth on marijuana?

A. Consequences of locating marijuana growing operations in residential dwellings

1. Actors

In my opinion, the answer to Ms. Wray's question needs to be considered in relation to at least three actors: the party interested to grow marijuana in a residence, bystanders, notably children and visitors and finally, a purchaser of the property at some time in the future. My answers consider each.

2. Grow operations

The consequences of illegal grow operations in residential have been described many times by many people. Most reports describe serious mold damage, non-code electrical systems and structural damage resulting from alterations to facilitate the installation of equipment and ducting for odours and for the addition of CO_2 from combustion heaters. For example, Canada Mortgage & Housing Corporation conducted a study of 12 former illegal marijuana grow operations. The summary report notes that the houses had alterations to accommodate the equipment and changes to the electrical system. Of the houses, 7 had serious mold damage homes and a further three more had some or moderate damage (CMHC 2007). A commentary from an official of Institut national de santé publique du Québec, also calls out mold damage as an important in former grow operations in a litany of other consequences (D'Halewyn 2006). Similar observations have been made in the U.S.A. (e.g. Martyny et al. 2013). As a consequence, the American Industrial Hygiene Association has developed guidelines for investigating and remediating clandestine grow operations (Koch et al. 2010). Because of the potential for serious damage to the building and safety risks, many cities in Canada have by-laws that require inspection of former grow operations and some have detailed rules for how remediation and testing is to be done.

A publication of the Canadian Real Estate Association states that homes that grow marijuana under Marihuana Medical Access Regulations are at similar risk for mold and potentially other damage (CREA 2013). Whether this was the case became the subject of my analysis conducted in 2009 referred to above. In brief: 'under what circumstances does growing marijuana result in damage to the building & risk to health in bystanders especially children and to people with a lawful right to enter'?

3. Damp building fungi (mold) & health

The fungi that dominate in outdoor air comprise mainly of species of two genera, *Cladosporium* and *Alternaria,* plant pathogens and mushroom spores. Species of *Cladosporium* and *Alternaria* cover the surfaces of healthy leaves of all plants (grass, trees, crops) and are hence called 'phylloplane fungi'. When the wind blows, spores detach from the leaves and become airborne, sometimes at very high concentrations. Approximately 10% of the population is allergic to these fungi resulting in 'hay fever' and asthma burdens (Horner et al. 1995). Thus, the fungi that dominate in clean and dry buildings are or should be the same as those in outdoor air. The fungi that grow on damp building materials are entirely different, being a mixture of species that, aside from their respective allergens, produce various metabolites (Prezant et al. 2008), some of which are quite toxic.

The US National Academy of Sciences (NAS 2004); Health Canada (2007), the US Centers for Disease Control (NIOSH 2012) and the World Health Organization (2009; see also Mendell et al. 2011) among many other cognizant authorities state that living or working in a moldy environment exacerbates asthma in mold sensitive asthmatics and on a population health basis results in increased risk of asthma to allergens (mold, dust mites, pollen), increased upper respiratory disease and a number of non- specific symptoms. The threshold for detecting these effects in a given population appears to be on the order of >0.2 m^2 of mold and water damage in a single family dwelling (Cho et al. 2006; Dales et al. 2010; Miller et al. 1999), that is to say not very much evident damage.

Mold and dampness has become more common in single family residential houses over the past 30 years. This is because ventilation rates were reduced to save energy, building materials that were more vulnerable to mold growth became common and building designs became less resilient to water intrusions (NAS 2004). When molds grow on building materials, spores and spore fragments become airborne and are inhaled. The allergens and toxins contained in the fragments affect lung biology and respiratory health of occupants. The estimated attributable risk for asthma from mold and damage from Canadian and US data was 20% (Dekker et al. 1991; Mudarri & Fisk 2006). The US government researchers estimated that mold and dampness increased direct health care costs by ~$3.5 billion (Mudarri & Fisk 2006). In short, mold damage of residential houses is a substantive issue for public and population health and health care costs.

4. Mold growth and cultivation in residential houses

Single family dwellings

Mold damage in the grow operations in single family homes discussed in the CMHC report (CMHC 2007) was probably caused because of increased moisture added to the environment from watering and then drying the marijuana plants. Aside from the ambient moisture, if the house is new, moisture is added from the construction materials, and the occupants of homes add water to the air from cooking, cleaning, showers & etcetera (Christian 1993; NAS 2004). Unless the ventilation capacity of the building is capable of removing this water from the air, the building materials and house dust take up the water which then becomes available for mold growth. This mold growth cannot always be seen. The research that underpins residential ventilation rates in Canada and the United States includes the assumption that a home would typically have three house plants. A study looking at the effects of humidity sources in the home found that plants are a constant source of moisture (Hite & Bray, 1949). Using data from studies of 7 different small to medium sized then common house plants, *Asparagus plumosus*, Boston fern, Bowstring hemp, friendly vine, English ivy, umbrella plant, and Peperomia, watered thoroughly every day, Hite & Bray (1949) found that these plants added an average of 2.5 g/h of water vapor/plant.

Using these data, an analysis was done that revealed that each marijuana plant would release 18g/h water vapour or 432 g/day (nearly one pound; Johnson & Miller 2012). This was consistent with an estimate made by researchers in the USA (Christian 1993). To assess the impact of adding marijuana plants, measured ventilation rates in winter were obtained from cities

representing different climates in across Canada (Windsor, Ottawa, Regina). There are extensive data (>20,000 homes from sea to sea to sea) on dampness and mold from Health Canada studies from 1988 (e.g. Miller et al. 1988; Dales et al. 1991; Dales et al. 2010).

Each marijuana plant adds as much moisture to the house as ca. 7-10 house plants. As marijuana plants are added to a house, moisture release will overwhelm home ventilation capacity and/or worsen the damage from an existing moisture failure present in ~30 of Canadians homes mainly from inadequate ventilation. We found that homes built after 1980 in Ottawa are already at high risk of moisture damage, meaning that adding additional moisture sources would result mold damage. Many homes in Windsor (41%) had air change rates below the recommended ventilation standard and would be unable to handle more than one or two house plants. The data from Regina homes showed a similar pattern: 37% were inadequately ventilated. These estimates do not include the release of moisture from improper drying of the harvested plants (Johnson & Miller 2012) nor from leaks from leaks from the pots/hydroponics systems or plumbing.

Multiunit residential buildings

Studies of recently constructed mid- and high rise residential suites in Canada found that measured total suite exhaust capacities were on average only 32% of the design capacities. Some 25% of the building suites tested had air change rates far less than what is required for single detached dwellings (Hill 1997). Air change rates and exhaust capacities in multiunit residential

buildings are complex. Although air leakage rates may be 30 to 40 times above the desirable upper limit (Proskiw & Phillips 2001), additional makeup air may not always be available. Inter-unit air transfer could pose a problem for neighbors of units where marijuana is grown. Inter-unit transfer air flows are prohibited by the National Building Code of Canada. However in a study of 10 units in a multiunit residential building, only two were found compliant (Moffat et al. 1998).

These different data sets suggest that approximately 1/3 of single family homes are at an increased risk for moisture problems from growing marijuana plants due to sub-standard ventilation rates. Compounding the problem 10-30% of the housing stock in Canada have existing moisture problems due to leaks in the building fabric, condensation from inadequate ventilation, and, unattended plumbing leaks (Dales et al. 2008). Multiunit residential buildings typically are smaller with a correspondingly reduced capacity for adding water and ventilation often below design expectations. The existing data show the chance that contaminants and odours being transferred from one unit to another would be quite common. There would be a risk of damage to common walls among other potential consequences of growing marijuana in a multiunit residential building.

Considering bystanders as I have defined this above, I note that exposure to dampness and mold is known to increase respiratory symptoms in mold sensitized individuals and mold sensitization is a risk factor for severe asthma. That is mold-sensitized people entering the building with sufficient mold damage are at special risk.

B. What would be required in order to deal with the consequences of growing marijuana in residential dwellings?

As discussed above, and assuming that marijuana producers do not duct emissions from their furnace or heater to increase CO_2 concentrations to accelerate plant growth, or use pesticides indoors, the major issue is water management. Adding point source ventilation to remove excess moisture from growing plants would be helpful. However, this would have to be done in a fashion that did not make rooms or the buildings negative to the envelope, crawl space and/or the basement concrete slab to prevent the introduction of potentially dangerous particulate (fungi, particles trapped in the building envelope or attic) and gaseous contaminants (volatiles, sewer gas, radon) through the slab or floor drain.

Aside from managing ventilation, the difficulties of managing the application of water and other inputs to the crop would require an engineered solution. Considering these factors, I cannot envision a generalizable solution to these difficulties for all homes in Canada that would stand up on re-sale of the house. A qualified professional engineer could presumably design suitable alterations and a balanced ventilation system coupled with an engineered plant drier to permit the cultivation of marijuana plants indoors without releasing moisture to the building for each house.

For multiunit residential buildings, I cannot envision an acceptable protocol to manage growing marijuana plants inside under any circumstance.

In summary, mold and dampness has become more common in single family residential houses over the past 30 years. This is an important population health problem in terms of increased risk particularly to vulnerable populations for respiratory disease and exacerbating existing asthma. Mold growth in homes is property damage and hidden mold damage is a concern for a purchaser of a home. The ventilation rates in single family homes were in part determined to prevent condensation and consequent mold damage and include the expectation that a few house plants will be typical. It is not reasonable to grow marijuana plants in the ~10-30% of Canadian homes with existing moisture damage. As plants are added to a house, the risk of condensation in the high percentage of Canadian homes with borderline ventilation capacities rises. Growing marijuana on any scale in a single family dwelling home would require a case by case engineered solution that would be very different depending on whether you lived in Canada. I cannot envisage growing marijuana on any scale in a multiunit residential building under any circumstances. Most units are small, have uncertain ventilation rates and the risk of odours and mold entering common spaces and neigbouring units is likely quite high.

C. The consequences of marijuana contaminated by mold

1. Mold growth on drying marijuana plants

As with the plants outdoors, when marijuana plants are healthy, the leaves are covered by various *Cladosporium* and *Alternaria*, so-called phylloplane fungi. Marijuana is at a much

increased risk for non-phylloplane mold growth during the drying period after harvest. Any dead plant material with moisture contents above ~ 12% has sufficient biologically available water to permit fungal growth. Moisture contents above 20% in dead plant material promote rapid fungal growth (Muller & Heindl 2006).

The facultative pathogen *Aspergillus fumigatus* grows and dominates on decaying vegetation under warm conditions or where biological heating has taken place, including piles of leaves or compost. This fungus is very common on samples of dried marijuana often at high concentrations. In one study in The Netherlands, all samples of marijuana were quite highly contaminated by fungi. *Aspergillus fumigatus, A. flavus* as well as various *Penicillium* species and actinomycetes were present in the marijuana tested at concentrations from 10^4-10^7 Colony Forming Units /g (Verweij et al. 2000). A study in the U.S.A. resulted in similar findings (Kurup et al. 1983). There is also indirect evidence of *A. fumigatus* contamination of marijuana. A study of marijuana users indicated a high prevalence of sensitization (allergy) to *A. fumigatus* (Kurup et al. 1983).

The prevalence of *A. fumigatus* contamination of marijuana resulting from growing, harvesting or smoking marijuana poses a potentially serious health population health risk. These risks include allergic reactions; sensitized individuals with chronic high exposure may also develop allergic bronchopulmonary aspergillosis. Allergy to *A. fumigatus* in a population of Canadian asthmatics was common (Malo & Paquin 1979). People suffering from cystic fibrosis are at high risk of acquiring aspergillosis which is very serious, often fatal. *A. fumigatus* infections have also

been reported in marijuana-exposed populations, normally in seriously immunosuppressed individuals. This is rare, but may be under-reported (Gargani et al. 2011; Gates et al. 2014; Johnson & Miller 2012).

Concerns about high exposures to *A. fumigatus* in workplaces (e.g. municipal composting) and the consequent disease even to healthy people is such that strict engineering controls and personal protective equipment strategies are required. Health concerns about the open population in homes and public spaces and people at risk are much greater (e.g. Fairs et al. 2013).

The drying, handling and using improperly dried marijuana poses small but significant risks to mold-sensitized asthmatics that might be exposed in a house (children, visitors), and users. Protocols to manage these risks for more than a few plants in a robust fashion are not immediately obvious to me. The medicinal herb industry has equipment and protocols for drying that could presumably be adapted (Muller & Heindl 2006). In the context of marijuana production in an appropriately designed building, drying requires the purchase of suitable equipment properly sized for capacity, and properly maintained.

2. Allergy to marijuana pollen

Marijuana pollen is allergenic. At general allergy consultation practices in Arizona and New Mexico, 63 of 129 patients were allergic to marijuana pollen (Mayoral et al. 2008). A similar

test in the Midwest USA found that 78 of 127 subjects (61%) were skin test positive to marijuana. In a selection of 30 of these individuals, 22 (73%) claimed respiratory symptoms during the pollination period of marijuana (Stokes et al. 2000). Cannabis pollen has also been found in air in Italy during pollination. The association between skin test sensitivity, respiratory symptoms, and pollination period suggest that Cannabis is a clinically important aeroallergen (Torre et al. 2007). Bystander exposure to the pollen including in laboratory and production workers can result in allergy. A number of allergens have been described and allergy in users may be common in atopics in Canada (Nayak et al. 2013; Tessmer et al. 2011). Atopy is the genetic predisposition toward developing allergy in all its forms.

In homes and multi-unit residential buildings, exposure to potently allergenic pollen is an undesirable and unnecessary risk for atopic bystanders.

Summary

Improperly dried marijuana is contaminated by the potently allergenic fungus *Aspergillus fumigatus* which is also a facultative pathogen capable of causing invasive disease in immune compromised individuals and people with cystic fibrosis. Occupational exposure to *Aspergillus fumigatus* can cause a serious lung disease. If the plant drying process is poor, the house will become highly contaminated as these materials are handled. I would regard this as a serious risk to occupants and some visitors and people with lawful right to enter the house. In the event

marijuana plants are permitted to produce pollen, atopic people are at high risk of acquiring allergy to the pollen. In my opinion, this is undesirable and unnecessary.

Literature cited

Cho SH, Reponen T, LeMasters G, Levin L, Huang J, Meklin T, Ryan P, Villareal M, Bernstein D (2006) Mold damage in homes and wheezing in infants. Ann Allergy Asthma Immunol 97:539-545.

CMHC (2007) A discussion paper on indoor air quality investigations of houses used for marijuana grow operations. Research Highlight 07-101, Canada Mortgage and Housing Corporation, Ottawa.

Christian JE (1993) A Search for Moisture Sources: Bugs Mold & Rot II: Workshop Proceedings, National Institute of Building Sciences, Washington, DC, November 16–17, 1993, pp. 71–81.

CREA (2013) Marihuana grow operations and synthetic drug labs: What REALTORS® need to know. 200 Catherine Street, Ottawa, ON K2P 2K9

http://www.crea.ca/sites/default/files/Grow%20Ops%20-%20What%20REALTORS%20Need%20to%20Know.pdf (accessed September 3, 2014).

Dales RE, Zwanenburg H, Burnett R, Franklin CA (1991) Respiratory health effects of home dampness and molds among Canadian children. Am J Epidemiol 134:196-203.

Dales R, Liu L, Wheeler AJ, Gilbert NL (2008) Quality of indoor residential air and health. Can Medical Assoc J 179:147-152.

Dales RE, Ruest K, Guay M, Marro K, Miller JD (2010) Residential fungal growth and incidence of respiratory illness during the first two years of life. Environmental Research 110:692–698.

1 Dekker C, Dales R, Bartlett S, Brunekreef B, Zwanenburg H (1991) Childhood asthma and the
2 indoor environment. Chest 100L 922-926.

3 D'Halewyn MA (2006) Contamination des maisons utilisée pour la culture de marijuana par les
4 moisissures. Bulletin d'Information en santé environmental (INSPQ). 17: 6-10.

5 Gargani Y, Bishop P, Denning DW (2011) Too many mouldy joints - marijuana and chronic
6 pulmonary aspergillosis. Mediterr J Hematol Infect Dis 3(1):e2011005.

7 Gates P, Jaffe A, Copeland J (2014) Cannabis smoking and respiratory health: consideration of
8 the literature. Respirology 19:655-662.

9 Health Canada (2007) Residential indoor air quality guidelines: moulds. Health Canada, Ottawa,
10 Ontario. Available at http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecssesc/pdf/pubs/air/mould-
11 moisissures-eng.pdf

12 Hite SC Bray JL (1949) Research in home humidity control Research Series No. 106,
13 Engineering Experiment Station, Purdue University, Lafayette, IN.
14

15 Hill D (1997) Field investigation of indoor environment and energy usage of mid-rise residential
16 buildings. Technical series 98-100, Canadian Mortgage and Housing Corporation, Ottawa.

17 Horner WE, Helbling A, Salvaggio JE, Lehrer SB (1995) Fungal Allergens. Clinical
18 Microbiology Reviews. 8: 161-179.

19 Fairs A, Agbetile J, Bourne M, Hargadon B, Monteiro WR, Morley JP, Edwards RE, Wardlaw
20 AJ, Pashley CH (2013). Isolation of Aspergillus fumigatus from sputum is associated with
21 elevated airborne levels in homes of patients with asthma. Indoor air 23:275-284.

1 Johnson L, Miller JD (2012) Consequences of large-scale production of marijuana in residential
2 buildings. Indoor Built Environment 21:595–600.

3 Koch KD, Chambers CL, Bucher S, Martyny J, Cotner J, Thomas S (2010) Clandestine indoor
4 marijuana grow operations - Recognition, assessment, and remediation guidance. American
5 Industrial Hygiene Association, Fairfax, VA. 978-1-935082-17-0

6 Kurup VP, Resnick A, Kagen SL, Cohen SH, Fink JN (1983) Allergenic fungi and
7 actinomycetes in smoking materials and their health implications. Mycopathologia 82:61-64.

8 Malo JL, Paquin R (1979) Incidence of immediate sensitivity to *Aspergillus fumigatus* in a North
9 American asthmatic population. Clin Allergy 9:377-384.

10 Martyny JW, Serrano KA, Schaeffer JW, & Van Dyke MV (2013) Potential exposures
11 associated with indoor marijuana growing operations. J Occ Environ Hygiene 10:622-639.

12 Mayoral M, Calderon H, Cano R, Lombardero M (2008) Allergenic rhinoconjunctivitis caused
13 by *Cannabis sativa* pollen. J Investig Allergol Clin Immunol 18:73-74.

14 Mendell MJ, Mirer AG, Cheung K, Tong M, Douwes J (2011) Respiratory and allergic health
15 effects of dampness, mold, and dampness-related agents: a review of the epidemiologic
16 evidence. Environ Health Perspect 119:748-756.

17 Miller JD, Dales RE, White J (1999) Exposure measures for studies of mold and dampness and
18 respiratory health. In: Johanning E (ed) Bioaerosols, fungi and mycotoxins: Health effects,
19 assessment, prevention and control. Eastern New York Occupational and Environmental Health
20 Center, Albany, NY, p. 298-305.

1 Miller JD, Laflamme AM, Sobol Y, Lafontaine P, Greenhalgh R (1988) Fungi and fungal
2 products in some Canadian houses. Int Biodeterioration 24:103 120.

3 Moffatt P Theaker I and Wray C (1998) Field testing to characterize suite ventilation in recently
4 constructed mid-and high-rise residential buildings. Technical Series 99-118. Canadian
5 Mortgage and Housing Corporation, Ottawa.

6 Mudarri D, Fisk WJ (2007) Public health and economic impact of dampness and mold. Indoor
7 Air 17:226-235.

8 Muller H and Heindl A (2006) Chapter 17: Drying of medicinal Plants. Medicinal and aromatic
9 plants. Springer pp. 237-252.

10 NAS (2004) Damp Indoor Spaces and Health. Institute of Medicine. National Academy of
11 Sciences, National Academy Press, Washington, DC.

12 Prezant B, Weekes D, Miller JD (2008; eds) Recognition, evaluation and control of indoor
13 mold. American Industrial Hygiene Association, Fairfax, VA. 253 p

14 Proskiw G and Phillips B (2001) Air leakage characteristics, test methods and specifications for
15 large buildings. Canadian Mortgage and Housing Corporation, Technical series 01-123, Ottawa,
16 Ontario, Canada.

17 Nayak AP, Green BJ, Sussman G, Berlin N, Lata H, Chandra S, ElSohly MA, Hettick JM,
18 Beezhold DH (2013) Characterization of *Cannabis sativa* allergens. Annals of Allergy, Asthma
19 & Immunol 111:32-37.

NIOSH (2012) Preventing occupational respiratory disease from exposures caused by dampness in office buildings, schools, and other nonindustrial Buildings, NIOSH Publication # 2013–102. National Institute for Occupational Safety and Health, Cincinnati, OH (www.cdc.gov/niosh).

Stokes JR Hartel R Ford LB Casale TB (2000) Cannabis (hemp) positive skin tests and respiratory symptoms. Ann Allergy Asthma Immunol 85:238-240.

Tessmer A, Berlin N, Sussman G, Leader, Chung EC, Beezhold D (2012). Hypersensitivity reactions to marijuana. Annals of Allergy, Asthma & Immunol 108:282-284.

Torre FD, Limonta A, Molinari A, Masala E, Vercelloni S, Torre ED (2007) Cannabaceae pollen in the atmosphere of Brianza, Northern Italy. Eur Ann Allergy Clin Immunol. 39: 9-11.

Verweij PE, Kerremans JJ, Voss A, Meis JF (2000) Fungal contamination of tobacco and marijuana. JAMA 284: 2875.

WHO (2009) WHO guidelines for indoor air quality: dampness and mould. World Health Organization, Regional Office for Europe, DK-2100. Copenhagen, Denmark.

Department of Justice Canada
Ministère de la Justice Canada

900-840 Howe Street
Vancouver, British Columbia
V6Z 2S9

Telephone: 604-666-1304
Facsimile: 604-775-5942
Email: hj.wray@justice.gc.ca

This is Exhibit " B " referred to in the affidavit of:
Ceci est la pièce mentionnée à l'affidavit de:
JOHN DAVID MILLER
Sworn before me this 3rd day of
Assermenté(e) devant moi ce jour de OCTOBER, 20 14
A Commr. & etc. / Commissaire à l'assermentation

Caroline Dawn Seguin, a Commissioner, etc.,
Province of Ontario, for the Government of Canada,
Department of Justice.
Expires November 27, 2016.

June 3, 2014

By Email to david.miller@carleton.ca

Dr. David Miller
Department of Chemistry
Carleton University
230 Steacie Building
1125 Colonel By Drive
Ottawa, ON K1S5B6

Dear Dr. Miller:

Re: ***Allard et al. v. Her Majesty the Queen in Right of Canada***
Instruction Letter for Expert Report

Thank you for agreeing to provide the Attorney General of Canada ("AGC") with an expert report in the matter of *Allard et al. v. Her Majesty the Queen in Right of Canada*. As discussed, this Federal Court litigation involves a constitutional challenge to the *Marihuana for Medical Purposes Regulations* (the "MMPR").

Background Information

The plaintiffs in this litigation, all of whom are medical marihuana users, are challenging the constitutionality of the MMPR on the basis that they cause several unjustified violations of their rights to liberty and security of the person under the Canadian *Charter of Rights and Freedoms*.

The plaintiffs' constitutional challenge in *Allard* focuses on four aspects of the MMPR that differ from the old medical marihuana regime: (1) the elimination of personal cultivation of marihuana in favour of requiring approved individuals to purchase from licensed producers; (2) the restriction that licensed producers may not cultivate marihuana in dwelling places or outdoor areas; (3) the limit on possession of marihuana to either 150g or 30 times the amount prescribed for daily consumption by the individual's medical practitioner, whichever is less; and (4) the failure of the MMPR to permit the production and possession of non-dried marihuana such as cannabis oils, salves, tinctures and edibles.

The plaintiffs have obtained an injunction from the Court that permits them to continue personal production of medical marihuana until the constitutionality of the MMPR is decided by the Court.

The AGC is the defendant and it is the AGC's position that the current medical marihuana regime is constitutionally sound, a position that will be defended by legal counsel on behalf of the AGC.

Facts and Assumptions

The facts alleged by the plaintiffs are outlined in the Amended Notice of Civil Claim which is enclosed.

Questions for Your Expert Report

Please address the following matters in your expert report:

1. Discuss the consequences of locating marihuana growing operations in residential dwellings, including single family dwellings, condominiums, and apartments;

2. Discuss the consequences of using marihuana that is contaminated with mould or other contaminants;

3. Discuss what would be required in order to deal with the consequences of growing marihuana in residential dwellings;

4. Discuss what would be required in order to deal with the prevention of contamination on marihuana.

Format of Your Expert Report

Your report must be prepared in accordance with the Federal Courts Rules. As such, we ask that you do the following within the body of your report:

1. Set out the issues to be addressed in the report;
2. Describe your qualifications on the issues to be addressed;
3. Attach your current curriculum vitae as a schedule to the report;
4. Attach this letter of instruction as a schedule to the report;
5. Provide a summary of your opinions on the issues addressed in the report;
6. Set out the reasons for each opinion that is expressed in the report;
7. Attach any publications or other materials specifically relied on in support of the opinions;
8. If applicable, provide a summary of the methodology used in the report;
9. Set out any caveats or qualifications necessary to render the report complete and accurate, including those relating to any insufficiency of data or research and an indication of any matters that fall outside of your field of expertise; and,
10. Particulars of any aspect of your relationship with a party to the proceeding or the subject matter of your report that might affect your duty to the Court.

Please number each paragraph of your report as this will aid us in referring to your report in Court.

Please sign and date your report.

Duty to the Court

As an expert witness, you have a duty to the Court which is set out in the attached Code of Conduct for Expert Witnesses. Please carefully review this Code of Conduct and, after doing so, sign the attached Certificate and send it back to us.

Due Dates and Procedural Matters

We are required to file our expert reports on or before November 1, 2014. The trial has been set for three weeks commencing February 23, 2015. You may be required to attend the trial for cross-examination and, if so, we will attempt to accommodate your schedule to the extent possible.

Please keep all correspondence pertaining to this assignment in a separate "Expert Witness Report" folder.

We look forward to receiving a draft of your report the **first week of September, 2013**. Please do not begin work on your expert report until your contract is in place.

Please do not hesitate to contact me by telephone at 604-666-4304 if you require further information or have questions regarding the foregoing.

Yours truly,

BJ Wray
Counsel

Enclosures: Certificate for Expert Witnesses; Code of Conduct for Expert Witnesses; Amended Notice of Civil Claim

FEDERAL COURT

BETWEEN:

NEIL ALLARD
TANYA BEEMISH
DAVID HEBERT
SHAWN DAVEY

PLAINTIFFS

and

HER MAJESTY THE QUEEN IN RIGHT OF CANADA

DEFENDANT

Certificate Concerning Code of Conduct for Expert Witnesses

I, David Miller, having been named as an expert witness by the Defendant, Her Majesty the Queen in Right of Canada, certify that I have read the Code of Conduct for Expert Witnesses set out in the schedule to the *Federal Courts Rules* and agree to be bound by it.

Date: June 18, 2014

Dr. J. David Miller
Department of Chemistry
Carleton University
230 Steacie Building
1125 Colonel By Drive
Ottawa, ON K1S5B6

This is Exhibit "C" referred to in the affidavit of:
Ceci est la pièce mentionnée à l'affidavit de:
JOHN DAVID MILLER
Sworn before me this 3RD day of
Assermenté(e) devant moi ce jour de OCTOBER, 2014

A Commr. & etc. / Commissaire à l'assermentation

Caroline Dawn Seguin, a Commissioner, etc.,
Province of Ontario, for the Government of Canada,
Department of Justice.
Expires November 27, 2016.

This is Exhibit " D " referred to in the affidavit of:
Ceci est la pièce mentionnée à l'affidavit de:
JOHN DAVID MILLER
Sworn before me this 3rd day of OCTOBER, 20 14
Assermenté(e) devant moi ce jour de
Caroline Seguin
A Comm. & etc. / Commissaire à l'assermentation

Caroline Dawn Seguin, a Commissioner, etc.,
Province of Ontario, for the Government of Canada,
Department of Justice.
Expires November 27, 2016.

J. David Miller

Department of Chemistry
Carleton University
Ottawa, Ontario
K1S 5B6

PLACE OF BIRTH Saint John, New Brunswick

EDUCATION

B.Sc. 1975 University of New Brunswick, Biology (Chemistry) 1975

M.Sc. 1978 University of New Brunswick, Biology (completed 08, 1977)

M.Sc. 1978 University of Portsmouth, Biodeterioration of materials

Ph.D. 1981 University of New Brunswick, Biology (O'Brien Foundation Fellowship)

NATO Science Fellow 1981-82 University of Portsmouth

EMPLOYMENT

Chemistry and Biology Research Institute, Agriculture Canada (03, 1982; SE-RES-02, 1984).
Eastern Cereal and Oilseed Research Centre, Mycotoxin Program.
Fusarium mycotoxin program study area leader 1988-1997.
Senior Research Scientist (SE-RES-03) 1990; (SE-RES-04) 1991
Visiting Professor, Carleton University, 1997-2000
Visiting Scientist & Science Advisor, Health Canada, 1999-2008
Professor & NSERC IRC 2001-2011

MAJOR ADDITIONAL TASKS (last 6 years)

2008- Member, American Industrial Hygiene Association Biosafety Committee
Member, National Center for Healthy Housing/ CDC panel on healthy housing interventions
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member OGS scholarship panel

2009- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member, fungal toxins STP 158 panel, International Agency for Research on Cancer (WHO)
Member OGS scholarship panel

2010- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member, fungal toxins STP 158 panel, International Agency for Research on Cancer (WHO)
Chair, USDA ARS program review committee for aflatoxin research
Member NSERC CREATE grant selection committee
Chair, OGS scholarship panel

2011- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member, fungal toxins STP 158 panel, International Agency for Research on Cancer (WHO)
Member, NSERC CREATE grant selection committee
Member, FAO panel on sampling methods for mycotoxins

2012- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member, fungal toxins STP 158 panel, International Agency for Research on Cancer (WHO)
Member, NSERC CREATE grant selection committee

2013- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Member, NSERC CREATE grant selection committee
Member, NIEHS grant selection committee
Co-Chair, panel on public health interventions for mycotoxins in highly affected areas (IARC)

2014- Member, American Industrial Hygiene Association Biosafety Committee
Member, Practice guideline panel, American Academy of Allergy Asthma & Immunology
Chair, expert panel "A health based agenda for reducing exposure to mycotoxins from groundnuts and maize aflatoxin and health in developing countries" (IARC)
Member, Advisory Committee Pathways to Global Mycotoxin Control, World Bank

OTHER

1985-86 - Ottawa Biological and Biochemical Society - President
06/1990 - NATO Senior Guest Fellowship to University of Bari, Italy.
1990-99 - Associate Editor, Canadian Journal of Botany
1991-99 -Co-editor, Natural Toxins (John Wiley, New York)
1991-13 - Director, Toxicology Forum, Inc., Washington, DC
1991 - Elected, Member of the International Academy of Indoor Air Sciences, Sweden
1992-93 - President, Ottawa Bacteriological Society
1993 - Ag Excellence team award for mycotoxin research
1994 - Ministry of Agriculture of China, Science and Technology Award
1998 -George Scott Award (Toxicology Forum)
2002 -Applied Research Award, Ottawa Life Sciences Council
2002-2010 -Associate Editor, Mycopathologia
2004-2010 -Review Board, Environmental Health Perspectives
2008 -AIHA award for editing the top selling book (green book) in 2008
2010 -AIHA award for contributions to the profession of industrial hygiene
2012 -Co-Organized MYCORED NAFTA (Ottawa)
2013 Elected Fellow, American Industrial Hygiene Association

INVITED SPEAKER (partial list; last 6 years)

2008 AllerGen/ CHILD workshop (Banff)
American Industrial Hygiene Association (Minneapolis)

Air & Waste Water Management Association (Ottawa)
City University of Hong Kong
Dipartimento di biologia Ambientale, University of Rome La Sapienza

2009 Toxicology Forum (Washington)
University of Tulsa
Air & Waste Water Management Association (Montreal)
American Industrial Hygiene Association (Toronto)
Syngenta (Greensboro, NC)
Distinguished lecture, City University of Hong Kong

2010 American College of Occupational & Environmental Medicine (Orlando)
International Mycology Congress 10 (Edinburgh)
Canada Grains Council (Winnipeg)

2011 MYCORED Africa (Cape Town),
University of Manitoba
International Society of Indoor Air Quality and Climate (Austin, TX)
Gordon Research Conference (Colby College, ME)
Toxicology Forum (Aspen)
Symposium on Global Public Health, US FDA (Little Rock, AR)
MYCORED Latin America (Mendoza, Argentina)

2012 American Industrial Hygiene Association (Indianapolis, IN)
Environmental Mutagen Society (Seattle, WA)
City University of Hong Kong
8th IUPAC International Symposium on Mycotoxins, opening plenary (Rotterdam)
US *Fusarium* consortium (Orlando)
Symposium sur les mycotoxines (Boucherville)

2013 G. Malcolm Trout Visiting Scholar Lecture, Michigan State University
Mycored 2013, Martina Franca, Italy

2014 Department of Plant Pathology/Plant-Microbe Biology, Cornell University
Sloan Foundation Building Microbes Symposium, U Colorado
U Saskatchewan Symposium on *Fusarium* & Ergot
IUMS, Montreal

PUBLICATIONS IN JOURNALS

1. Stanley SO, Leftly J, Miller JD, Pearson TH (1978) Chemical changes in the sediments of Loch Eil arising from the input of cellulose fibre. Pergamon Ser Environ 3: 409-418.

2. Miller JD, Brown CM, Pearson TH, Stanley SO (1979) Some biological important low molecular weight organic acids in the sediments of Loch Eil. Marine Biology 50: 374-383.

3. Cone DK, Miller JD, Austin WK (1980) The pathology of saddleback disease of underyearling salmon (*Salmo salar*). Can J Zoology 58:1283-1287.

4. Miller JD, Whitney NJ (1981) Fungi of the Bay of Fundy I: Lignicolous marine fungi. Can J Botany 59: 1128-1333.

5. Miller JD, Holland H (1981) Biodeteriogenic fungi in two Canadian historic houses subject to different environmental controls. Int Biodetn Bull 17: 39-45.

6. Miller JD, Whitney NJ (1981) Fungi of the Bay of Fundy II: Some observations on fungi isolated from seaweed. Botanica Marina 24: 405-411.

7. Miller JD, Whitney NJ (1981) Fungi of the Bay of Fundy III: Geofungi in the marine environment. Marine Biology 65: 61-68.

8. Miller JD, Schneider MH, Whitney NJ (1982) Fungi on wood fuel chips in a home. Wood and Fiber 14: 54-59.

9. Miller JD, Whitney NJ (1981) Fungi of the Bay of Fundy IV: Thraustochytrids. Nova Hedwigia 35: 407-416. (published 06, 1982).

10. Miller JD, Fleming LC (1981) Fungi associated with an infestation of *Pseudocarcinonemertes homari* on *Homarus americanus*. Trans British mycology Soc 80: 9-12.

11. Miller JD, Jones EBG (1983) Observations on the association of Thraustochytrid marine fungi with decaying seaweed. Botanica Marina 26: 345-351.

12. Greenhalgh R, Neish GA, Miller JD (1983) Deoxynivalenol, acetyl deoxynivalenol, and zearalenone formation by Canadian isolates of *Fusarium graminearum* on solid substrates. Appl Environ. Microbiology 46: 625-629.

13. Miller JD, Young JC, Trenholm HL (1983) *Fusarium* toxins in field corn. I. Parameters associated with fungal growth and production of deoxynivalenol and other mycotoxins. Can J Botany 61: 3080-3087.

14. Miller JD, Taylor A, Greenhalgh R (1983) Production of deoxynivalenol and related compounds in liquid culture by *Fusarium graminearum*. Can J Microbiol 29: 1171-1178.

15. Miller JD, Whitney NJ (1983) Fungi of the Bay of Fundy V: Fungi from living *Spartina alterniflora* Shreber. Proc Nova Scotia Inst Sci 33: 75-83.

16. Miller JD, Ivarson KC, Kaeppner MW (1984) Growth of *Scytalidium acidophilum* on defined media, whey and acid sulphite waste. Int Biodetn Bull 20: 27-31.

17. Miller JD, Moharir YE, Findlay JA, Whitney NJ (1984) Marine fungi of the Bay of Fundy VI: Growth and metabolites of *Leptosphaeria oraemaris*, *Sphaerulina oraemaris*, *Monodictys pelagica* and *Dendryphiella salina*. Proc Nova Scotia Inst Sci 34: 1-8.

18. Greenhalgh R, Hanson AW, Miller JD, Taylor A (1984) Production and X-ray crystal structure of 3-acetoxy-7, 15-dihydroxy-12, 13-epoxytrichothec-9-en-8one. J Agric Food Chem 32: 945-948.

19. Miller JD, Young JC, Sampson DR (1985) Deoxynivalenol and *Fusarium* head blight resistance in spring cereals. Phytopathol Zeitschrift 113: 359-367.

20. Miller JD, Greenhalgh R (1984) Nutrient effects on the biosynthesis of trichothecenes and other metabolites by *Fusarium graminearum*. Mycologia 77: 130-136.

21. Young JC, Miller JD (1984) Appearance of fungus, ergosterol and *Fusarium* mycotoxins in the husk, axial stalk and stem after ear inoculation of field corn. Can J Plant Sci 65: 47-53.

22. Blackwell BA, Miller JD, Greenhalgh R (1984) ^{13}C NMR study of the biosynthesis of toxins of *Fusarium graminearum*. J Biological Chemistry 260: 4243-4247.

23. Greenhalgh R, Meier RM, Blackwell BA, Miller JD, Taylor A, ApSimon JW (1984) Minor metabolites of *Fusarium roseum* (ATCC 28114). J Agric Food Chem 32: 1261-1264.

24. Miller JD, Jones EBG, Moharir Y, Findlay JA (1985) Colonisation of wood blocks by marine fungi in Langstone Harbour. Botanica Marina 28: 251-257.

25. Greenhalgh R, Miller JD, Neish GA, Schiefer HB (1985) Toxigenic potential of *Fusarium* isolates from southeast Asia. Appl Environ Microbiol 50: 550-552.

26. Miller JD, Strongman D, Whitney NJ (1985) Observations on fungi associated with spruce budworm infested balsam fir needles. Can J Forest Res 15: 896-901.

27. Miller JD, Young JC (1985) Deoxynivalenol in an experimental *Fusarium graminearum* infection in wheat. Can J Plant Pathology 7: 132-134.

28. Miller JD, Blackwell BA (1986) Biosynthesis of 3-acetyl- deoxynivalenol and other metabolites by *Fusarium culmorum* HLX 1503 in a stirred jar fermentor. Can J Botany 64: 1-5.

29. Greenhalgh R, Levandier D, Adams W, Miller JD, Blackwell BA, McAlees AJ, Taylor A (1986) Production and characterization of deoxynivalenol and other secondary metabolites of *Fusarium culmorum* (CMI 14764, HLX 1503). J Agric Food Chem 34: 98-102.

30. Greenhalgh R, Meier RM, Blackwell BA, Miller JD, Taylor A, ApSimon JW (1986) Minor metabolites of *Fusarium roseum* (ATCC 28114) Part 2. J Agric Food Chem 34: 115-118.

31. Strongman DB, Miller JD, Whitney NJ (1986) Lignicolous marine fungi from Prince Edward Island with a description of *Didymosphaeria lignomaris* sp. nov. Proc Nova Scotia Inst Sci 35: 99-105.

32. Strongman DB, Miller JD, Calhoun L, Findlay JA, Whitney NJ (1986) The biochemical basis for interference competition among some lignicolous marine fungi. Botania Marina 30: 21-26.

33. Prelusky DB, Trenholm HL, Hamilton RMG, Miller JD (1986) Tissue distribution and excretion of radioactivity following administration of 14 C-labelled deoxynivalenol to white leghorn hens. Funl Applied Toxicology 7: 635-645.

34. Miller JD, Arnison PG (1986) Degradation by suspension cultures of the Fusarium head blight resistant cultivar Frontana. Can J Plant Pathology 8:147-150.

35. Prelusky DB, Trenholm HL, Hamilton RMG, Miller JD (1987) Studies on the transmission of ^{14}C deoxynivalenol to eggs following oral administration to laying hens. J Agric Food Chem 35:182-186.

36. Lauren DR, Ashley A, Blackwell BA, Greenhalgh R, Miller JD, Neish GA (1987) Trichothecenes produced by *Fusarium crookwellense* DAOM 193611 in liquid culture. J Agric Food Chem 35:884-889.

37. Wang YZ, Miller JD (1987) Effects of *Fusarium graminearum* metabolites on wheat tissue in relation to Fusarium head blight resistance. J Phytopathology 122:118-125.

38. Newell SY, Miller JD, Fallon RD (1987) Ergosterol content of salt-marsh fungi: effect of growth conditions and mycelial age. Mycologia 79: 688-695.

39. Greenhalgh R, Blackwell BA, Savard ME, Miller JD, Taylor A (1988) Secondary metabolites produced by *Fusarium sporotrichioides* DAOM 165006. J Agric Food Chem 36:216-219.

40. Prelusky DB, Hartin KE, Trenholm HL Miller JD (1988) Pharmacokenetic fate of 14 C-labelled deoxynivalenol in swine. Fundamental Applied Toxicology 10: 276-286.

41. Newell SY, Miller JD, Fell JW (1987) Rapid and pervasive occupation of fallen mangrove leaves by a marine zoosporic fungus. Appl Environ Microbiol 53: 2464-2469.

42. Miller JD, Laflamme AM, Sobol Y, Lafontaine P, Greenhalgh R (1988) Fungi and fungal products in some Canadian houses. International Biodeterioration 24: 103-120.

43. Lauren DR, DiMenna ME, Greenhalgh R, Miller JD, Neish GA, Burgess LW (1988) Toxin-producing potential of some *Fusarium* species from a New Zealand pasture. NZ J Agric Research 31: 219-225.

44. Trenholm HL, Prelusky DB, Young JC, Miller JD (1988) A practical guide to the prevention of *Fusarium* mycotoxins in grain and animal feedstuffs. Arch Environ Contam Toxicology 18: 443-451.

45. Dowd PF, Miller JD, Greenhalgh R (1989) Toxicity and interactions of some *Fusarium graminearum* metabolites to caterpillars. Mycologia 81:646-650.

46. Newell SY, Fallon RD, Miller JD (1989) Decomposition and microbial dynamics for standing, naturally positioned leaves of a salt-marsh grass. Marine Biology 101: 471-481.

47. Clark C, Miller JD, Whitney NJ (1989) Toxicity of conifer needle endophytes to spruce budworm. Mycological Research 93: 508-512.

48. Savard ME, Miller JD, Salleh B, Strange RN (1989) Chlamydosporol, a new metabolite from *Fusarium chlamydosporum*. Mycopathologia110:177-181.

49. Miller JD, Savard ME (1989) Antibiotic activity of the marine fungus *Leptosphaeria oraemaris*. Proc Nova Scotia Inst Sci 39: 51-58.

50. Miller JD (1990) Contamination of food by *Fusarium* toxins: studies from Austria-Asia. Proc. Japanese Association of Mycotoxicology 32: 17-24.

51. Greenhalgh R, Fielder DA, Blackwell BA, Miller JD, Charland SP, ApSimon JW (1990) Some minor secondary metabolites of *Fusarium sporotrichioides* DAOM 165006. J Agric Food Chem 38: 1978-1984.

52. Greenhalgh R, Miller JD, Visconti A (1991) Toxigenic potential of *Fusarium compactum* R8287 and R8293. J Agric Food Chem 39: 809-812.

53. Miller JD, Greenhalgh R, Wang YZ, Lu M (1991) Trichothecene Mycotoxin chemotypes of three *Fusarium* species. Mycologia 83:121-130.

54. Savard ME, Miller JD (1992) Characterization of fusarin F, a new fusarin from *Fusarium moniliforme*. J Natural Products 55: 64-70.

55. Laflamme AM, Miller JD (1992) Collection of spores of various fungi by a Reuter centrifugal sampler. Int Biodet 29: 101-110.

56. Kasitu GC, ApSimon JW, Blackwell BA, Fielder DA, Greenhalgh R, Miller JD (1992) Isolation and characterization of culmorin derivatives produced by *Fusarium culmorum* CMI 14764. Can J Chemistry 70: 1308-1316.

57. Calhoun LA, Findlay JA, Miller JD, Whitney JD (1992) Metabolites toxic to spruce budworm from balsam fir needle endophytes. Mycological Research 96: 281-286.

58. Miller JD (1992) Fungi as contaminants of indoor air. Atmospheric Environment 26A: 2163-2172.

59. Rotter RG, Thompson BK, Trenholm HL, Prelusky DB, Hartin KE, Miller JD (1992) A preliminary examination of potential interactions between deoxynivalenol and other selected Fusarium metabolites in growing pigs. Can J Animal Sci 72: 107-116.

60. Blais LA, ApSimon JW, Blackwell BA, Greenhalgh R, Miller JD (1992) Isolation and characterization of enniatins from *Fusarium avenaceum* DAOM 196490. Can J Chemistry 70: 1281-1287.

61. Visconti A, Blais L, ApSimon JA, Greenhalgh R, Miller JD (1992) Production of enniatins by *Fusarium acuminatum* and *Fusarium compactum* in liquid culture: isolation and characterization of three new enniatins, B2, B3 and B4. J Agric Food Chem 40:1076-1082.

62. Rapior S, Miller JD, Savard ME, ApSimon JW (1993) Production de fumonisins et de fusarins par des souches européennes de *Fusarium moniliforme*. Microbiologie-Aliments Nutrition 11: 327-333.

63. Miller JD, Savard ME, Sibilia A, Rapior S, Hocking AD, Pitt JI (1993) Production of fumonisins and fusarins by *Fusarium moniliforme* from southeast Asia. Mycologia 85: 385-391.

64. Schaafsma AW, Miller JD, Savard ME, Ewing RJ (1993) Ear rot development and mycotoxin production in corn in relation to inoculation method and corn hybrid for three species of Fusarium. Can J Plant Pathology 15: 185-192.

65. Blackwell BA, Miller JD, Savard ME (1993) Production of carbon 14-labelled fumonisin in liquid culture. J AOAC International 77: 506-511.

66. Vudathala DK, Prelusky DB, Ayroud M, Trenholm HL, Miller JD (1994) Pharmokinetic fate and pathological effects of ^{14}C fumonisin B_1 in laying hens. Natural Toxins 2: 81-88.

67. Wilson RW, Wheatcroft RGC, Miller JD, Whitney NJ (1994) Genetic diversity among natural populations of endophytic *Lophodermium pinastri* from *Pinus resinosa*. Mycological Research 98: 740-744.

68. Savard ME, Miller JD, Blais LA, Seifert KA, Samson RA (1994) Secondary metabolites of *Penicillium bilaii* strain PB-50. Mycopathologia 127:19-27.

69. Miller JD, Savard ME, Rapior S (1994) Production and purification of fumonisins from a stirred jar fermentor. Natural Toxins 2:354-359.

70. Scott PM, Delgado T, Prelusky DB, Trenholm HL, Miller JD (1994) Determination of fumonisins in milk. J Environ Science Health B29:989-998.

71. Findlay JA, Li G, Penner PE, Miller JD (1994) Novel diterpenoid insect toxins from a conifer endophyte. J Natural Products 58:197-200.

72. Miller JD (1995) Fungi and mycotoxins in grain: implications for stored product research. J Stored Product Research 31:1-6.

73. Miller JD, Savard ME, Schaafsma AW, Seifert KA, Reid LA (1995) Mycotoxin production by *Fusarium moniliforme* and *Fusarium proliferatum* from Ontario and occurrence of fumonisin in the 1993 corn crop. Can J Plant Pathology 17: 233-239.

74. Cossette F, Miller JD (1995) Phytotoxic effect of deoxynivalenol and Gibberella ear rot resistance of corn. Natural Toxins 3:383-388.

75. Findlay JA, Buthelezi S, Lavoie R, Pena-Rodrigues L, Miller JD (1995) Bioactive isocoumarins and related metabolites from conifer endophytes. J Natural Products 58:1759-1766.

76. Prelusky DB, Miller JD, Trenholm HL (1996) Disposition of ^{14}C-derived residues in tissues of pigs fed radiolabelled fumonisin B_1. Fund App Toxicol 13:155-162.

77. Rotter BA, Thompson BK, Prelusky DB, Trenholm HL, Stewart B, Miller JD, Savard ME (1996) Response of growing swine to pure fumonisin B1 during an 8 week period: growth and clinical parameters. Natural Toxins 4:42-50.

78. Miller JD, Fielder DA, Dowd PF, Norton RA, Collins FW (1997) Isolation of 4-acetyl-benzoxazolin-2-one (4-ABOA) and diferuloylputrescine from an extract of gibberella ear rot-resistant corn that blocks mycotoxin biosynthesis, and the insect toxicity of 4-ABOA and related compounds. Biochemical Systematics Ecology 24:647-658.

79. Miller JD, Young JC (1997) The use of ergosterol to measure exposure to fungal propagules. American Industrial Hygiene Association J 58:39-43.

80. Dales E, Miller JD, McMullan E (1997) Indoor air quality and health: validity and determinants of reported home dampness and moulds. Int J Epidemiology 26:120-125.

81. Snijders CHA, Samson RA, Hoekstra ES, Ouellet T, Miller JD, de Rooj-van der Goes PCEM, Baar AJM, Debois AE, Kauffman HF (1997) Analysis of *Fusarium* causing dermal toxicosis in marram grass planters. Mycopathologia 135:119-128.

82. Savard ME, Miller JD, Ciotola M, Watson AK (1997) Secondary metabolites produced by a strain of *Fusarium oxysporum* used for Striga control in West Africa. Biocontrol Science & Technology 7:61-64.

83. Miller JD, Day JD (1997) Indoor mold exposure: epidemiology, consequences and immunothapy. Can J Allergy & Clinical Immunology 2:25-32

84. Rotter BA, Prelusky DB, Fortin A, Miller JD, Savard ME (1997) Impact of pure fumonisin B1 on various metabolic parameters and carcass quality of growing-finishing swine- preliminary findings. Can J Animal Science 77:465-470.

85. Fernando WGD, Paulitz TC, Seaman WL, Dutilleul D, Miller JD (1997) Head blight gradients caused by *Gibberella zeae* from area sources of inoculum in wheat field plots. Phytopathology 87:414-421.

86. Wild CP, Castegnaro M, Ohgaki H, Garren L, Galendo D, Miller JD (1997) Absence of a synergistic effect between fumonisin B1 and n-nitrosomethlbenzylamine in the induction of oesopageal papillomas in rat. Natural Toxins 5:126-131.

87. Miller JD, Miles M, Fielder DA (1997) Kernel concentrations of 4-acetyl-benzoxazolin-2-one and diferuloylputrescine in maize genotypes and Gibberella ear rot. J Agric Food Chem 45:4456-4459.

88. Findlay JA, Butelezi S, Li Q, Seveck M, Miller JD (1997) Insect toxins from an endophytic fungus from Wintergreen. J Natural Products 60:1214-1215.

89. Miller JD, Ewen MA (1997). Toxic effects of deoxynivalenol on ribosomes and tissues of the spring wheat cultivars Frontana and Casavant. Natural Toxins 5:234-237.

90. Tryphonas H, Bondy G, Miller JD, Lacroix F, Hodgen H, McGuire P, Fernie S, Miller JD, Hayward S (1997) Effects of fumonisin B1 on the immune system of Sprague-Dawley rats following a 14-day oral (gavage) exposure. Fundamental Applied Toxicology 39:53-59.

91. MacKenzie SA, Savard ME, Blackwell BA, Miller JD, ApSimon JW (1998) Isolation of a new fumonisin from *Fusarium moniliforme* grown in liquid culture. J Natural Products 61:367-369.

92. Miller JD, Culley J, Fraser K, Hubbard S, Meloche F, Ouellet T, Seaman L, Seifert KA, Turkington K, Voldeng H (1998) Effect of tillage practice on Fusarium head blight of wheat. Can J Plant Pathology 20:95-103.

93. Dales R, Miller JD, White JM, Dulberg C, Lazarovitis AI (1998). The influence of residential Fungal contamination on peripheral blood lymphocyte populations in children. Arch Environ Health 53:190-195.

94. Hodgeson MJ, Morey P, Leung W-Y, Morrow L, Miller JD, Jarvis BB, Robbins B, Halsey JF, Storey E (1998) Building-associated pulmonary disease from exposure to *Stachybotrys chartarum* and *Aspergillus versicolor*. J Occupational Environmental Medicine 40:241-249

95. Methta R, Lok E, Rowsell PR, Miller JD, Suzuki CAM, Bondy GS (1998) Glutothione S-transferase-placental form expression and proliferation in fumonisin B1-treated male and female Sprague-Dawley rats. Cancer Letters 128:31-39.

96. Pinelli E, Proux N, Pipy B, Miller JD, Castegnaro M, Pfohl-Leszkowicz A (1999). Activation of mitogen-activated protein kinase by fumonisin B1 stimulates arachadonic acid cascade and cAMP production. *Carcinogenesis* 20:1683-1688.

97. Blackwell BA, Gilliam JT, Savard ME, Miller JD, Duvick JP (1999) Oxidative deamination of hydrolyzed fumonisin B1 (AP1) by cultures of *Exophiala spinifera*. Natural Toxins 7:31-38.

98. Dillon HK, Miller JD, Sorenson WG, Douwes J, Jacobs RJ (1999) A review of methods applicable to the assessment of mold exposure to children. Environmental Health Perspectives 107 (s.3):473-480.

99. Dales RE, Miller JD (1999) Residential fungal contamination and health: microbial cohabitants as covariates. Environmental Health Perspectives 107 (s.3):481-483.

100. Piñeiro M, Miller JD, Silva G, Musser S (1999) Effect of commercial processing on fumonisin concentrations of maize-based foods. Mycotoxin Research 15:2-13.

101. Dales RE, Miller JD, White J (1999) Testing the association between residential fungus and health using ergosterol measures and cough recordings. Mycopathologia 147:21-27.

102. Reid LM, Nicol RW, Ouellet T, Savard M, Miller JD, Young JC, Stewart DW, Schaafsma DW (1999) Interaction of *Fusarium graminearum* and *F. moniliforme* in maize ears: disease progress, fungal biomass and mycotoxin accumulation. Phytopathology 89:1028-1037.

103. Pedersen PB, Miller JD (1999) The fungal metabolite culmorin and related compounds. Natural Toxins 7:305-310.

104. Miller JD, Mackenzie S (2000) Secondary metabolites of *Fusarium venenatum* strains with deletions in the Tri5 gene encoding trichodiene synthetase. Mycologia 92:764-771.

105. Fernando WGD, Miller JD, Seaman L, Seifert K, Paulitz TC (2000) Daily and seasonal dynamics of airborne spores of *Fusarium graminearum* and other *Fusarium* species sampled over wheat plots. Can J Botany 78:497-505.

106. Miller JD (2001) Factors that affect the occurrence of fumonisin. Environmental Health Perspectives 109(s. 2):321-324.

107. Miller JD, Haisley PD, Reinhardt JH (2000) Air sampling results in relation to extent of fungal colonization of building materials in some water damaged buildings. Indoor Air 10:146-151.

108. Schaafsma AW, Tamburic-Ilinic L, Miller JD, Hooker DC (2001) Influence of agronomics on reducing deoxynivalenol content in winter wheat grain. Can J Plant Pathology 23:279-285.

110. Langseth W, Ghebremeskel M, Kosiak B, Kolsaker P, Miller JD (2001) Production of culmorin compounds and other secondary metabolites by *Fusarium culmorum* and *F. graminearum* strains isolated from Norwegian cereals. Mycopathologia 152:23-34.

111. Miller JD, Mackenzie S, Foto M, Adams GW, Findlay JA (2002) Needles of white spruce inoculated with rugulosin-producing endophytes contain rugulosin reducing spruce budworm growth rate. Mycological Research 106:471-479.

112. Enongene E N, Sharma R, Bhandari N, Miller JD, Meredith FI, Voss KA, Riley RT (2003) Persistence and reversibility of the elevation in free sphingoid bases induced by fumonisin inhibition of ceramide synthase. Tox Sci 67:173-181.

113. Meky FA, Turner PC, Ashcroft AE, Miller JD, Qiao YL, Roth ML, Wild CP (2002) Development of a urinary biomarker of human exposure to deoxynivalenol. Food Chemical Toxicology 41:265-273

114. Findlay JA, Li G, Miller JD, Womilouju TO (2003) Insect toxins from spruce endophytes. Can J Chemistry 81:284-292.

115. Miller JD, Rand TG, Jarvis BB (2003) *Stachybotrys chartarum*: cause of human disease or media darling. Medical Mycology 41:271-291.

116. Horner E, Miller JD (2003) Microbial volatile organic compounds with emphasis on those arising from filamentous fungal contaminants of buildings. ASHRAE Transactions 109:215-231

117. Avantaggiato G, De La Campa R, Miller JD, Visconti A (2003) Effect of muffin processing on fumonisins from ^{14}C-labeled toxins produced in vivo in corn kernels. J Food Protection 66:1873-1878

118. Womiloju TO, Miller JD, Mayer PM, Brook JR (2003) Methods to determine the biological composition of particulate matter collected from outdoor air. Atmospheric Environment 37:4335-4344.

119. Wu F, Miller JD, Casman EA (2004) Bt corn and mycotoxin reduction: economic impacts in the United States and the developing world. Journal of Toxicology, Toxin Reviews 23:397-424.

132. Sumarah MW, Miller JD, Adams GW (2005) Measurement of a rugulosin-producing endophyte in white spruce seedlings. Mycologia 97:770-776.

133. Sumarah MW, Miller JD, Blackwell BA (2005) Isolation and metabolite production by *Penicillium roqueforti, P. paneum* and *P. crustosum* isolated in Canada. Mycopathologia 159:571-577.

134. Voss KA, Liu J, Anderson SP, Dunn C, Miller JD, Owen JR, Riley RT, Bacon CW, Corton JC (2006) Toxic effects of fumonisin in mouse liver are independent of the peroxisome proliferator-activated receptor α.. Toxicological Sciences 89:108-119.

135. Karsh J, Angel JB, Young CD, Sahni V, Judek S, Miller JD, Dales RE (2005) The frequency of respiratory illness in early childhood is associated with a change in the distribution of blood lymphocyte subpopulations. Allergy, Asthma and Clinical Immunology 1:135-141.

136. Womiloju TO, Miller JD, Mayer P (2006). Phospholipids from some common fungi associated with damp building materials. Analytical Bioanalytical Chemistry 384:972-979.

137. Heffer MJ, Ratz JD, Miller JD, Day JH (2005) Comparison of the Rotorod to other air samplers for the determination of *Ambrosia artemisiifolia* pollen concentrations conducted in the Environmental Exposure Unit. Aerobiologia 21:233-239.

138. Dales RE, Miller JD, Ruest K, Guay M, Judek S (2006). Airborne endotoxin is associated with respiratory illness in the first two years of life. Environ Health Perspect 114:610-614.

139. Kovesi T, Creery D, Gilbert NL, Dales RE, Fugler D, Thompson R, Randhawa N, Miller JD (2006) Indoor Air Quality Risk Factors for Severe Lower Respiratory Tract Infections in Inuit Infants in Baffin Region, Nunavut: A Pilot Study. Indoor Air 16:266-275.

140. Nielsen KF, Sumarah MW, Frisvad JC, Miller JD (2006) Production of metabolites by species in the *Penicillium roqueforti* complex. J Agric Food Chem 54:3756 -3763.

141. Abdeen N, Cross A, Cron G, White S, Rand T, Miller D, Santyr G (2006) Measurement of xenon diffusing capacity in the rat lung by hyperpolarized 129Xe MRI and dynamic spectroscopy in a single breath-hold. Magn Reson Med 56:255-264.

142. Wu F, Jacobs D, Mitchell C, Miller JD, Karol, MH (2007) Improving indoor environmental quality for public health: impediments and policy recommendations. Environmental Health Perspectives 115:953-957.

143. Miller JD, Dugandzic R, Frescura A-M, Salares, V (2007) Indoor and outdoor-derived contaminants in urban and rural homes in Ottawa, Canada. J Air Waste Management Association 57:297-302.

144. Sorensen D, Raditsis A, Trimble LA, Blackwell BA, Sumarah MW, Miller JD (2007) Isolation and structure elucidation by LC-MS-SPE/NMR: PR Toxin- and cuspidatol-related eremophilane sesquiterpenes from *Penicillium roqueforti.* J Natural Products 70:121 -123.

145. De La Campa R, Seifert K, Miller JD (2007) Toxins from strains of *Penicillium chrysogenum*

isolated from buildings and other sources. Mycopathologia 163:161-168.

146. Dillon HK, Boling DK, Miller JD (2007) Comparison of detection methods for *Aspergillus fumigatus* in environmental air samples in an occupational environment. J Occupational Environmental Hygiene 4:509-513

147. Adams GW, Smith T, Miller JD (2007) The absence of glyphosate residues in wet soil and the adjacent watercourse after a forestry application in New Brunswick. Northern Journal Forestry Research 24:230-232.

148. Kovesi T, Gilbert NL, Stocco C, Fugler D, Dales RE, Guay M, Miller JD (2007) Indoor air quality and the risk of lower respiratory tract infection in young Canadian Inuit children. Canadian Medical Association Journal 177:155-160.

149. Loiseau N, Debrauwer L, Sambou T, Bouhet S, Miller JD, Martin PG, Viadère JL, Pinton P, Puel O, Pineau T, Tulliez T, Galtier P, Oswald IP (2007) Fumonisin B1 Exposure and its selective effect on porcine jejunal segment: sphingolipids, glycolipids and trans-epithelial passage disturbance. Biochem Pharm 74:144-152.

150. Xu J, Jensen JT, Liang Y, Belisle D, Miller JD (2007) The biology and immogenicity of a 34 kDa antigen of *Stachybotrys chartarum sensu latto*. International Biodegradation Biodeterioration 60:308-318.

152. Sumarah MW, Adams GW, Berghout J, Slack G, Wilson A, Miller JD (2008) Spread and persistence of a rugulosin-producing endophyte in white spruce seedlings. Mycological Research 112:731–736.

152. Rand TG, Miller JD (2008) Immunohistochemical and immunocytochemical detection of SchS34 antigen in *Stachybotrys chartarum* spores and spore impacted mouse lungs. Mycopathologia 165:73-80.

153. Miller JD (2008) Mycotoxins in small grains and maize: old problems, new challenges. Food Additives Contaminants 25:219-230.

154. Xu J, Liang Y, Belisle DP, Miller JD (2008) Characterization of monoclonal antibodies to an antigenic protein from *Stachybotrys chartarum* and its measurement in house dust. J. Immunol. Methods 332:121-128.

155. Miller JD, Sumarah MW, Adams GW (2008) Effect of a rugulosin-producing endophyte in *Picea glauca* on *Choristoneura fumiferana*. J Chemical Ecology 34:362–368.

156. Sumarah MW, Puniani E, Blackwell BA, Miller JD (2008) Characterization of polyketide metabolites from foliar endophytes of *Picea glauca*. J Natural Products 71:1393–1398.

157. Slack GJ, Puniani E, Frisvad JC, Samson RA, Miller JD (2009) Secondary metabolites from *Eurotium* species, *A. calidoustus* and *A. insuetus* common in Canadian homes with a review of their chemistry and biological activities. Mycological Research 113: 480-490.

158. Miller JD, Cherid H, Sumarah MW, Adams GW (2009) Horizontal transmission of the *Picea*

glauca foliar endophyte *Phialocephala scopiformis* CBS 120377. Fungal Ecology 2:98-101.

159. Schaafsma AW, Limay-Rios V, Paul DE, Miller JD (2009) Mycotoxins in fuel ethanol co-products derived from maize - a mass balance for deoxynivalenol. J Science Food Agriculture 89:1574-1580.

160. Kovesi T, Zaloum C, Stocco C, Fugler D, Dales RE, Ni A, Barrowman N, Gilbert NL, Miller JD (2009) Randomized controlled trial of heat recovery ventilators for the prevention of lower respiratory tract illness in Inuit children. Indoor Air 19: 489–449.

161. Salares VR, Hinde CA, Miller JD (2009) Analysis of settled dust in homes and fungal glucan in air particulate collected during HEPA vacuuming. Indoor Built Environment 18:485–491.

162. Wilson, AW, Luo W, Miller JD (2009) Using human sera to identify a 52 kDa exoantigen of *Penicllium chrysogenum* and implications of polyphasic taxonomy of anamorphic ascomycetes in the study of allergens. Mycopathologia 168:213-226.

163. Sumarah MW, Miller JD (2009) Anti-insect metabolites from foliar fungal endophytes of conifer trees. Natural Products Communications Nat Prod Commun 4:1497-1504.

164. Miller JD, Sun M, Gilyan A, Roy J, Rand TG (2010) Inflammation-associated gene transcription and expression in mouse lungs induced by low molecular weight compounds from fungi from the built environment. Chem Biol Interact 183:113–124.

165. Rand TG, Sun M, Gilyan A, Downey J, Miller JD (2010) Dectin-1 and inflammation-associated gene transcription and expression in mouse lungs by a toxic (1,3)-beta-D: glucan. Arch Toxicol. 84:205-220.

166. Luo W, Wilson AW, Miller JD (2010) Characterization of a 52 kDa exoantigen of *Penicillium chrysogenum* and monoclonal antibodies suitable for its detection. Mycopathologia 169:15–26.

167. Sumarah MW, Puniani E, Sørensen D, Blackwell B, Miller JD (2010) Secondary metabolites from anti-insect extracts of endophytic fungi isolated from *Picea rubens*. Phytochemistry 71:760-765.

168. Krieger J, Jacobs DE, Ashley PJ, Baeder A, Chew GL, Dearborn D, Hynes HP, Miller JD, Morley R, Rabito F, Zeldin DC (2010) Housing interventions and control of asthma-related indoor biologic agents: a review of the evidence. J Public Health Man & Practice 16: s11-S20.

169. Johnson L, Smith ML, Begin M, Fraser, B, Miller JD (2010) Remediating office environments of spore-forming bacteria. J Occupational Environmental Hygiene 7: 585–592.

170. Dales RE, Ruest K, Guay M, Marro K, Miller JD (2010) Residential fungal growth and incidence of respiratory illness during the first two years of life. Environmental Research 110:692–698.

171. Loo CKJ, Foty RG, Wheeler AJ, Miller JD, Evans G, Stieb DM, Dell SD (2010) Do questions reflecting indoor air pollutant exposure from a questionnaire predict direct measure of exposure in owner-occupied houses? Int J Environ Res Public Health 7:3270-3297.

172. Shi C, Smith ML, Miller JD (2011) Characterization of human antigenic proteins SchS21 and SchS34 from *Stachybotrys chartarum*. Int Arch Allergy Immunol 155: 74-85.

173. Wheeler AJ, Xu X, Kulka R, You H, Wallace L, Mallach G, Van Ryswyk K, MacNeill M, Kearney J, Rasmussen P, Dabek-Zlotorzynska E, Wang D, Poon R, Williams R, Stocco C, Anastassopoulos A, Miller JD, Dales RE, Brook JR (2011) Windsor, Ontario exposure assessment study: design and methods validation of personal, indoor and outdoor air pollution monitoring. J Air Waste Man Assoc 61:142-156.

174. Liang Y, Zhao W, Xu J, Miller JD (2011) Characterization of two related exoantigens from the biodeteriogenic fungus *Aspergillus versicolor*. Int Biodeg Biodet 65:217-226.

175. McKeague M, Bradley C, Degirolamo A, Visconti A, Miller JD, Derosa M (2011) Screening and initial binding assessment of fumonisin B1 aptamers. Int J Molecular Sci 11:4864-4881.

176. Arrandale VH, Brauer M, Brook JR, Brunekreef B, Gold DR, London SJ, Miller JD, Ozkaynak H, Ries NH, Sears MR, Silverman FS, Takaro TK (2011) Exposure assessment in cohort studies of childhood asthma. Environ Health Perspect 119:591-597.

177. Cherid H, Foto M, Miller JD (2011) Performance of two different Limulus Amebocyte Lysate assays for the quantitation of fungal glucan. J Occ Environ Hygiene 8:540-543.

178. De Girolamoa A, McKeague M, Miller JD, DeRosa MC, Visconti A (2011) Determination of ochratoxin A in wheat after clean-up through a DNA aptamer-based solid phase extraction column. Food Chemistry 127:1378–1384.

179. Rand TG, DiPenta J, Robbins C, Miller JD (2011) Effects of low molecular weight fungal compounds on inflammatory gene transcription and expression in mouse alveolar macrophages. Chem Biol Interact 190:139–147.

180. Sumarah MW, Kesting JR, Sørensen D, Miller JD (2011) Antifungal metabolites from fungal endophytes of *Pinus strobus*. Phytochemistry 72:1833-1837.

181. Shi C, Miller JD (2011) Characterization of the 41 kDa allergen Asp v 13, a subtilisin-like serine protease from A*spergillus versicolor*. Molecular Immunology 48:1827-1834.

182. Shi C, Belisle D, Miller JD (2011) Quantification of the *Aspergillus versicolor* allergen in house dust. J Immunol Methods 372:89–94.

183. Shi C, Belisle D, Levac S, Miller JD (2012) The development and validation of an assay for the quantification of the *P. chrysogenum* allergen Pch52. J Occ Environ Hygiene 9:211-216.

184. Johnson L, Miller JD (2012) Consequences of large-scale production of marijuana in residential buildings. Indoor Built Environment 21:595–600.

185. Trimble LA, Sumarah MW, Blackwell BA, Wrona MD, Miller JD (2012) Characterization of (16R) and (16S)-hydroxyroquefortine C; diastereomeric metabolites from *Penicillium crustosum* DAOM 215343. Tetrahedron Letters 53:956–958.

186. Shi C, Miller JD (2012) Sta c 3 epitopes and their application as biomarkers to detect specific IgE. Molecular Immunology 50:271-277.

187. Portnoy JM, Kennedy K, Sublett JL, Phipatanakul W, Matsui E, Barnes C, Grimes C, Miller JD, Seltzer JM, Williams PB, Bernstein JA, Bernstein DI, Belssing-Moore J, Cox L, Khan DA, Lang DM, Nicklas RA, Oppenheimer JA (2012) Environmental assessment and exposure control: a practice parameter--furry animals. Ann Allergy Asthma Immunol 108:223-238.

188. Bondy G, Mehta R, Caldwell D, Coady L, Armstrong C, Savard M, Miller JD, Chomyshyn E, Bronson R, Zitomer N, Riley RT (2012) Effects of long term exposure to the mycotoxin fumonisin B(1) in p53 heterozygous and p53 homozygous transgenic mice. Food Chem Toxicol 50:3604-3613.

189. Phipatanakul W, Matsui E, Portnoy J, Williams PB, Barnes C, Kennedy K, Bernstein D, Blessing-Moore J, Cox L, Khan D, Lang D, Nicklas R, Oppenheimer J, Randolph C, Schuller D, Spector S, Tilles SA, Wallace D, Sublett J, Bernstein J, Grimes C, Miller JD, Seltzer J (2012) Environmental assessment and exposure reduction of rodents: a practice parameter. Ann Allergy Asthma Immunol 109: 375–387.

190. McMullen DR, Sumarah MW, Miller JD (2012) Chaetoglobosins and azaphilones produced by Canadian strains of *Chaetomium globosum* isolated from the indoor environment. Mycotoxin Research 29:47-54.

191. Tellenbach C, Sumarah, MW, Grünig CR, Miller JD (2013) Inhibition of *Phytophthora* species by secondary metabolites produced by the dark septate endophyte *Phialocephala europaea*. Fungal Ecology 6:12–18.

192. McMullin DR, Sumarah MW, Blackwell BA, Miller JD (2013) New azaphilones from *Chaetomium globosum* isolated from the built environment. Tetrahedron Letters 54:568–572.

193. Provost NB, Shi C, She, Y-M, Cyr TD, Miller JD (2013) Characterization of an antigenic chitosanase from the cellulolytic fungus *Chaetomium globosum*. Medical Mycology 51:290-299.

194. Rand TG, Robbins C, Rajaraman D, Sun M, Miller JD (2013) Induction of Dectin-1 and asthma-associated signal transduction pathways in RAW 264.7 cells by a triple helical (1, 3)-β-D glucan, curdlan. Arch Toxicol 87:1841-1850.

195. Portnoy J, Sublett J, Kennedy K, Barnes C, Chew GL, Grimes C, Matsui EC, Miller JD, Miller JD, Phipatanakul W, Seltzer J, Williams PB (2013). Environmental assessment and exposure reduction of cockroaches: A practice parameter. J Allergy Clin Immunol 132:802-32.

196. Portnoy J, Miller J, Williams B, Chew GL, Miller JD, Zaitoun F, Phipatanakul W, Kennedy K, Barnes C, Grimes C, Larenas-Linnemann D, Sublett J, Bernstein D, Blessing-Moore J, Khan D, Lang D, Nicklas R, Oppenheimer J, Randolph C, Schuller D, Spector S, Tilles SA, Wallace D (2013) Environmental assessment and exposure control of dust mites: a practice Parameter. Ann Allergy Asthma Immunol 111:465-507.

197. Shi C, Provost NB, Desroches T, Miller JD (2014) The quantification of *C. globosum* spores in house dust samples. Annals Agric Environ Medicine 21:449–454.

198. Miller JD, Schaafsma AW, Bhatnagar D, Bondy G, Carbone I, Harris LJ, Harrison G, Munkvold GP, Oswald IP, Pestka JJ, Sharpe L, Sumarah MW, Tittlemier SA, Zhou T (2014) Mycotoxins that affect the North American Agri-Food sector: state of the art and directions for the future. World Mycotoxin J 7:63-82.

199. McMullin DW, Nsiama T, Miller JD (2014) Isochromans and α-pyrones from *Penicillium corylophilum*. J Natural Products 77:206-212.

200. McMullin DW, Nsiama T, Miller JD (2014) Secondary metabolites from *Penicillium corylophilum* isolated from damp buildings. Mycologia 106:621–628.

201. Desroches T, McMullin DW, Miller JD (2014) Extrolites of *Wallemia sebi*, a very common fungus in the built environment. Indoor Air 24: 533–542.

202. Dell SD, Jerrett M, Beckerman B, Brook JR, Foty RG, Gilbert NL, Marshall L, Miller JD, Toa T, Walter SD, Stieb DM (2014). Presence of other allergic disease modifies the effect of early childhood traffic-related air pollution exposure on asthma prevalence. Environ Int 65:83-92.

203. Richardson, SN, Walker AK, Nsiama TK, McFarlane J, Sumarah MW, Ibrahim A, Miller JD (2014) Griseofulvin-producing *Xylaria* endophytes of *Pinus strobus* and *Vaccinium angustifolium*: evidence for a conifer-understory species endophyte ecology. Fungal Ecology 11:107–113.

204. Frasz SL, Walker AK, Nsiama TK, Adams GA, Miller JD (2014) Distribution of the foliar fungal endophyte *Phialocephala scopiformis* and its toxin in the crown of a mature white spruce tree as revealed by chemical and qPCR analyses. Can J Forest Rès doi: 10.1139/cjfr-2014-0171

205. Sumarah MW, Walker AK, Seifert KA, Todorov A, Miller JD (2014) Screening of fungal endophytes isolated from Eastern White Pine needles. Recent Adv Phytochem (in press)

BOOKS

1. Miller JD, Trenholm HL (eds; 1994). Mycotoxins in grain: compounds other than aflatoxin. Eagan Press, St. Paul, MN. 552 p

2. Howard DH, Miller JD (eds; 1996) The Mycota, Vol. VI, Human and Animal Relationships. Springer-Verlag, Berlin. 399 p

3. Flannigan B, Samson RA, Miller JD (eds; 2001; reprinted with corrections 2004). Microorganisms in Home and indoor work environments: Diversity, Health Impacts, Investigation and Control. Taylor & Francis, London. 490 p

4. Dillon HK, Heinsohn PA, Miller JD (eds; 1996) Field guide for the determination of biologicalcontaminants in environmental samples. American Industrial Hygiene Association, Fairfax, VA. 174 p

5. Hung LL, Miller JD, Dillon HK (eds; 2002) Field guide for the determination of biological contaminants in environmental samples, second edition. American Industrial Hygiene Association,

Fairfax, VA. 284 p

6. Prezant B, Weekes D, Miller JD (2008; eds) Recognition, evaluation and control of indoor mold. American Industrial Hygiene Association, Fairfax, VA. 253 p

7. Flannigan B, Samson RA, Miller JD (eds; 2011) Microorganisms in home and indoor work environments: diversity, health impacts, investigation and control, second edition. Taylor & Francis, New York. 529 p.

8. Pitt JI, Wild CP, Baan RA, Gelderblom WCA, Miller JD, Riley RT, Wu F (2012). Improving public health through mycotoxin control. International Agency for Research on Cancer Scientific Publications Series, No. 158. Lyon, France. 151p

BOOK AND REVIEW CHAPTERS

1. Contributed a section on *Fusarium* toxin physiology to "Protection against trichothecene mycotoxins" National Academy of Sciences, Washington, D.C. p. 27-31.

2. Miller JD (1984) Biosynthetic studies in Canadian mycotoxin research. In: Scott PM, Trenholm HL, Sutton MD (eds) Mycotoxins: A Canadian perspective. Environmental Substances Publication 22848. National Research Council, Ottawa. p. 37-42.

3. Miller JD (1986) Secondary metabolites in marine fungi. In: Moss ST (ed) Biology of marine fungi. Cambridge University Press, UK p. 61-67.

4. Miller JD (1986) Toxins of endophytic and epiphytic fungi of conifer needles. In: Fokkema NJ, Van Huevel J (eds) Microbiology of the phyllosphere. Cambridge University Press, UK p. 223-231.

5. Newell SY, Fallon RD, Miller JD (1986) Measuring fungal biomass dynamics in standing dead leaves of a salt marsh plant. In: Moss ST (ed) Biology of marine fungi. Cambridge University Press, UK p. 19-25.

6. Tobin RS, Baranoski E, Gilman AP, Kuiper-Goodman T, Miller JD (1987) Significance of fungi in indoor air. Can J Public Health 78 (s): i-32.

7. Miller JD, Greenhalgh R (1988) Biotechnology in crop protection-metabolites of fungal pathogens and plant resistance. In: Hedin P, Menn JJ, Hollingworth P (eds) Biotechnology in crop protection. American Chemical Society, Washington, DC p. 117-129.

8. Wang YZ, Miller JD (1988) Screening techniques and sources of resistance to Fusarium head blight. In: Klatt AY (ed) Wheat Production constraints in tropical environments. CIMMYT, Mexico, DF p. 239-250.

9. Nathanson T, Miller JD (1989) Studies of fungi in indoor air in large buildings. In: Flannigan B (ed) Airborne deteriogens and pathogens. Biodeterioration Society. Kew, UK p. 129-138.

10. Miller JD (1989) Biochemical nature of mycotoxins and host tolerance. In: Kohli MM (ed) Taller sobre la fusariosis de la espiga en América del sur. CIMMYT, Mexico, DF p.131-140.

11. Jones EBG, Miller JD (eds; 1989) Aspects of marine microbiology. Progress in Oceanography 21:1-120.

12. ApSimon JW, Blackwell BA, Blais L, Fielder DA, Greenhalgh R, Kasitu G, Miller JD, Savard ME (1990) Mycotoxins from *Fusarium* species: detection, determination and variety. Pure and Applied Chemistry 62: 1339-1346.

13. Miller JD (1991) Mycology, mycologists and biotechnology. In: Hawksworth DL (ed) Frontiers in mycology. CAB International, Kew, UK p. 225-240.

14. Miller JD (1991) Significance of grain mycotoxins for health and nutrition. In: Champ BR, Heighley E (eds) Fungi and mycotoxins in stored products. Australian Centre for International Agricultural Research Proceedings #36. ISBN 1 863200401 p. 126-135.

15. Walkinshaw DS, Miller JD (eds;1992) IAQ 90: Characterization of indoor Air. Atmospheric Environment 26A: 2137-2258.

16. Miller JD (1994) Epidemiology of *Fusarium graminearum* diseases of wheat and corn. In: Miller JD, Trenholm HL (eds), Mycotoxins in grain: compounds other than aflatoxin. Eagan Press, St. Paul, MN. p. 19-36.

17. Beardall JA, Miller JD (1994) Human disease in which mycotoxins have been suggested as among the causal factors. In: Miller JD, Trenholm HL (eds) Mycotoxins in grain: compounds other than aflatoxin. Eagan Press, St. Paul, MN. p. 487-540.

19. Drafted sections on *Fusarium* toxins and ochratoxin to the International Agency for Research on Cancer (WHO) Monographs on the evaluation of carcinogenic risks to humans. Vol. 56. Lyon, France, 1993.

20. Beardall J, Miller JD (1994) Natural occurrence of mycotoxins other than aflatoxin in Africa, Asia and South America. Mycotoxin Research 10:21-4.

21. ApSimon JW, Blackwell BA, Edwards OE, Fruchier A, Miller JD, Savard ME, Young JC (1994) The chemistry of fumonisins and related compounds. Fumonisins from *Fusarium moniliforme*: chemistry, structure and biosynthesis. Pure & Appl Chem 66: 2315-2318.

22. Miller JD (1994) Mycotoxins. In: Rylander R, Jacobs RR (eds) Handbook of organic dusts. Lewis Publishers, Boca Raton, FL. p. 87-92.

23. Flannigan B, Miller JD (1994) Health implications of fungi in indoor environments - an overview. In: Samson R, Flannigan B, Flannigan ME, Graveson S (eds) Health implications of fungi in indoor environments. Elsevier, Amsterdam. p. 3-28.

25. Miller JD (1999) Mycotoxins. In: Francis FJ (ed) Encyclopedia of food science and technology. John Wiley, New York. p.1698-1706.

26. Miller JD (2000) Mycotoxins- a food related problem. In: Moller L (ed) Environmental medicine. Joint Industrial Safety Council, Stolckholm, Sweden. p. 248-259.

27. Miller JD (2000) Screening for secondary metabolites. In: Hyde KD, Pointing SB (eds) Marine mycology: A practical approach. Fungal Diversity Research Series 1, Fungal Diversity Press, Hong Kong. p. 158-171.

28. Marasas WFO, Miller JD, Riley RT, Visconti A (drafting authors; 2000) Fumonisin B1. Environmental Health Criteria 219. WHO, Geneva. 150 p.

29. Flannigan B, Miller JD (2001) Microbial growth in indoor environments. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control. Taylor & Francis, London. p. 35-67.

30. Dales RE, Miller JD (2001) Building-related illness: epidemiological and case-related evidence. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control. Taylor & Francis, London p.217-227.

31. Miller JD (2001) Mycological investigations of indoor environments. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control. Taylor & Francis, London. p. 231-246.

32. Samson RA, Houbraken J, Summerbell RC, Flannigan B, Miller JD (2001) Common and important species of fungi and actinomycetes in indoor environments. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control. Taylor & Francis, London. p. 287-473.

33. Miller JD, ApSimon JW, Blackwell BA, Greenhalgh R, Taylor A (2001) Deoxynivalenol: A 25 year perspective on a trichothecene of agricultural importance. In: Summerell BA, Leslie JL, Backhouse D, Bryden WL, Burgess LW (eds) *Fusarium*: Paul E. Nelson Memorial Symposium. APS Press, St. Paul, MN. p. 310-320.

34. Marasas WFO, Miller JD, Riley JT, Visconti A (2001) Fumonisin- occurrence, toxicology, metabolism and risk assessment. In: Summerell BA, Leslie JL, Backhouse D, Bryden WL, Burgess LW (eds) *Fusarium*.APS Press, St. Paul, MN. p. 332-359.

35. Miller, J.D. (2001) Mycotoxins. In: Pimentel, D. (editor). Encylopedia of pest management. Marcel Dekker, New York. p. 517-519.

36. Drafted sections on Fumonisin B1 and aflatoxin for the International Agency for Research on Cancer WHO) Monographs on the evaluation of carcinogenic risks to humans. Vol. 82: Lyon, France, 2003.

37. Miller JD, Heinsohn P (2005) Total Spore Trap Samplers. In: Hung LL, Miller JD, Dillon HK (eds) Field guide for the determination of biological contaminants in environmental samples, second edition. American Industrial Hygiene Association, Fairfax, VA p.141-159.

38. Miller JD (2005) Fungal glucan, β 1,3 D glucan. In: Hung LL, Miller JD, Dillon HK (eds) Field guide for the determination of biological contaminants in environmental samples, second edition. American Industrial Hygiene Association, Fairfax, VA p. 195-198.

39. Fedoruk J, Miller JD (2005) Health effects of bioaerosols. In: Hung LL, Miller JD, Dillon

HK Field guide for the determination of biological contaminants in environmental samples, second edition. American Industrial Hygiene Association, Fairfax, VA p. 3-28.

40. Miller JD, Dillon HK (2005) Viable fungi and bacteria in air, bulk, and surface samples In: Hung LL, Miller JD, Dillon HK (eds) Field guide for the determination of biological contaminants in environmental samples, second edition. American Industrial Hygiene Association, Fairfax, VA
p. 93-128.

41. Miller JD, Rand TG , McGregor H, Solomon J, Yang C (2008) Mold ecology: recovery of Fungi from certain moldy building materials. In: Prezant B, Weekes D, Miller JD (eds) Recognition, Evaluation and Control of Indoor Mold. American Industrial Hygiene Association, Fairfax, VA. pp. 43-51.

42. Miller JD (2011) Mycological investigations of indoor environments. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control, second edition. Taylor & Francis, New York. pp. 229-245.

43. Rand TG, Miller JD (2011) Toxins and inflammatory compounds. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control, second edition. Taylor & Francis, New York. pp. 291- 306.

44. Flannigan B, Miller JD (2011) Microbial growth in indoor environments. In: Flannigan B, Samson RA, Miller JD (eds) Microorganisms in home and indoor work environments: Diversity, Health Impacts, Investigation and Control, second edition. Taylor & Francis, New York. pp. 57- 107.

45. Miller JD (2011) Foliar endophytes of spruce species found in the Acadian forest: basis and potential for improving the tolerance of the forest to spruce budworm. In: Frank CA, Pirttila AM (eds) Endophytes of forest trees: biology and applications. Springer, New York. pp. 237-249.

46. Miller JD (2011) Health effects from mold and dampness in housing in western societies: early epidemiology studies and barriers to further progress. In: Adan O, Samson RA (eds). Molds, water, and the built environment. Wageningen Academic Press, The Netherlands. pp. 211-243.

47. Norbäck S, Miller JD (2013) Building-Related Illnesses and mold related conditions. In Bernstein DI, Malo J-L, Chan Yeung M, Bernstein L (2012) Asthma in the Workplace, 4th edition. Taylor & Francis, New York. pp. 406-417.

48. Miller JD (2013) Mycotoxins. In: Jorgenson SV (ed) Encyclopedia of Environmental Management, Taylor & Francis, New York. pp 1696-1699.

REVIEWED CONFERENCE PROCEEDINGS

1. ApSimon JW, Blackwell BA, Greenhalgh R, Meier RM, Miller JD, Paré JRJ, Taylor A (1986) Secondary metabolites produced by some *Fusarium* species. In: Steyn PS (ed) Proceedings of the 6th IUPAC international symposium on mycotoxins and phycotoxins. Elsevier Press, Amsterdam p. 137-152.

2. Greenhalgh R, Blackwell BA, Paré JRJ, Miller JD, Levandier D, Meier RM, Taylor A, ApSimon JW (1986) Isolation and characterization by mass spectrometry and NMR spectroscopy of secondary metabolites of some *Fusarium* species. Steyn PS (ed) Proceedings of the 6th IUPAC international symposium on mycotoxins and phycotoxins. Elsevier Press, Amsterdam p. 125-136.

3. ApSimon JW, Fielder D, Meier RM, Delmond B, Greenhalgh R, Blackwell BA, Miller JD (1987) Trichothecenes and other sesquiterpenes from Fusarium species. In: Progress in terpene chemistry. Edited by D. Joulain, Edition Frontieres, Gif-sur-Yvette, France.

4. Miller JD (1988) Effects of *Fusarium graminearum* metabolites on wheat cells. In: Graniti A, Durbin R, Ballio A (eds) NATO Advanced Workshop on phytotoxins in plant pathogenesis. Springer-Verlag. p. 449-452.

5. Miller JD (1988) Mycotoxins. In: Issues in Food Safety. Beijing, China. Toxicology Forum, Washington DC p. 65-77

6. Greenhalgh R, Fielder DA, Morrison LA, Charland JP, Blackwell BA, Miller JD, Savard ME, ApSimon JW (1989) Apotrichothecenes. Minor metabolites of the *Fusarium* species. In: Natori S, Hashimoto K, Ueno Y (eds) Proceedings of the 7th international symposium on mycotoxins and phycotoxins. Tokyo. Elesevier Science Publisher, Amsterdam. p. 223-232.

7. ApSimon JW, Blackwell BA, Blais L, Fielder DA, Greenhalgh R, Kasitu G, Kendel JE, Miller JD, Savard ME (1990) The genus *Fusarium*: a versitile biosynthetic engine. In: Atta-ur-Rahman (ed) Studies in natural products chemistry 9:201-218.

8. Miller JD (1990) Fungi as contaminants of indoor air. In: Proceedings 5th international conference on indoor air quality and climate, Toronto 5: 51-64.

9. Miller JD (1991) Significance of molds in indoor air. Chronic diseases in Canada, Health & Welfare Canada, Ottawa. ISSN-0228-8699. p. 15-17.

10. Miller JD (1991) *Fusarium* toxins in food. In: Merican Z (ed) Proceedings 1st Asian conference on food safety. Malaysian Institute of Food Technology, Malaysia. ISBN 967 9986020. p. 46-52.

11. Miller JD (1992) Microbial contamination of indoor air. In: Haghighat F (ed) Acts de la 5e conférence internationale Jacques Cartier: Qualité de l'air ambiant, ventilation et économie de énergie dans les bâtements. Concordia University, Montreal. p. 1-11.

12. Miller JD (1993) Fungi and the building engineer. In: Geshwiler M (ed) ASHRAE IAQ '92, Environments for people. ASHRAE, Atlanta, GA. p. 147-162.

13. Miller JD (1993) The toxicological significance of mixtures of fungal toxins. In: Wild CP (ed) Proceedings of the Pan African Environmental Mutagen Society, Cairo. African newsletter on occupational health and safety 3: 32-38. Institute of Occupational Health, Helsinki, Finland.

14. Flannigan B, Miller JD (1993) Humidity and fungal contaminants. In: Rose WB, TenWolde (eds) Bugs, molds and rot II. National Institute of Building Sciences, Washington, DC. p. 43-50.

15. Makowski RMD, Miller JD (1994) Phytotoxic metabolites of *Colletotichum gleosporioides* f.sp. *malvae*, a mycoherbicide for round leaf mallow control. In: Delfosse ES, Scott RR (eds) Proceedings of the 8th International Symposium on Biological Control of Weeds. DSIRO/CSIRO, Melbourne, New Zealand p.78-87.

16. Miller JD (1994) Fungi and mycotoxins: implications for product research. In: Highley E, Wright EJ, Banks HJ, Champ BR (eds) Stored product protection. CAB International, UK p. 971-977.

17. Miller JD (1995) Quantification of health effects of combined exposures: a new beginning. In: Morawska L, Bofinger ND, Maroni M (eds) Indoor Air - An integrated approach. Elsevier, Amsterdam. p. 159-168.

18. Prelusky DB, Trenholm HL, Rotter BA, Miller JD, Savard ME, Young JM, Scott PM (1995) Biological fate of fumonisin B_1 in food-producing animals. In: Jackson L, DeVries JW, Bullerman LB (eds) Fumonisins in food. Plenum Press, NY. p. 265-278.

19. Bondy GM, Barker M, Mueller R, Fernie S, Miller JD, Armstrong C, Hierling SL, Rowsell P, Suzuki C (1995) Fumonisin B_1 toxicity in male sprague-Dawley rats. In: Jackson L, DeVries JW, Bullerman LB (eds) Fumonisins in food. Plenum Press, NY p. 251-264.

20. Blackwell BA, Edwards OE, Fruchier A, Asimon JW, Miller JD (1995) NMR structural studies of fumonisin B_1 and related compounds from *Fusarium moniliforme*. In: Jackson L, DeVries JW, Bullerman LB (eds) Fumonisins in food. Plenum Press, NY p. 75-92.

21. Jarvis BB, Miller JD (1996) Secondary metabolism, complexity and evolution. In: Romeo J, Saunders JA, Barbosa F (eds) Phytocehmical diversity and redundancy in ecological systems. Plenum Press, NY p. 265-293.

22. Miller JD (1996) Food-borne natural carcinogens: issues and priorities. In: Marasas WFO, Vismer HF, Lehtinen S (eds) Proceedings of the Pan African Environmental Mutagen Society, Cape Town. African Newsletter on Occupational Health and Safety. 6 (S1): 22-28.

23. Fedak G, Armstrong KC, Sinha RC, Gilbert J, Procunier JD, Miller JD, Pandea R (1997) Wide crosses to improve *Fusarium* head blight resistance to wheat. Cereal Research Communications. 25:651-654.

24. Miller JD (1998) Global significance of mycotoxins. In: Miraglia M, van Egmond H, Brera C, Gilbert J (eds) Mycotoxins and phycotoxins- Developments in chemistry, toxicology and food safety. Fort Collins, CO p.1-9.

25. Miller JD, Dales RE, White J (1999) Exposure measures for studies of mold and dampness and respiratory health. In: Johanning E (ed) Bioaerosols, fungi and mycotoxins: Health effects, assessment, prevention and control. Eastern New York Occupational and Environmental Health Center, Albany, NY, p. 298-305.

26. Poux N Pinelli E, Castegnaro M, Miller JD, Pfol-Leszkowicz A (2001) Fumonisin B1 alters expression of components of the mitogen-activated protein kinase cascade in a human epithelial cell line. In: de Koe W, Samson RA, van Egmond HP, Gibert J, Sabino, M (eds) Mycotoxins and

phycotoxins in perspective at the turn of the millennium. de Koe, Den Haag [ISBN 90-9014801-9]. p 251-260.

27. Miller JD (2002) Aspects of the ecology of *Fusarium* toxins in cereals. In: DeVries JW, Trucksess MW, Jackson LS (eds) Mycotoxins and food safety. Advances in Experimental Medicine and Biology 504: 19-28.

28. Findlay JA, Lia G, Miller JD, Womiloju T (2003). Insect toxins from conifer endophytes. In: Yayli N, Küçük M (eds) Proceedings of the 1st International Congress on the Chemistry of Natural Products (ICNP-2002) Karadeniz Technical University, Trabzon, Turkey. p.13-16.

29. Miller JD (2007) Indoor air quality and occupant health in the residential built environment: future directions. In: Yoshino H (ed) Proceedings IAQVEC 2007, Sendai, Japan. ISBN 978-4-86163-069-9, p. 15-22. http://www.aivc.org/resource/indoor-air-quality-and-occupant-health-residential-built-environment-future-directions

30. Miller JD, Jiang D, Ruest K, Dales RE (2011) The impact of wood heating in houses on airborne endotoxin & sustainable heating in rural forested areas. Indoor air 2011, Austin Texas. Electronic Proceedings, paper A1080 2, 4 pp.

MISCELLANEOUS PUBLICATIONS

1. Miller JD (1984) Marine fungi in Bermuda ecosystems. Bull Dept Agric & Fisheries, Bermuda 55: 18-27.

2. Miller JD, Dussault R, Shirtliffe C, Laflamme AM, Richardson M (1985) Studies concerning the association of filamentous fungi with UFFI in some Canadian homes. Report to the UFFI Research Committee, Consumer & Corporate Affairs, Ottawa. 105 p

3. Anon (1986) UFFI and fungus interaction. Consumer and Corporate Affairs, Ottawa, 100 p (contributed ca. 50%).

4. Miller JD (1987) Report for the Quebec Superior Court regarding the fungal research outlined in the document UFFI and fungus interaction: A working group report published by the UFFI Centre, Consumer and Corporate Affairs, June 1986. Montreal Superior Court Exhibit # SCHL, 339 A, B.

5. Miller JD (1987) Control of plant pathogens: Opportunities for the 1990's - In: Biological Control in Canada. Research Branch, Agriculture Canada, Ottawa. p. 79-85.

6. Trenholm HL, Prelusky DB, Young JC, Miller JD (1988) Reducing mycotoxins in animal feeds. Publication 1827E. Agriculture Canada, Ottawa. 22 p (also published in French, Spanish, Japanese). http://archive.org/details/reducingmycotoxi00tren

7. Van Die P, Stumborg M, Miller JD (1988) An assessment of Agriculture Canada's liquid fuels program. ESRC Report C-006, Agriculture Canada, Ottawa. 43 p

8. Wang YZ, Miller JD, Neish GA (1989) The toxins produced by three isolates of *Fusarium graminearum* from Nanjing, China. Acta Phytopathologica Sinica 19:40.

16. Miller JD (1990) Indoor air quality-research and applied perspectives. In: Real property managment in changing world. Treasury Board of Canada, Ottawa. p. 315-318.

10. Bhat RV, Miller JD (1991) Mycotoxins and the food supply. Food, Nutrition and Agriculture 1: 27-31.

11. Auger PL, Gourdeau P, Miller JD (1994) Clinical experience with patients suffering from a chronic fatigue-like syndrome and repeated upper respiratory infection in relation to airborne molds. Am J Industrial Medicine 25: 41-42.

12. Miller JD (1994) Agriculturally-important mycotoxins. ASEAN Food Handling Newsletter. 44: 5-7.

13. Wang YZ, Miller JD (1994) Toxin producing potential of *Fusarium graminearum* from China. Acta Mycologia Sinica 13: 229-234.

14. Miller JD (1995) Mycotoxins in Asia: policies for the future. ACIAR Postharvest Newsletter 32: 5-15.

15. Miller JD, Prelusky DB, Rotter BA (1995) Fumonisins: a new risk for Ontario corn. Ontario Corn Producer 11: 10.

16. Miller JD, Maroni M, Pickering A (1995) Attributable risk of air quality problems. Working group summary. In: Morawska L, Bofinger ND, Maroni M (eds) Indoor Air - An integrated approach. Elsevier, Amsterdam. p. 11-13.

17. Gammage, R., M. Maroni, J. McLaughlin, J.D. Miller, A. Pickering and G. Raw. 1995. Health risk and discomfort: summary of consensus building session. In: Morawska L, Bofinger ND, Maroni M (eds) Indoor Air - An integrated approach. p. 19-21.

18. ApSimon JW, Miller JD (1996) Fumonisins. Natural Toxins. 4: 1-2.

19. Cardwell K, Miller JD (1996) Mycotoxins in foods in Africa. Natural Toxins. 4: 103-107.

20. Miller JD (1996) Mycotoxins. In: Cadwell KF (ed) Workshop of mycotoxins in food in Africa. International Institute for Tropical Agriculture, Benin. p. 18-22.

21. Miller JD (1997) Fungi and indoor air quality. Invironment Professional 3:1-6

22. Dearborne DG, Infeld MD, Smith PG, Carroll-Pankhust C, Kosick R, Dahms BB, Balraj ER, Challenger R, Allen TM, Horgan TE, Staib R, Wallace C, Halpin HJ, Jarvis BB, Miller JD (1997) Update: Pulmonary hemorrhage/hemosiderosis among infants- Cleveland, Ohio. CDC Mortality Morbidity Weekly Report 46:33-35.

23. Horner E, Miller JD (2000) Byproducts of fungal growth that affect indoor environments. 1072-TRP, ASHRAE, 1337 Capital Circle, Atlanta, GA. 30067 USA 58 p

24. Miller JD (2001) Health and safety issues relating to mold contamination of wood chips in the wood fiber industries. Technical Bulletin 823, National Council for Air and Stream Improvement, P.O. Box 13318, Research Triangle Park, NC 27709-3318 USA 33 p

25. Miller JD (2003) Fungus among us: is your house a hold for toxic mold? Canadian Chemical News 55:19

26. Riley RT, Miller JD (2003) Case study: Risk analysis of fumonisin. In "Food Safety - Risk Analysis, A manual published by the United Nations Food & Agriculture Organization, ILSI and The Industry Council For Development. United Nations Food and Agriculture Organization, The International Life Sciences Institute and the Industry Council for Development, Rome, Italy. pp. 47

27. Miller JD (2004) Mold growth on insulation materials: From UFFI to modern products. INTC 2004 Book of papers. INDA. PO Box 1288, Cary, NC 27512 USA 11 pp.

28. Johnson L, Miller JD (2009) Consequences of the production of marijuana under the Medical Marijuana Access Regulations in residential buildings: Health and Safety. HECS, Health Canada, Ottawa. 65 pages.

29. Smith B, King E, Belisle D, Miller JD, Chapman, JD (2009) Quantitation of *Stachybotrys chartarum* Sch34 Antigen Using ELISA and Fluorescent Multiplex Array Technology. J Allergy Clin Immunol 123:S172.

30. Smith B, King E, Belisle D, Miller JD, Chapman, JD (2009) Quantitation of *Stachybotrys chartarum* Sch34 Antigen Using ELISA and Fluorescent Multiplex Array Technology. 59. 2009 AIHCE Abstracts, Toronto, p. 16.

31. Rand TG, Sun M, Gilyan A, Downey J, Miller JD (2010) The (1, 3)-β-D glucan, curdlan, induces dose and time dependent dectin-1 and inflammatory gene transcription and expression in mouse lungs. J Allergy Clin Immunol 125 S1:80.

32. Miller JD, Sun M, Gilyan A, Roy J, Rand TG (2010) Low molecular weight compounds from fungi from damp building materials induce inflammatory gene transcription and expression in mouse lungs. J Allergy Clin Immunol 125, S1:82.

33. Miller JD, Richardson SN, McMullin DR, Falardeau J (2013) Literature review on deoxynivalenol, zearalenone, T-2/H-T2 toxins, fumonisins and the fungi that produce them in Canada with a commentary on *Alternaria alternata* toxins in grains and the potential for *Aspergillus flavus* to become a problem in Ontario corn. Industry Branch, AAFC, Ottawa. pp. 233

34. Miller JD, Richardson S (2013) Mycotoxins in Canada: A Perspective for 2013. Regulatory Governance Initiative, Carleton University, Ottawa. pp 34
http://www.regulatorygovernance.ca/publications/rgi-briefs/

PATENTS

Miller JD, Adams GW (2012) Endophyte enhanced seedlings with increased pest tolerance and methods. Canadian Patent 2562175. US20130219569 [other foreign patent equivalents granted]
Miller JD Adams GW Sumarah M (2012) Antifungal metabolites from fungal endophytes of *Pinus strobus*. Canadian Patent Application CA 2766412

Indoor and Built Environment
http://ibe.sagepub.com/

Consequences of Large-scale Production of Marijuana in Residential Buildings

Luke I. Johnson and J. David Miller

Indoor and Built Environment 2012 21: 595 originally published online 1 November 2011
DOI: 10.1177/1420326X11411954

The online version of this article can be found at:
http://ibe.sagepub.com/content/21/4/595

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
ISBE

International Society of the Built Environment

>> Version of Record - Aug 12, 2012

OnlineFirst Version of Record - Nov 1, 2011

Case Report

Indoor and Built Environment

Indoor Built Environ 2012;21;4:595–600 Accepted: May 1, 2011

Consequences of Large-scale Production of Marijuana in Residential Buildings

Luke I. Johnson J. David Miller

Department of Chemistry, Carleton University, Ottawa, Canada

Key Words

Health · Marijuana grow operations · Ventilation rates · Moisture

Abstract

Based on the data from the breadth of Canada (~4300 km), one-third of Canadian homes have ventilation rates below the recommended standard of 0.3 air changes per hour and are at risk for moisture problems. For the purposes of this investigation, a literature review was performed on the health risks associated with exposure to living and drying marijuana plants and the fungi associated with large numbers of indoor plantings. Analysis was made of the impact on Canadian homes if used to grow marijuana. These are commonly called "marijuana grow operations" based on measured ventilation rates from homes in Windsor, Ontario and Regina, Saskatchewan (representing diverse climates) and derived moisture loadings from published data. The growing and drying of marijuana plants contributes considerable amounts of water vapour to the indoor environment. Depending on the scale of production, considerable mould damage in the building can result. There are also a number of abiotic hazards resulting from marijuana production including pesticides, carbon monoxide, and products of unvented combustion appliances. Both indirect and direct evidence are described for the health impact of living in these conditions. This has a number of implications in terms of documentation and personal protection for industrial hygienists, home inspectors, and public health officials.

Introduction

Canada is second to the USA among industrialized nations in marijuana production, although it is illegal to produce and sell this plant in both nations. This demand has caused an increase in the number of illegal "marijuana grow operations" (MGOs) in homes [1,2]. To 2003, the average number of seized plants in Ontario MGOs was *ca.* 340. The exposed population to these conditions is not well defined. As a proxy for the total, *ca.* 1000 children were found in a 3-year period in MGOs in Ontario and the estimated total number might be considerably larger, 10,000 [3]. A study from the greater Vancouver area indicated many MGOs are "guarded" by immigrant families including young children (*ca.* 20%), and that these families are accessing the health care system [4]. Across Canada, there is an increasing number of former

DOI: 10.1177/1420326X11411954
Accessible online at http://ibe.sagepub.com

Dr J. David Miller,
Department of Chemistry, Carleton University, Ottawa, ON K1S 0M3 Canada
Tel. 1 613 520 2600 ext 1053, Fax 1 613 520 3749,
E-Mail david_miller@carleton.ca

MGOs that were not detected by the police. These homes are often purchased by unsuspecting people who face both health and legal challenges, although the exact number of affected people is not known [5,6].

In 2001, the Canadian Medical Marijuana Access Regulation (MMAR) [7] came into effect. In terms of population size, there were 4900 license holders of whom 3600 grow between 2 and 292 marijuana plants for personal use in January 2010 (http://www.hc-sc.gc.ca/dhp-mps/marihuana/stat/index-eng.php). This option is not available in the USA. The percentage of licensees that grow their own plants has been stable at ~70% for some years; the remaining individuals pool their permits to a maximum of three. The average number of plants grown by individuals is 25. Approximately, 2000 physicians issue permits under these regulations. The larger, legal MGOs in Canada potentially pose many of the same risks as illegal MGOs.

There are two main sources of moisture associated with the cultivation of marijuana indoors (1) moisture from the cultivation of the plant and (2) moisture arising from the drying of the plant. These sources are additional to those associated with the normal operation of the house or apartment building. These may include occupant sources, water leaks and ventilation failure leading to condensation [8–11]. Increased moisture results in growth of the saprophytic fungi characteristic of damp building materials [12,13]. Such growth is a function of internal moisture source strength [9]. Cultivation and drying of marijuana in residential dwellings may result in extensive environmental contamination and damage to the building. A study of illegal MGOs across Canada found that 11 of 12 had serious mould and moisture damage and evidence of the use of large amounts of pesticides and fertilizers. An attempt is made to keep grow operations warm and humid, and the odour of growing marijuana is distinctive, i.e. detected by authorities and/or neighbours. For both these reasons, efforts are made to seal the buildings to avoid detection [6]. This reduces the designed ventilation rate for the homes and hence moisture removal.

The purpose of this paper is to describe the potential damage and public health consequences of the input of additional moisture to the air within residential housing from the growth and drying of different numbers of large plants indoors in the existing housing stock in representative cities in Canada. We calculated the moisture load that a typical marijuana plant adds to a house. This is interpreted in relation to how this relates to mould growth on the building fabric and the effects of saprophytic mould on population health. Except under controlled conditions, the dominant fungus on drying plants is *Aspergillus fumigatus*, an allergenic species and a facultative pathogen. Additional literature reviews were conducted in order to evaluate the health risks more specific to the conditions associated with marijuana production in residential environments.

Methods

Moisture release of potted plants varies from 7 to 15 $g \cdot h^{-1}$ [14]. Based on the moisture release rate of a related plant [15] and scaled for mass after Kaa [16], a full-grown marijuana plant was calculated to release 18 $g \cdot h^{-1}$ of water vapour (432 $g \cdot day^{-1}$). This value is consistent with an estimate by Christian [17].

Typically, moulds require a water activity (a_w) of at least 0.80–0.85 to promote rapid growth [13,14]. Like all "medicinal" plants, marijuana is at a much increased risk of mould growth during the drying period after harvest unless appropriate equipment is used. During this time, water previously bound to cells becomes available to fungi as the plant begins to decay. Dead and drying plant material with moisture contents above ~12% has an a_w sufficient to promote fungal growth. Moisture content >20% in drying plant material promotes rapid fungal growth [18]. This formed the indirect evidence to exposure from moulds on the plants, which were more directly answered by looking at concentrations of moulds on the marijuana and from patient reactions to smoking it.

Measured ventilation rates in winter were obtained from CMHC and Health Canada for 59 homes in Windsor and 103 in Regina (Wheeler, Heroux, Fugler, unpublished data). This was done by the Oak Ridge National Laboratory method; also, see Ref. [19] for an explanation of the method. Conditions in Windsor, Ontario (hot and humid in summer, moderate in winter) and Regina, Saskatchewan (moderate in summer; cold and dry in winter) were calculated and measured data were obtained for Ottawa (hot, often cold in winter) [20,21]. These cities represent communities with different climates in Canada. Growth of fungi on drying plants was assessed from the literature and from objective data.

Information on health effects of dampness and housing was taken from recent cognizant authority reviews [22–27]. A literature search of published peer reviewed journal articles was conducted in early 2009 for additional hazards that might relate to marijuana production in houses. The following databases were included: Web of Science, PubMed, EMBASE, MEDLINE, the Cochrane Library,

Sci Finder, government documents and those of professional groups. The search included publications from 1978. Boolean searching was used to combine up to 20 keywords and/or MESH headings. Keywords were classified as fungal (e.g. fungi, mould, *A. fumigatus*), environmental hazard (e.g. pesticides, herbicides, defoliant), relating to marijuana grow operations (e.g. marijuana, cannabis, MGOs), health (e.g. rhinitis, dermatitis, lung function), and moisture. Studies were assessed for relevance and whether they met all the Klimisch criteria [28]. The primary screening process involved one reviewer screening *ca.* 5000 articles. Two reviewers conducted the secondary screening process applying the relevance and quality criteria independently for the 300 studies selected. Biological and chemical contaminants arising from medium to large-scale cultivation of marijuana were identified during this process.

Results

Moisture Burdens

As plants are added to an MGO, moisture release will overwhelm home ventilation capacity and/or worsen the situation, if ventilation failure already exists. In Canada, the recommended combined infiltration and mechanical ventilation is 0.3 air changes per hour ($ac{\cdot}h^{-1}$) for a household of typical occupancy [20]. Air change rates are a function of outside air infiltration and mechanical ventilation in comparison to house volume. The recommended rate is meant to handle the daily moisture load produced by a typical family, prevent mould growth and reduce other airborne contaminants. A five person family releases $15\,kg{\cdot}day^{-1}$ water vapour [29].

In general, homes built after 1980 in Ottawa are at high risk of moisture damage if used as MGOs. Air change rates much higher than those normally found in new homes would be required to tolerate the additional moisture. Many Windsor homes (41%) had air change rates below the recommended standard and would be unable to handle more than one or two house plants (Table 1). The additional moisture released by 100 plants would result in mould growth in all the Windsor homes. The average air change rate for Windsor homes tested was $0.45\,ac{\cdot}h^{-1}$ (range $0.11–1.98\,ac{\cdot}h^{-1}$), at this rate ~16 plants could be theoretically tolerable. Data collected from Regina homes showed a similar trend. Many homes (38 of 103, i.e. 37%) were inadequately ventilated. Air change rates ranged from 0.072 to $3.02\,ac{\cdot}h^{-1}$ with a median of $0.463\,ac{\cdot}h^{-1}$. Of all 103 homes tested, only eight could theoretically tolerate the moisture released by >100

Table 1. Maximum tolerable number of marijuana plants for houses in Windsor, ON

No.	Air change rate ($ac{\cdot}h^{-1}$)	House volume (m^3)	Maximum tolerable number of marijuana plants
1	0.105	680	[a]
2	0.106	566	[a]
3	0.118	1019	[a]
4	0.121	657	[a]
5	0.147	498	[a]
6	0.162	521	[a]
7	0.167	566	[a]
8	0.174	770	4
9	0.185	612	[a]
10	0.186	634	[a]
11	0.225	748	14
12	0.227	680	10
13	0.243	634	10
14	0.244	634	10
15	0.247	453	[a]
16	0.253	408	[a]
17	0.256	453	[a]
18	0.258	177	[a]
19	0.258	408	[a]
20	0.269	295	[a]
21	0.271	453	1
22	0.286	362	[a]
23	0.311	181	[a]
25	0.336	634	27
26	0.337	725	36
27	0.347	544	20
28	0.354	227	[a]
29	0.355	222	[a]
30	0.369	227	[a]
31	0.422	476	24
32	0.427	725	55
33	0.466	227	[a]
34	0.468	295	[a]
35	0.482	283	5
36	0.495	453	30
37	0.513	227	[a]
38	0.521	215	[a]
39	0.527	430	31
40	0.535	680	71
41	0.544	340	19
42	0.549	340	19
43	0.553	453	38
44	0.556	630	67
45	0.571	680	78
46	0.571	385	29
47	0.595	906	122
48	0.603	362	29
49	0.612	249	9
51	0.650	272	17
52	0.657	272	17
53	0.697	261	18
54	0.723	204	8
55	0.748	283	27
56	0.877	227	23
57	0.923	396	72
58	0.934	204	21
59	1.982	227	96
Average	0.442	451	19

Note: [a]Existing risk to moisture problems.

marijuana plants, assuming that the home did not have an existing mould problem. On average, houses in Regina could theoretically tolerate 31 marijuana plants; however, when homes with air change rates above 1 $ac \cdot h^{-1}$ (7 homes) are excluded, the number of home drops to 19 (data not shown), comparable to Windsor data.

These estimates cannot include the moisture released from drying. To assess this, the presence of mould on the product was used as an indicator of the percentage that is not dried properly (which would demonstrate the use of an appropriate drier indoors). Most samples (>90%) of dried marijuana test showed evidence growth of the allergenic and opportunistic pathogens such as *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus niger*, *Mucor* species, and various *Penicillium* species. In most samples tested, mould contamination was high (10^4–10^7 $CFU \cdot g^{-1}$) [30–33].

Discussion

Infiltration was essentially the sole source of air change within Canadian homes built before World War II (WWII). These poorly insulated, air leaky homes have (or had) air change rates well above 0.3 $ac \cdot h^{-1}$. Since WWII, however, there has been a need for greater energy efficiency and hence better insulation in homes. To maintain air change rates, mechanical ventilation was developed; however, many new homes have been left with inadequate ventilation [20].

Leaves of all plants bear various phylloplane fungi. The spores of these dominate outdoor air during the growing season and primarily comprise the fungus *Alternaria alternata* and a number of species of *Cladosporium*, but mainly *Cladosporium herbarum* and *Cladosporium cladosporioides*. A large percentage of the population is allergic to these fungi [34]. *A. fumigatus* grows and dominates on decaying vegetation under warm conditions or where biological heating has taken place, including piles of leaves or compost. It is cellulolytic on delignified materials including leaves as well as paper and fabrics. The prevalence of *A. fumigatus* contamination of marijuana resulting from growing, harvesting, or smoking marijuana poses a health risk. These risks include allergic reactions [13,35]. Aside from respiratory disease, those allergic individuals with chronic high exposure may also develop allergic bronchopulmonary aspergillosis or ABPA [35,36]. *A. fumigatus* infections have also been reported in marijuana-exposed populations [37–41].

Dales et al. [8] note that apart from floods, there are four major sources of mould growth in residences: leaks in building fabric (rare in Canada because it is cold to very cold in winter and for the particular reason noted previously, uncommon in MGOs), ventilation failure leading to condensation, unattended plumbing leaks and household mould (e.g. mould growth on kitchen and bathroom surfaces, hidden food spills, etc.). Some degree of mould damage is present in ~30% of Canadian homes [42,43]. Inadequate ventilation for the internal moisture sources in a house accounts for most mould growth [9,10]. As noted, field experience indicates that mould damage in MGOs is often extensive [3–6].

Reviews by cognizant authorities, Health Canada (2004) [22], INSPQ (2002) [23], the Institute of Medicine, US National Academy of Sciences [24,25], an expert panel of the United States Centers for Disease Control/National Center for Healthy Homes [26] and the World Health Organization [26] emphasize the effects on population health of mould in the context of building dampness. These include increased allergic and upper respiratory disease. Health Canada [44] and Krieger et al. [26] state that there is sufficient evidence for health benefit from remediation of mould and dampness. Fungi are associated with new onset asthma in both adults and children and with non-atopic asthma [45,46].

The field data that exist reveal a number of poorly quantified abiotic factors. The cultivation of marijuana requires the large-scale use of liquid fertilizers, insecticides and fungicides [3,4,6] not authorized for indoor use. Residues of the pesticides are detected on marijuana [33]. It is common for operators of detected MGOs in Vancouver to disconnect the furnace and re-vent the exhaust into the grow area to increase the carbon dioxide concentration (60% of detected MGOs) [4]. Virtually, all these houses had illegal wiring, and by-passes to the electrical meters [3,4]. Aside from the potential for CO poisoning, heating is also done with unvented combustion appliances thus increasing NO_2 and particulate exposures which are harmful to respiratory health [8]. There has been little systematic study of these contaminants.

From Ontario to British Columbia, the large majority of MGOs are occupied by families including children [3,4,47]. It is reasonable to anticipate that this is also the case in the USA. In response, Alberta enacted the *Drug-Endangered Children Act*. This legislation states that children exposed to an environment where manufacturing occurs, may need protection on health grounds. In the rest of Canada, Medical Officers of Health, the Provincial Health Department, and other authorities can act to

protect child health. Documenting the environmental conditions is required before taking any legal action.

Of particular concern is that at least one-third of Canadian homes could not theoretically tolerate the additional water vapour released by marijuana plants. Considering the number of plants found at illegal MGOs (and MMAR), few, if any, homes in the cities examined would be able to tolerate additional moisture. There are few data on ventilation rates in multi-unit apartment buildings. However, the available data suggest that they are likely lower than assumed and that odour transfer problems are not uncommon [48,49]. Again, this assumes that the home or apartment does not have an existing mould problem, which is an uncertain assumption. Both US and Canadian studies indicate that the attributable risk for asthma and respiratory disease from mould growth in homes is on the order of 20% [50,51]. Some risk to population health is associated with exposure to *A. fumigatus* and is related to the extent of marijuana drying that is done in a MGO. In the case of marijuana production under MMAR, houses and apartments would have to be evaluated on a case by case basis and special rooms built to permit the cultivation of the plant indoors.

It is important to note that well-maintained house plants (which are much smaller than marijuana plants) are not a particular risk. The assumption has been made that homes have fewer than three plants [29]. However, as the number increases and if the plants are not well maintained, this can increase both moisture burdens and the growth of *A. fumigatus* [52].

Conclusion

When addressing situations where families are discovered living in MGOs resulting from police action as well as public concerns of the inadvertent purchaser of undetected former MGOs, primary care physicians and municipal public health officials need to be aware of the issues discussed in this paper. These include (1) the cultivation of marijuana typically leading to moisture and mould problems, (2) risk of unusual exposures to *A. fumigatus* and, potentially, (3) chemical residues. Similarly, more information on these hazards may be needed for industrial hygienists, home inspectors, police and other first responders and public health officials in Canada and the USA.

Acknowledgments

This review was funded by Health Canada and an NSERC IRC to JDM. Helpful reviews were provided by Don Fugler PEng, Mark Lawton PEng, Morrison Hershfield, Ltd., and Richard Summerbell PhD (University of Toronto, Sporometrics, Ltd.). It is based on a larger report for Health Canada. Comments from two anonymous reviewers are appreciated.

References

1 Royal Canadian Mounted Police National Conference: Illegal Marihuana Grow Operations Post Conference Report. Royal Canadian Mounted Police, Ottawa, ON, 2004.
2 United Nations Office on Drugs and Crime (UNODC): World Drug Report for 2007. United Nations Publications, Geneva, 2008.
3 OACP: Green Tide: Indoor marijuana cultivation and its impact on Ontario. Ontario Association of Chiefs of Police, 40 College Street, Toronto, ON, 2003.
4 Douglas JL: The Health and safety of children living in marijuana grow operations: A child welfare perspective. PhD thesis, School of Social Work, University of British Columbia, 2010. Available at: https://circle.ubc.ca/handle/2429/25751 (accessed May 7, 2011).
5 D'Halewyn M-A: Contamination des maisons utilisée pour la culture de marijuana par les moisissures. Vol. 17, Quebec, QC, Bulletin d'Information en santé environmental (INSPQ), 2006, pp. 6–10.
6 Salares V, Dyck M: Research highlight: A discussion paper on indoor air quality investigations of houses used for marijuana grow operations, Canada Mortgage and Housing Corporation, Ottawa, ON, Technical series: 07-101, 2007.
7 Government of Canada: Medical marihuana access regulations SOR/2001-27 pursuant to the Controlled Drugs and Substances Act s.c.1996, c.19, ss55(1), Government of Canada, Ottawa, ON, 2001.
8 Dales R, Liu L, Wheeler AJ, Gilbert NL: Quality of indoor residential air and health: Can Med Assoc J 2008;179:147–152.
9 Lawton MD, Dales RE, White J: The influence of house characteristics in a Canadian community on microbiological contamination: Indoor Air 1999;8:2–11.
10 Prezant B, Weekes D, Miller JD: Recognition, Evaluation and Control of Indoor Mold, Sections 5, 7.1, 7.11, Fairfax, VA, American Industrial Hygiene Association, 2008.
11 ASHRAE: Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning, Atlanta, GA, ASHRA Engineers, 2009.
12 Prezant B, Weekes D, Miller JD: Recognition, Evaluation and Control of Indoor Mold, Section 4, Fairfax, VA, American Industrial Hygiene Association, 2008.
13 Flannigan B, Samson RA, Miller JD: Microorganisms in Home and Indoor Work Environments: Diversity, Health Impacts, Investigation and Control, 2nd edn, Boca Raton, FL, CRC, 2011.
14 International Energy Agency: A Sourcebook, Report Annex XIV, Leuven, Belgium, International Energy Agency, 2006.
15 Brands SJ: Systema Naturae 2000, Amsterdam, The Netherlands, 1989-2005. Available at: http://sn2000.taxonomy.nl/ (accessed September 19, 2010).
16 Kaa E: Cannabis plants illicitly grown in Jutland (Denmark): Z Rechtsmed 1989;102:367–375.
17 Christian JE: A Search for Moisture Sources: Bugs Mold & Rot II: Workshop Proceedings, National Institute of Building Sciences, Washington, DC, November 16–17, 1993, pp. 71–81.
18 Muller H, Heindl A: Drying of medicinal plants: in Bogers RJ, Craker LE, Lange D (eds): Medicinal and Aromatic Plants, New York, Springer, 2006, pp. 237–252.
19 Kovesi T, Gilbert NL, Stocco C, Fugler D, Dales RE, Guay M, Miller JD: Indoor air

quality and the risk of lower respiratory tract infection in young Canadian Inuit children: Can Med Assoc J 2007;177:155–160.
20 Reardon J, Fugler D: Assessment of natural ventilation for Canadian residential buildings. Canada Mortgage and Housing Corporation. Ottawa, ON. Technical series 08-100. 2008.
21 Miller JD, Dugandzic R, Frescura A-M, Salares V: Indoor and outdoor-derived contaminants in urban and rural homes in Ottawa: Canada: J Air Waste Manage Assoc 2007;57: 297–302.
22 Health Canada: Fungal Contamination in Public Buildings: Health Effects and Investigation Methods. ON, Health Canada, 2004. ISBN 0-662-37432-0.
23 INSPQ: Les risques à la santé associés à la présence de moisissures en milieu intérieur. Québec, QC, Institut national de santé publique du Québec, 2002.
24 NAS: Clearing the Air: Asthma and Indoor Air Exposures. Washington, DC, National Academy Press, Institute of Medicine, National Academy of Sciences. 2000.
25 NAS: Damp Indoor Spaces and Health. Washington, DC. National Academies Press, Institute of Medicine, National Academy of Sciences, 2004.
26 Krieger J, Jacobs DE, Ashley PJ, Baeder A, Chew GL, Dearborn D, Hynes HP, Miller JD, Morley R, Rabito F, Zeldin DC: Housing interventions and control of asthma-related indoor biologic agents: A review of the evidence: J Public Health Manage Pract 2010: 16:s11–s20.
27 WHO: Guidelines for Indoor Air Quality: Dampness and Mould. DK-2100 Copenhagen, Denmark, WHO Regional Office for Europe. ISBN 978 92 890 4168 3. 2009.
28 Klimisch HJ, Andreae M, Tillmann U: A systematic approach for evaluating the quality of experimental toxicological and ecotoxicological data: Regul Toxicol Pharmacol 1997: 25:1–5.
29 TenWolde A, Walker IS: Interior moisture design loads for residences: in Buildings VIII: Performance of Exterior Envelopes of Whole Buildings: VIII: Integration of Building Envelopes, Atlanta, GA, ASHRAE, 2001. ISBN: 1883413966.
30 Kurup VP, Resnick A, Kagen SL, Cohen SH, Fink JN: Allergenic fungi and actinomycetes in smoking materials and their health implications: Mycopathologia 1983;82:61–64.
31 Verweij PE, Kerremans JJ, Voss A, Meis JFGM: Fungal contamination of tobacco and marijuana: JAMA 2000;284:2875.
32 Kagen SL, Kurup VP, Sohnle PG, Fink JN: Marijuana smoking and fungal sensitization: J Allergy Clin Immunol 1982;71:389–393.
33 McLaren J, Swift W, Dillon P, Allsop S: Cannabis potency and contamination: A review of the literature: Addiction 2008;103: 1100–1109.
34 Horner WE, Helbling A, Salvaggio JE, Lehrer SB: Fungal allergens: Clin Microbiol Rev 1995;8:161–179.
35 Gibson PG: Allergic bronchopulmonary aspergillosis: Semin Respir Crit Care Med 2006;27:185–191.
36 Llamas R, Hart DR, Schneider NS: Allergic bronchopulmonary aspergillosis associated with smoking moldy marijuana: Chest 1978: 73:871–872.
37 Hii SW, Tam JDC, Thompson BR, Naughton MT: Bullous lung disease due to marijuana: Respirology 2008;13:122–127.
38 Wallace JM, Lim R, Browdy BL, Hopewell PC, Glassroth J, Rosen MJ, Reichman LB, Kvale PA: Risk factors and outcomes associated with identification of *Aspergillus* in respiratory specimens from persons with HIV disease: Chest 1998;114:131–137.
39 Szyper-Kravitz M, Lang R, Manor Y, Lahav M: Early invasive pulmonary aspergillosis in a leukemia patient linked to *Aspergillus* contaminated marijuana smoking: Leuk Lymph 2001;42:1433–1437.
40 Sutton S, Lum BL, Torti FM: Possible risk of invasive pulmonary aspergillosis with marijuana use during chemotherapy for small cell lung cancer: Drug Intell Clin Pharm 1986;20: 289–291.
41 Cescon DW, Page AV, Richardson S, Moore MJ, Boerner S, Gold W: Invasive pulmonary aspergillosis associated with marijuana use in a man with colorectal cancer: J Clin Oncol 2008;26:2214–2215.
42 Dales RE, Zwanenburg H, Burnett R, Franklin CA: Respiratory health effects of home dampness and molds among Canadian children: Am J Epidemiol 1991;134:196–203.
43 Dales RE, Ruest K, Guay M, Marro L, Miller JD: Residential fungal growth and incidence of acute respiratory illness during the first two years of life: Environ Res 2010;110:692–698.
44 Health Canada: Residential indoor air quality guidelines: moulds. Ottawa, Ontario, Canada, 2007. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/air/mould-moisissure-eng.php (accessed December 5, 2007).
45 Cox-Ganser JM, White SK, Jones R, Hilsbos K, Storey E, Enright PL, Rao CY, Kreiss K: Respiratory morbidity in office workers in a water-damaged building: Environ Health Perspect 2005;113:485–490.
46 Jaakkola JJ, Hwang BF, Jaakkola N: Home dampness and molds, parental atopy, and asthma in childhood: A six-year population-based cohort study: Environ Health Perspect 2005;113:357–361.
47 Plecas D, Malm A, Kinney B: Marihuana growing operations in British Columbia revisited (1997-2003). Department of Criminology and Criminal Justice. University of the Fraser Valley. Abbotsford. 2005.
48 CMHC: Air leakage characteristics, test methods and specifications for large buildings. Canada Mortgage and Housing Corporation. Ottawa, ON. Technical Series 01-123. 2001.
49 CMHC: Solving odour transfer problems in your apartment. Canada Mortgage and Housing Corporation. Ottawa, ON. Available at: http://www.cmhc-schl.gc.ca/en/co/reho/reho_002.cfm (accessed September 19, 2010).
50 Fisk WJ, Lei-Gomez Q, Mendell MJ: Meta-analyses of the associations of respiratory health effects with dampness and mold in homes: Indoor Air 2007;17:284–296.
51 Dekker C, Dales R, Bartlett S, Brunekreef B, Zwanenburg H: Childhood asthma and the indoor environment: Chest 1991;100:922–926.
52 ASHRAE: Strategy 2.6 – Indoor and Outdoor Plants that may affect IAQ. Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning. 1791 Tullie Circle, Atlanta, GA. 30329. American Society of Heating, Refrigeration & Air-Conditioning Engineers, 2009.