All Survey Results of Research on the Health Effects of Exposure to Indoor Mold

Recently Completed Research

Agency	Project Title	Project Description	Agency Contact	Telephone Number
EPA	**Meta-Analyses of the Associations of Respiratory Health Effects with Dampness and Mold in Home, and Public Health and Economic Impact of Dampness and Mold**	**This activity was conducted to analyze for associations between respiratory health effects with dampness and mold in homes and to analyze the associated public health and economic impacts. Authors' conclusions from these two articles include: • Dampness and mold in buildings were associated with increases of approximately 30 percent to 50 percent in a variety of respiratory and asthma-related health outcomes. • The results of the meta-analyses reinforce the Institute of Medicine's (IOM's) recommendation that actions be taken to prevent and reduce building dampness problems. • Exposure to dampness and mold in buildings poses significant public health and economic risks in the United States. • Approximately 4.6 million of the 21.8 million reported cases of asthma in the United States are associated with dampness and mold in homes. • The national annual cost of asthma linked to dampness and mold in homes is an estimated $3.5 billion ($2.1 billion to $4.8 billion in 2004 dollars). • Effective control of dampness or moisture in buildings is important for public health.**	**Gregory Brunner**	**202-343-9052**
EPA	**Risk Factors in Heating, Ventilating, and Air-Conditioning Systems for**	**This effort analyzed data on indoor air quality characteristics and self-reported occupant health symptoms from the U.S. EPA's BASE Study of indoor air quality**	**Gregory Brunner**	**202-343-9052**

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	Occupant Symptoms in U.S. Office Buildings: the U.S. EPA BASE Study; and Contaminan	**in 100 U.S. office buildings. Two analytical efforts were documented in the following reports: 1) Risk Factors in Heating, Ventilating, and Air-Conditioning Systems for Occupant Symptoms in U.S. Office Buildings: the U.S. EPA BASE Study (Report Number LBNL-61870)—This analysis investigated characteristics of heating, ventilating, and air conditioning (HVAC) systems in the BASE study buildings for potential associations with self-reported occupant health symptoms. While this activity may not be directly identified as mold research, findings reveal some HVAC systems characteristics were statistically associated with increased occupant health symptoms that may be indications of inadequate moisture management and occupant exposures to biological contaminants, including the presence of humidification systems in poor condition and less frequent cleaning of cooling coils and condensate drain pans. 2) Contaminants in Buildings and Occupied Spaces as Risk Factors for Occupant Symptoms in U.S. Office Buildings: Findings from the U.S. EPA BASE Study (Report Number LBNL-63370)—This analysis investigated associations between self-reported occupant health symptoms and potential contaminant sources in offices. While this activity may not be directly identified as mold research, the findings show increased prevalence of occupant symptoms with some building risk factors that suggest possible relationships with moisture or biological contaminants.**		

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		However, there are analytical limitations described in the report.		
EPA	A Rapid DNA Extraction Method for PCR Identification of Fungal Indoor Air Contaminants	Following air sampling fungal DNA needs to be extracted and purified to a state suitable for laboratory use. Our laboratory has developed a simple method of extraction and purification of fungal DNA appropriate for enzymatic manipulation and PCR applications. The methodology described is both rapid and cost effective for use with multiple fungal organisms.	Timothy R. Dean	919-541-2304
EPA	A Simple Multiplex Polymerase Chain Reaction Assay for the Identification of Four Environmentally Relevant Fungal Contaminants	Historically, identification of filamentous fungal (mold) species has been based on morphological characteristics, both macroscopic and microscopic. These methods have proven to be time consuming and inaccurate, necessitating the development of identification protocols that are rapid, sensitive, and precise. The polymerase chain reaction (PCR) has shown great promise in its ability to identify and quantify individual organisms from a mixed culture environment; however, the cost effectiveness of single organism PCR reactions is quickly becoming an issue. Our laboratory has developed a simple method to identify four mold species, Stachybotrys chartarum, Aspergillus versicolor, Penicillium purpurogenum, and Cladosporium spp. by performing multiplex PCR and distinguishing the different reaction products by their mobility during agarose gel electrophoresis. The amplified genes include the Tubulin gene from Aspergillus versicolor, the	Timothy R. Dean	919-541-2304

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		Tri5 gene from Stachybotrys chartarum, and ribosomal sequences from both Penicillium purpurogenum and Cladosporium spp. This method was found to be both rapid and easy to perform while maintaining high sensitivity and specificity for characterizing isolates, even from a mixed culture.		
EPA	A Simple Polymerase Chain Reaction/Restriction Fragment Length Polymorphism Assay Capable of Identifying Medically Relevant Filamentous Fungi	In recent years the adverse health effects resulting from indoor fungal contamination have become of greater concern and importance. This is due to the accumulating evidence that suggests that numerous unhealthy conditions in the indoor environment are the result of abnormal growth of the filamentous fungi (mold) in and on building surfaces. In order to accurately reflect the organisms responsible for these maladies it is of utmost importance to identify them in an accurate and timely manner. To this end, we performed a simple Polymerase Chain Reaction/Restriction Fragment Length Polymorphism (PCR/RFLP) analysis on multiple members of species known to negatively influence the indoor environment. The genera analyzed were Stachybotrys, Penicillium, Aspergillus, and Cladosporium. Each organism underwent PCR with universal primers that amplified ribosomal sequences, followed by enzymatic digestion with EcoRI, HaeIII, MspI, and HinfI. Our results show that using this combination of restriction enzymes enables the identification of these fungal organisms at the species level. This method is rapid, cost effective, easy to perform, and	Timothy R. Dean	919-541-2304

Agency	Project Title	Project Description	Agency Contact	Telephone Number
		accurate.		
EPA	A Simple Polymerase Chain Reaction-Sequencing Analysis Capable of Identifying Multiple Medically Relevant Filamentous Fungal Species	Due to the accumulating evidence that suggests that numerous unhealthy conditions in the indoor environment are the result of abnormal growth of the filamentous fungi (mold) in and on building surfaces, it is necessary to accurately reflect the organisms responsible for these maladies and to identify them in an accurate and timely manner. Historically, identification of filamentous fungal (mold) species has been based on morphological characteristics, both macroscopic and microscopic. These methods may often be time-consuming and inaccurate, necessitating the development of identification protocols that are rapid, sensitive, and precise. To this end, we have devised a simple multiplex PCR method, which when coupled to cloning and sequencing of the clones allows for the unambiguous identification of multiple fungal organisms. Universal primers are used to amplify ribosomal DNA sequences, which are then cloned and transformed into Escherichia coli. Individual clones are then sequenced, and individual sequences analyzed and organisms identified. Using this method we were capable of identifying Stachybotrys chartarum, Penicillium purpurogenum, Aspergillus sydowii, and Cladosporium cladosporioides from a mixed culture. This method was found to be rapid, highly specific, easy to perform, and cost effective.	Timothy R. Dean	919-541-2304
EPA	Analysis of Fungal	Due to mounting evidence	Timothy R.	919-541-

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	Spore Mycotoxin and the Relationship Between Spore Surface Area and Mycotoxin Content Utilizing a Protein Translation Inhibition Assay	**suggesting that biological contamination in the built environment may cause a myriad of adverse health effects, research aimed at understanding the potential exposure to fungal organisms and their metabolites is of utmost importance. To this end, we utilized a protein translation inhibition assay to determine the relative amounts of mycotoxin present in various fungal spore preparations. Basing our results on the transformation of firefly luciferase in a rabbit reticulocyte system, our initial data showed that spores from different fungal genera contained varying amounts of mycotoxins. However, by calculating the surface area of the spores and then normalizing the assay by keeping surface areas equivalent, we determined that there is a direct relationship between spore size and mycotoxin content. This is an important finding because simply knowing the numbers of spores is clearly not sufficient; one needs to know the specific species present to formulate an effective risk assessment and remediation regimen. This work illuminates the potential inhalation exposure to trichothecene mycotoxins that are suspended in the air of the indoor environment. Currently many methods of fungal analysis in the indoor environment are simply based on spore counts. Our analysis clearly demonstrates that it is equally important to know the species of organisms present to accurately determine potential exposure to mycotoxins, thereby enabling effective risk management decisions to be made.**	**Dean**	**2304**

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EPA	Destruction of Aspergillus Versicolor, Penicillium Chrysogenum, Stachybotrys Chartarum, and Cladosporium Cladosporioides Spores Using Chemical Oxidation T	The survival of aqueous suspensions of Penicillium chrysogenum, Stachybotrys chartarum, Aspergillus versicolor, and Cladosporium cladosporioides spores was evaluated using various combinations of hydrogen peroxide with iron (II) as a catalyst. Spores with concentrations of 106 - 107 CFU/mL were suspended in water and treated with initial hydrogen peroxide concentrations ranging from 0.05 to 10 percent and initial iron concentrations of 100 and 200 ppm. After 4 hours of reaction time, samples were plated on potato dextrose agar plates, and the viable fraction of spores was determined by the number of colonies formed. Hydrogen peroxide concentrations above 50,000 ppm resulted in greater than 6-log10 reduction of viable spores for both catalyzed and noncatalyzed reactions. Iron had strong catalytic effect when added to solutions with hydrogen concentration above 5,000 ppm and resulted in two to three orders of magnitude greater reduction compared to hydrogen peroxide alone. Additional samples taken after 24 hours of reaction time showed that the effect of addition of 100 and 200 ppm of Fe2+ catalyst was mostly kinetic and noncatalyzed hydrogen peroxide had sporicidal effects similar to catalyzed hydrogen peroxide. This study identified the initial reagent concentrations of hydrogen peroxide and Fe(II) that can accomplish a 6-log reduction of viable mold spores within reaction times of 4 and 24 hours.	Timothy R. Dean	919-541-2304

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EPA	Detection of Stachybotrys Chartarum Using rRNA, tri5, and Tubulin Primers and Determining Their Relative Copy Number by Real-time PCR	Highly conserved regions are attractive targets for detection and quantitation by PCR, but designing species-specific primer sets can be difficult. Ultimately, almost all primer sets are designed based upon literature searches in public domain databases such as the National Center for Biotechnology Information (NCBI). By judicious clustering of DNA sequences that aligned well, we were able to design three sets of primers for the rRNA region of Stachybotrys chartarum. The two primer sets for tri5 and tubulin produced satisfactory PCR results for all four strains of Stachybotrys chartarum used in this study, while only one rRNA primer set of three produced similar satisfactory results. Ultimately, we were able to show that rRNA copy number is approximately 2-log greater than for tri5 and tubulin in the four strains of Stachybotrys chartarum tested.	Timothy R. Dean	919-541-2304
EPA	The Asthma Health Outcomes Project	The Asthma Health Outcomes Project (AHOP) was an assessment of asthma programs with an environmental component. This assessment sought to identify the characteristics of successful programs, that is, those programs reporting positive health outcomes and included an environmental component (e.g., asthma trigger assessment and reduction activities, environmental asthma trigger education). The study design was a literature review and field investigation, including a detailed interview questionnaire and subsequent statistical analyses to uncover program features	Laura Kolb	202-343-9438

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		associated with health outcomes, including reduced ER visits and hospitalizations, fewer school or work absences, and improved quality of life. The final report is available at www.asthma.umich.edu/ahop.		
EPA	Comparison of the Identification and Quantification of Molds Sampled Inside and Outside Simultaneously	Traditionally, the indoor mold burden has been estimated by comparison to outdoor air samples. However, these results were usually based on identification only to the genus level. We wanted to see if the application of the MSQPCR technology could be applied to the comparison of these kinds of samples and to determine if there is any relationship between indoor and outdoor molds at the species level. There was essentially no correlation between the mold populations found outside of a residence compared to inside when the species of mold, rather than just genus, are identified and quantified. The results of this research suggest that the meaning of short-term (less than 48 hours) mold measurements in indoor and outdoor air samples must be interpreted with caution.	Stephen Vesper	513-569-7367
EPA	Determination of the Occurrence of Mold Species in U.S. and U.K. Homes	Dust samples were collected in U.K. homes and analyzed by MSQPCR to see if the common mold species in U.S. homes were the same as in U.K. homes. The molds found in British homes were compared to typical U.S. homes. Only 13 of 81 mold species-tested for showed significant differences in concentrations between U.S. and U.K. homes. The same approach to identifying and quantifying molds may be appropriate in the	Stephen Vesper	513-569-7367

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		U.K.		
EPA	Measurement of Molds in the Sinuses of Chronic Rhinosinusitis Patients	Chronic rhinosinusitis is the most common chronic disease of adults in the United States. Mayo Clinic researchers had linked molds in the sinuses of chronic rhinosinusitis patients to this disease. Mold-specific quantitative polymerase chain reaction (QPCR) was performed on sinus samples to identify 1 of 82 different species of mold. Statistical analysis was used to categorize the recovered mold DNA. The recovery rate of molds from the middle meatus of patients with and without chronic rhinosinusitis is 45.9 percent using QPCR techniques. QPCR can be used to monitor mold populations in human sinuses.	Stephen Vesper	513-569-7367
EPA	Measurement of Opportunistic Aspergillus Species in Tap Water	Molds are usually thought to enter the home by way of the air. This study was designed to test whether opportunistic fungal pathogens could come into the home by way of tap water. Opportunistic fungal pathogens are a concern because of the increasing number of immunocompromised patients. The goal of this research was to test a simple extraction method and rapid quantitative PCR (QPCR) measurement of the occurrence of potential pathogens, Aspergillus fumigatus, Aspergillus flavus, Aspergillus terreus, and Aspergillus niger, in home tap water and a hospital water supply. Water samples were taken from the kitchen tap in homes of 60 patients who were diagnosed with legionellosis. Water samples were also taken from three locations in a hospital	Stephen Vesper	513-569-7367

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		that generated all of its hot water by flash heating. Opportunistic infectious agents Aspergillus fumigatus, Aspergillus flavus, Aspergillus terreus, and Aspergillus niger were measured using QPCR. Aspergillus terreus DNA was found in 16.7 percent and Aspergillus fumigatus DNA in 1.7 percent of the samples taken from the kitchen tap. None of the Aspergillus species were found in any of the hospital water samples. The development of a simple DNA extraction method along with QPCR analysis is suitable for rapid screening of tap water for opportunistic fungal pathogens. This simple method can be used to obtain pathogen occurrence results in about 3 hours, instead of waiting days to weeks for culture data. Obtaining pathogen occurrence data in a timely manner could promote the elimination of the pathogens from the water supply of immunocompromised patients.		
EPA	Understanding the Role of Mold Hemolysin Proteins, e.g. Chrysolysin	Hemolysins are proteins produced by microorganisms that cause red blood cells to lyse. They also sometimes create holes in other cell membranes in mammals and have other negative effects. We discovered that many molds produce hemolysins (e.g. Penicillium chrysogenum produces chrysolysin). We described this hemolysin and showed that could affect immune functions, at least in tissue-cultured cells.	Stephen Vesper	513-569-7367
EPA	Understanding the Role of Mold Hemolysin Proteins, e.g. Nigerlysin	Hemolysins are proteins produced by microorganisms that cause red blood cells to lyse. They also sometimes create holes in other cell membranes in	Stephen Vesper	513-569-7367

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		mammals and have other effects. We discovered that many molds produce hemolysins (e.g. Aspergillus niger produces nigerlysin). We described this hemolysin and showed that it could kill neurons, at least in tissue cultured-cells. The common occurrence of Aspergillus niger in the environment, along with the toxic characteristics and the stability of nigerlysin, highlight a potential threat to human health.		
EPA	Adjuvant Effects of Metarhizium Anisopliae	There is evidence that some molds or mold components can stimulate the immune system to enhance responses. This collaborative study investigated the ability of Metarhizium anisopliae to act as an adjuvant. It was shown that Metarhizium anisopliae mycelium extract could enhance the allergic response to ovalbumin a classic experimental allergen.	Marsha D. W. Ward	919-541-1193
EPA	Developing an Animal Model for Mold-Induced Allergic Asthma	An animal model was developed to assess the potential for molds or fungi to induce allergy and asthma. In initial studies animals were sensitized to mold (Metarhizium anisopliae) extract by intraperitoneal injection and challenged via the respiratory tract. Endpoints characteristic of human allergic asthma were identified and quantified. The model was subsequently modified so that animals were sensitized and challenged via the respiratory tract. Stachybotrys chartarum was assessed in this model and found to induce allergic asthma endpoints. Additionally, the dose response to Penicillium chrysogenum was assessed using this model.	Marsha D. W. Ward	919-541-1193

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		Allergic asthma responses were found to occur in a dose-dependent manner.		
EPA	Does Mold Induced Allergy Effect Neurotrophin Production?	Neurotrophins, including nerve growth factor (NGF), brain-derived neurotrophic factor (BDNF), and neurotrophin (NT)-3, have been implicated in the pathogenesis of many features and symptoms of asthma. The role of neurotrophins in fungal allergic asthma, however, is unknown. Repeated pulmonary challenge with Penicillium chrysogenum extract (PCE) induces dose-dependent allergic asthma-like responses in mice. This is the first study to link fungal allergic asthma in an experimental model with enhanced production of neurotrophins in the airways and suggests that neurotrophins may play a role in the etiology of mold-induced asthma in humans.	Marsha D. W. Ward	919-541-1193
EPA	Inflammatory Response to Penicillium Chysogenum Hemolytic Protein, Chrysolysin	Treatment of murine macrophage cell line with purified chrysolysin caused a statistically significant increase in the production of macrophage inflammatory protein-2 (MIP-2) in a dose-dependent manner. This suggests that chrysolysin might act to promote the host's inflammatory response after Penicillium chrysogenum exposures.	Marsha D. W. Ward	919-541-1193
EPA	Moisture Movement within Gypsum Wallboard	Gypsum wallboard readily absorbs moisture through direct contact with standing water and by differences in water vapor pressure. Prolonged exposure to water or high humidity may cause loss of structural integrity and provide a growth medium for biological contaminants. Most	Dale Greenwell	919-541-2828

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		wallboard remediation techniques involve visual inspection and moisture content measurements to determine the extent of water damage and the presence of or potential for mold growth. Because of gypsum wallboard's widespread use in commercial and residential construction, understanding the absorption rate and vertical movement of moisture in gypsum wallboard is essential to adequately assess the potential impacts and provide appropriate recommendations. A report on this project is ready to be submitted for publication.		
EPA	A Summary of Gypsum Wallboard Research	Reducing occupant exposure to mold growing on damp gypsum wallboard is a research objective of the U.S. EPA. Controlling mold contamination in the indoor environment has been studied through 1) the delineation of environmental conditions required to promote and avoid mold growth, and 2) efficacy testing of antimicrobial products on gypsum wallboard surfaces. The effects of moisture and RH on mold growth and transport are important to avoiding and eliminating problems. These effects have been demonstrated on gypsum wallboard and are discussed for use as control guidance. Often mold-contaminated building materials are not properly removed, but instead surface cleaners are used and then paint is applied in an attempt to alleviate the problem. The efficacy of antimicrobial cleaners and paints to remove, eliminate, or control mold growth on gypsum wallboard has been documented. Research to control Stachybotrys chartarum growth	Marc Y. Menetrez	919-541-7981

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		using 13 separate antimicrobial cleaners and nine varieties of antimicrobial paint on contaminated gypsum wallboard has been performed in laboratory testing. A variety of gypsum wallboard surfaces were subjected to high RH for the 6-month period of testing. These gypsum wallboard control measures are summarized for public and commercial application use.		
EPA	An Evaluation of the Antimicrobial Effects of Gas-Phase Ozone	This project evaluated the effectiveness of ozone (100 – 1,000 ppm) to kill fungi (including mold) and bacteria on surfaces of building materials tested at low and high humidity. Both porous and nonporous building materials were used to represent actual indoor surfaces, and controlled chamber exposures were conducted to maintain consistent exposure concentrations. The ozone efficacy results varied for the organisms inoculated on the surface of glass slides and gypsum wallboard coupons. Even at relatively high concentrations of ozone, it was difficult to get significant inactivation of organisms on surfaces. In agreement with earlier experiments conducted at low ozone concentrations, the organisms exposed to high concentrations of gaseous ozone were more readily killed on glass slides than on gypsum wallboard. Increasing relative humidity increased the biocidal capability of high levels of ozone. However, maintaining consistently high concentrations of 1,000 ppm of ozone gas could be difficult throughout the volume of air contained in a building	Marc Y. Menetrez	919-541-7981

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		remediation application due to unwanted reactions with building materials. As a consequence, achieving a significant reduction of biocontamination concentrations on surfaces, as well as inside porous materials, wall cavities, and voids within a building is very difficult.		
EPA	An Evaluation of the Protein Mass of Particulate Matter	This research study provides the characterization of mass percent of protein-based particulate matter in total-ambient-particulate matter collected in a metropolitan area of North Carolina. The project determined the percentages of protein-based ambient bioaerosols for particles in the 2.5 to 10 micron range (PM10-2.5) and for particles in the range of 2.5 microns or less (PM2.5) in 298 samples taken over a 6-month period. The analysis of total protein mass was used as an all-inclusive indicator of biologically-based aerosols. These organic bioaerosols may have nucleated with inorganic nonbiological aerosols, or they may be combined with inert aerosols. The source of these bioaerosols may be any combination of pollen, mold, bacteria, insect debris, fecal matter, or dander, and they may induce irritational, allergic, infectious, and chemical responses in exposed individuals. Ambient samples of PM2.5 and PM10-2.5 were analyzed for gravimetric mass and total protein mass. The results for 19 of 24 sample periods indicated that between 1 percent and 4 percent of PM10-2.5 and between 1 percent and 2 percent of PM2.5 mass concentrations were made of ambient protein bioaerosols. (The remaining 5 of 24 sample	Marc Y. Menetrez	919-541-7981

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		periods yielded protein results which were below detectable limits.)		
EPA	Testing Antimicrobial Cleaner Efficacy on Gypsum Wallboard Contaminated with Stachybotrys Chartarum	• Goal, Scope and Background: Reducing occupant exposure to indoor mold is the goal of this research, through the efficacy testing of antimicrobial cleaners. Often mold-contaminated building materials are not properly removed, but instead surface cleaners are applied in an attempt to alleviate the problem. The efficacy of antimicrobial cleaners to remove, eliminate, or control mold growth on surfaces can easily be tested on nonporous surfaces. However, the testing of antimicrobial cleaner efficacy on porous surfaces, such as those found in the indoor environment such as gypsum board, can be more complicated and prone to incorrect conclusions regarding residual organisms. The mold Stachybotrys chartarum has been found to be associated with idiopathic pulmonary hemorrhage in infants and has been studied for toxin production and its occurrence in water damaged buildings. Growth of Stachybotrys Chartarum on building materials such as gypsum wallboard has been frequently documented. • Methods: Research to control Stachybotrys Chartarum growth using 13 separate antimicrobial cleaners on contaminated gypsum wallboard has been performed in laboratory testing. Popular brands of cleaning products were tested by following directions printed on the product packaging. • Results: A variety of gypsum wallboard surfaces were used to	Marc Y. Menetrez	919-541-7981

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		test these cleaning products at high relative humidity. The results indicate differences in antimicrobial efficacy for the 6-month period of testing. • Discussion: Results for the six types of gypsum wallboard surfaces varied extensively. However, three cleaning products exhibited significantly better results than others. Lysol All-Purpose Cleaner-Orange Breeze (full strength) demonstrated results that ranked among the best in five of the six surfaces tested. Both Borax and Orange Glo Multipurpose Degreaser demonstrated results which ranked among the best in four of the six surfaces tested. • Conclusion: The best antimicrobial cleaner to choose is often dependent on the type of surface to be cleaned of Stachybotrys chartarum contamination. For plain gypsum wallboard without paint (see Table 3), the best cleaners were Borax, Lysol All-Purpose Cleaner-Orange Breeze (full strength), Orange Glo Multipurpose Degreaser, and Fantastik Orange Action. • Recommendation		
EPA	Testing Antimicrobial Paint Efficacy on Gypsum Wallboard Contaminated with Stachybotrys Chartarum	Reducing occupant exposure to indoor mold is the goal of this research, through the efficacy testing of antimicrobial paints. An accepted method for handling Stachybotrys chartarum contaminated gypsum wallboard is removal and replacement. This practice is also recommended for water damaged or mold-contaminated gypsum wallboard; however, it not always followed completely. The efficacy of antimicrobial paints to eliminate or control mold regrowth on	Marc Y. Menetrez	919-541-7981

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		surfaces can easily be tested on nonporous surfaces. However, the testing of antimicrobial efficacy on porous surfaces found in the indoor environment, such as gypsum wallboard can be more complicated and prone to incorrect conclusions regarding residual organisms. The mold Stachybotrys chartarum has been studied for toxin production and its occurrence in water damaged buildings. Growth of Stachybotrys chartarum on building materials such as gypsum drywall has been frequently documented. Research to control Stachybotrys chartarum growth using seven separate antimicrobial paints and two commonly used paints on contaminated gypsum wallboard has been performed in laboratory testing. Manufacturers directions were followed and common gypsum wallboard was used as the base to test these products at high relative humidity. The results indicate differences in antimicrobial efficacy for the period of testing, and that proper cleaning and resurfacing of gypsum wallboard with an antimicrobial paint can allow for an option in those unique circumstances when removal may not be possible.		
EPA	Testing The Effectiveness of UV Irradiation on Vegetative Bacteria and Fungi Surface Contamination	Ultraviolet irradiation has commonly been used in the indoor environment to eliminate or control infectious diseases in medical care facilities. Heating, ventilating, and air-conditioning (HVAC) system components such as duct liners, cooling coils, drip pans, interior insulation, and areas subjected to high levels of moisture can create an environment that is prone to	Marc Y. Menetrez	919-541-7981

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		biological contamination. The movement of indoor air being dominated by HVAC system operation can carry biological contaminants which can expose large numbers of building occupants to bioaerosols. The use of germicidal ultraviolet lamps (UVGI) in commercial and residential HVAC systems has increased. UVGI treatment has focused on HVAC component internal surfaces and airflow. A method to determine the antimicrobial efficacy of UVGI irradiation was developed and tested on the surface of agar plates with four species of vegetative bacteria and seven species of fungi. The percent kill and k value for each organism were calculated for various periods of exposure.		
EPA	**The Measurement of Ambient Bioaerosol Exposure**	**Monitoring of ambient bioaerosol concentrations through the characterization of outdoor particulate matter (PM) has not previously been performed in North Carolina and was the goal of this research. A study of PM10-2.5 (<10 microns in aerodynamic diameter >2.5 microns) and PM2.5 (<2.5 microns in aerodynamic diameter) fractions of ambient bioaerosols was undertaken for a 6-month period to evaluate potential total long-term exposure. These airborne biological particles can induce irritational, allergic, infectious, and chemical responses in exposed individuals. The health effects were the focus of clinical and epidemiological investigation conducted by other members of the collaborative research team. Ambient samples of PM2.5 (fine) and PM10-2.5 (coarse) were**	**Marc Y. Menetrez**	**919-541-7981**

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		analyzed for mold, endotoxins, and protein. PM2.5 and PM10-2.5 concentrations of these bioaerosols were reported as a function of PM mass, as well as volume of air sampled. The mass of PM2.5 was almost twice that of the PM10-2.5; however, the protein and endotoxin masses were greater in the coarse than the fine PM indicating an enrichment in the coarse PM. The protein and mold results demonstrated a seasonal pattern, both being higher in the summer than in the winter. Except for an occasional excursion, the endotoxin data remained fairly constant throughout the 6 months of the study.		
CDC	Identification and Cloning of a Stachybotrys Antigen	The presence of fungi in water-damaged homes and businesses has been implicated in a number of adverse health effects including subjective symptoms, such as fatigue, cognitive difficulties, and problems with memory to more definable diseases such as allergy, asthma, and hypersensitivity pneumonitis. One fungus in particular, Stachybotrys, has received a great deal of public attention because it is commonly found in water-damaged indoor environments and produces several potent mycotoxins. The association between Stachybotrys and building related disease is somewhat controversial in the medical literature, and direct evidence as to its involvement is lacking. To gain a better understanding of the role of this and various other fungi in building-related complaints, it is necessary to develop methods to measure the extent of exposure. To that end, it is essential to have	Donald Beezhold	304-285-5963

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		sensitive tests but also tests that are specific for the various fungal species. Monoclonal antibody based tests are particularly suited for such a task, but crossreactivity between fungal species can be a problem. Recent work has lead to the development of a species-specific monoclonal antibody for Stachybotrys chartarum spores. This antibody can be used to specifically detect Stachybotrys in the environment, but development of quantitative methods will require purification of the antigen. The overall objective of the proposed project is to characterize the antigen to which this monoclonal antibody is directed with the goal of developing more accurate tests for Stachbotrys. Specifically, we will: (1) identify and characterize the antigen, (2) clone its cDNA and express the recombinant protein, and (3) develop an ELISA assay for detection and quantification of Stachybotrys. Production of the antigen as a recombinant protein allows for a continuous supply of the antigen for use in ELISA methods development and standardization. Furthermore, it is hypothesized that characterization of this Stachybotrys antigen will identify a class of proteins that could serve as the target for developing similar species-specific reagents for other fungi.		
CDC	Species-Specific Reagents for Measuring Airborne Fungi.	Occupational exposure to fungi and especially fungal spores is of growing concern in a number of home and work environments. Currently, the actual effects of different fungi to cause or aggravate such adverse effects are not clear, and exposure	Donald Beezhold	304-285-5963

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		guidelines for fungi have not been proposed. The purpose of this project was to produce diagnostic reagents for airborne fungi. The reagents will help to develop accurate monitoring techniques for fungal aerosols that are critical for the characterization and definition of exposure and disease relationships of fungal contamination in indoor environments. The principles and methods developed in this project should help provide healthier work environments in a variety of industries.		
CDC	Dampness and Mold in the Home and Depression: An Examination of Mold Related Illness and Perceived Control Over One's Home as Possible Depression Pathways	Cross-sectional study of mold and depression in eight European cities.	Mary Jean Brown	770-488-3727
CDC	Characterization of Airborne Molds, Endotoxins and Glucans in New Orleans after Hurricanes Katrina and Rita	In August and September 2005, Hurricanes Katrina and Rita caused breaches in the New Orleans levee system, resulting in catastrophic flooding. The city remained flooded for several weeks, leading to extraordinary mold growth in homes. To characterize the potential risks of mold exposures, we measured airborne molds and markers of molds and bacteria in New Orleans area homes. In October 2005, we collected air samples from 5 mildly waterdamaged houses, 15 moderately to heavily water-damaged houses, and 11 outdoor locations. The air filters were analyzed for culturable fungi, spores,	Paul Garbe	770-488-3727

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		(1?3,1?6)-ß-D-glucans, and endotoxins. Culturable fungi were significantly higher in the moderately/heavily water-damaged houses (geometric mean = 67,000 CFU/m3) than in the mildly water-damaged houses (geometric mean = 3,700 CFU/m3) (P = 0.02). The predominant molds found were Aspergillus niger, Penicillium spp., Trichoderma, and Paecilomyces. The indoor and outdoor geometric means for endotoxins were 22.3 endotoxin units (EU)/m3 and 10.5 EU/m3, respectively, and for (1?3,1?6)-ß-D-glucans were 1.7 μg/m3 and 0.9 μg/m3, respectively. In the moderately/heavily water-damaged houses, the geometric means were 31.3 EU/m3 for endotoxins and 1.8 μg/m3 for (1?3,1?6)-ß-D-glucans. Molds, endotoxins, and fungal glucans were detected in the environment after Hurricanes Katrina and Rita in New Orleans at concentrations that have been associated with health effects. The species and concentrations were different from those previously reported for non-water-damaged buildings in the southeastern United States. heeze asthma or other allergic diseases. Our assembled team includes an aeroallergen scientist, asthma and social epidemiologists, a pediatric pulmonologist, and a statistician, all of which are experienced in conducting large-scale, populationbased studies. If we show that travel to Puerto Rico is associated with sensitization to HDM, will this deter parents		

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		from taking their children with them to the island? We hope not, because familial and cultural relations are important. This is where the blend of social and environmental science is crucial. We must understand how the two lead to allergic sensitization and be cognizant that they both will be required for the most effective primary prevention of allergic asthma.		
CDC	Knowledge, Attitudes, and Practices Related to Mold Exposure Among Residents and Remediation Workers in Posthurricane New Orleans	To assess knowledge, attitudes, and practices related to mold exposure in postflood New Orleans, the authors surveyed 159 residents and 76 remediation workers, using logistic regression to explore associations. Nearly all answered "yes" to the questionnaire item, "Do you think mold can make people sick?" Most knew respirators were recommended for cleaning mold. Residents (87 percent) and workers (47 percent) said they believed that television or radio were the best ways to communicate information about mold. Workers (24 percent) also suggested employers provided the best means for communication of this information. Few participants reliably used all recommended protective equipment. Residents cited respirator discomfort and unavailability as reasons for noncompliance; workers cited discomfort and inadequate training, with 50 percent reporting respirator fit testing. Spanish-speaking workers relied on employers for information. Self-employed workers used protective equipment infrequently. The authors recommend that information on	Paul Garbe	770-488-3727

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		postflood mold exposure be disseminated through media and employers, that protective equipment be made readily available for residents, and that workers receive better training and fit testing. In addition, they suggest that targeted approaches may benefit Spanish-speaking workers and the self-employed.		
CDC	Moisture and Mold in New Orleans Homes after Hurricanes Katrina and Rita	This project assessed resident cleanup activities, characteristics of flood-damaged homes and airborne microbial concentrations in New Orleans, Louisiana, following Hurricanes.	Paul Garbe	770-488-3727
CDC	Hazard Evaluation and Technical Assistance 2003-0300-2993: West Virginia Department of Health and Human Resources—Webster Springs District Office	To investigate health complaints of employees and conduct environmental testing at an office building with indoor air quality problems, including the evaluation of methacholine challenge testing in support of building-related asthma investigation.	Kathleen Kreiss	304-285-5800
CDC	Hazard Evaluation and Technical Assistance 2004-0138-2967: Samuel Staples Elementary School	To investigate health complaints of employees at a school with indoor air quality problems, including linking of environmental observations with health complaints.	Kathleen Kreiss	304-285-5800
CDC	Monitoring Bioaerosols on Commercial Passenger Aircraft	The aim of this research was to comprehensively characterize bioaerosol contaminants (bacteria, fungi, and allergens) on widebody commercial passenger aircraft. On 12 randomly selected flights, samples were collected to monitor airborne and surface bacteria, airborne and surface fungi, and nonviable total spore counts at six distinct time periods within each flight. Comparison samples were collected both	Lauralynn Taylor McKernan	513-847-4751

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		inside and outside the airport terminal at the origin and destination cities. While the results only relate to fungal and bacterial sized particles, they illustrate the time periods when the risk of potential airborne exposure will be highest. The results suggest disease prevention efforts focus on the time period before air is entrained into the filtration system. Three manuscripts have been published that pertain to this research.		
CDC	Health Hazard Evaluation Report: HETA-2004-0005-3024, Grove Park Inn Resort and Spa, Asheville, North Carolina	To determine if stachylysin, a hemolysin produced by the fungus Stachybotrys chartarum, is a good biomarker of exposure to Stachybotrys chartarum. We also field tested a prototype minicentrifugal bioaerosol sampler that allows for fungal air sampling for extended time periods (8 hours) and separation of fungal fragments and spores.	Allison Tepper	513-841-4386
CDC	Health Hazard Evaluation Report: HETA-2005-0126 and HETA-2005-0138-3004 International Marine Terminal, Portland, Maine	To determine if stachylysin, a hemolysin produced by the fungus Stachybotrys chartarum, is a good biomarker of exposure to Stachybotrys chartarum	Allison Tepper	513-841-4386
NIH	Socio-Cultural Influences on Allergic Sensitization	The prevalence of asthma among children of Puerto Rican ethnicity residing in New York City (NYC) has already been reported as among the highest in the world. In addition, we understand that housing factors influence levels of indoor allergens, such that poor housing lends rise to cockroach and mouse allergens, and high humidity is associated with high house dust mite (HDM) allergen	Kim Gray	919-541-0293

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		levels. What is NOT known is the critical period of exposure in early life, the level of allergen exposure, and the duration of the exposure that leads to sensitization to indoor allergens, and how socioeconomic status, level of acculturation, and travel between NYC and Puerto Rico among these families influences this critical exposure. Our hypothesis is that Puerto Rican children living in NYC are exposed to more indoor allergens early in life than other children in NYC because they do travel to tropical environments where different types of dust mites are more abundant than in NYC. We will assess socioeconomic status, level of acculturation, travel between NYC and Puerto Rico, and the indoor allergen levels in their home environment in NYC and in the homes in Puerto Rico that are visited by them during the first 4 years of life among a birth cohort of Puerto Rican ethnicity from families where the mother has inhalant allergy living in NYC. At two timepoints, 2 and 4 years, we will collect blood from the child and measure IgE specific for dust mite, cat, cockroach, and mouse allergens. At the 4 year clinic visit, we will also assess whether the child has a diagnosis of probable persistent wheeze asthma or other allergic diseases. Our assembled team includes an aeroallergen scientist, asthma and social epidemiologists, a pediatric pulmonologist, and a statistician, all of which are experienced in conducting large-scale, populationbased studies. If we show that travel to Puerto Rico is associated with sensitization to HDM, will this deter parents		

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		from taking their children with them to the island? We hope not, because familial and cultural relations are important. This is where the blend of social and environmental science is crucial. We must understand how the two lead to allergic sensitization and be cognizant that they both will be required for the most effective primary prevention of allergic asthma.		
NIH	Proteolytic Enzymes And Inhibitors In Lung Disease	Host proteolytic enzymes are believed to play a central role in the pathogenesis of pulmonary emphysema, through degradation of alveolar connective tissue proteins. However, little is known about whether this lung disease can be either caused or exacerbated by proteinases secreted by bacterial or fungal respiratory pathogens. Significantly, none of these enzymes are known to be regulated by host proteinase inhibitors. While it is believed that their primary function is to degrade host proteins to provide nutrients for the growth and proliferation of the invading organism, we propose that they also provide a means for evasion of host defense. For these reasons, the specific aims of this project are as follows: (1) to isolate and characterize selected proteinases secreted by lung pathogens, including Aspergillus fuimigatus, Stachybotrys chartarum, Pseudomonas aeruginosa, and Staphylococcus aureus; (2) to investigate the effect of pathogen-derived proteinases on the degradation/inactivation of host bactericidal peptides and proteins utilized to maintain homeostasis within the lung; and	James P. Kiley	301-435-0233

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		(3) to study the effect of exposure to these proteinases on (a) the responsiveness of human monocytes and neutrophils to major pro-and anti-inflammatory stimulation and (b) the ability of proteinase-exposed monocytes to clear apoptotic neutrophils. Long-term goals are to determine whether the proteinases to be investigated play major roles in host defense evasion and tissue destruction within the lung. If this is the case, then they might be considered as targets for the development of inhibitors in order to control or eradicate lung microbial infections.		
NIH	National Survey of Lead and Allergens in Housing	This cross-sectional study surveyed a nationally representative sample of 831 housing units inhabited by 2,456 individuals in 75 different locations throughout the United States. Information on housing and household characteristics was obtained by questionnaire and environmental assessments. The survey estimated levels of several indoor allergens, including levels of the fungus Alternaria alternata, in U.S. homes. Allergen concentrations in dust collected from various indoor sites were assessed with immunoassays. We examined the prevalence of Alternaria exposure and identified independent predictors of Alternaria concentrations in U.S. homes. We also investigated the associations between indoor exposures to Alternaria and asthma-realted symptoms among the study population.	Darryl Zeldin	919-541-1169