National Toxicology Program

Headquartered at the
National Institute of Environmental
Health Sciences NIH-HHS

Mold

What is mold?

Mold is a visible group of fungi that forms and spreads on various kinds of damp or decaying organic matter, such as dry wall and other building materials. There are many different types of mold, with some 1.5 million species estimated to exist. Some people may refer to mold as mildew. Both are terms used to describe fungal growth. Mildew is typically powdery and light in color, whereas mold is often fuzzy and more colorful.

How do people get exposed to mold?

People are exposed to molds every day and everywhere, at home, at work, at school, both indoors and out. Molds are generally not harmful to healthy humans.

Inhalation is considered the primary way that people are exposed to mold. Mold spores and fragments can become airborne and get into the air we breathe. People may also be exposed to mold through the skin. Workers should be properly protected with safety equipment when remediating, or cleaning up mold after a disaster. In some cases, people may be exposed to mold through their diet.

What do we know about health effects from mold?

It is sometimes difficult to determine specific health outcomes from exposure to mold, since the effects depend on the characteristics, magnitude, and duration

of the exposure. People who have an existing respiratory condition, such as asthma or allergies, are more likely to suffer adverse effects.

It is well established that allergic reactions to molds are the most commonly experienced health effects in humans.[1] Symptoms can range from sneezing to wheezing. Individuals without allergies may also experience symptoms, including eye irritation, sore throat, congestion, skin rash, and headaches.

The National Academy of Sciences (NAS) conducted a comprehensive literature review and analysis, and found there was sufficient evidence to link mold and other factors related to damp indoor environments with some upper respiratory tract symptoms, coughing, wheezing, and asthma in sensitized persons or people who already have respiratory problems, the elderly, or the very young. However, NAS found there was not enough evidence to make conclusions for many other health outcomes, including rheumatologic and other inflammatory diseases, neurological symptoms, cancer, and reproductive effects.[2]

Most molds are not harmful to healthy humans. Some molds are used to produce foods or medications, such as penicillin. Allergic reactions to molds are perhaps the most commonly experienced health effects.

PO Box 12233 • Research Triangle Park, NC 27709
Phone: 919-541-3345 • http://ntp.niehs.nih.gov

June 2013

Printed on recycled paper

In research conducted in human populations, the World Health Organization found sufficient evidence to show that occupants of damp and moldy buildings are at increased risk of respiratory symptoms, respiratory infections, shortness of breath, and worsening of asthma.[3]

In people who have a weak immune system, some molds may cause infections. A small group of molds, known as dimorphic fungi, are pathogens, which are capable of causing infections in both healthy people and those who suffer from immune suppression.

Why are we studying mold?

Mold is everywhere and people are concerned about potential health effects, especially effects on respiratory health. People who already have asthma or a respiratory condition may be more affected by mold than healthy people.

As molds grow, some, but not all, may produce toxins or poisonous substances called mycotoxins that may cause effects in humans. Although there are many types of mycotoxins, aflatoxins are probably the best known and most extensively researched. Aflatoxin-producing fungi commonly grow on corn and other grains, peanuts, tree nuts, and other crops. Exposure to aflatoxin can cause liver cancer. In many countries around the world, particularly in Africa and Asia, large numbers of people regularly consume foods heavily contaminated with aflatoxin. In the United States, the U.S. Food and Drug Administration (FDA) has established guidelines to minimize mycotoxins in the food supply.

What types of studies is NTP supporting?

The National Toxicology Program (NTP) is looking into the health effects that may be associated with exposure to mold.

Most of the NTP work is being done in collaboration with our interagency partner, the National Institute for Occupational Safety and Health (NIOSH). NIOSH is interested in health effects for workers in moldy environments, such as remediation, agriculture, or waste handling. NIOSH is also concerned with indoor exposures where moisture infiltration and fungal contamination can affect children, teachers, and other workers. Through an interagency agreement, both NIEHS and NIOSH use their expertise to address important questions related to preventing potential health effects from workplace exposures.

With NTP support, NIOSH has developed a device known as an acoustical generator that can create and disperse molds for rodent studies that closely mimic real world human exposure. Until now, it has been extremely difficult to aerosolize dry mold for laboratory studies, so that the exposure is similar to what humans may experience.

NIOSH has tested the device in several different exposure paradigms. The acoustical generation system is now ready to be used in short-term toxicology studies. This device will help characterize how an animal responds to several different species of mold.

NTP originally proposed conducting a series of animal toxicity studies to look at a variety of specific molds, including *Stachybotrys chartarum* (*S. chartarum*), as well as several mixtures of molds, to determine if different molds caused different health effects.[4]

Stachybotrys chartarum (*S. chartarum*), is not a commonly found mold, though it is not rare. It can grow indoors on materials such as fiberboard and wall paper, if there is constant moisture from water damage, excessive humidity, water leaks, or flooding.

S. chartarum and other molds, often referred to as black or toxic molds in the popular press, were brought to the public's attention after natural disasters such as Hurricane Katrina. The public first became aware of *S. chartarum* in the 1990s and 2000s, after a cluster of infants in Cleveland were thought to have become sick from being exposed to this mold.[5] However, a CDC review of the data did not find an association between acute pulmonary hemorrhage/hemosiderosis, in infants and exposure to molds.[6]

Due to the overwhelming challenges and costs in making and maintaining the various types of molds needed to properly conduct these studies and equip the laboratories, NTP has decided, instead, to invest its resources by expanding its ongoing research activities with NIOSH. NTP also plans to launch a research program to study the long-term, low-dose health effects of a mycotoxin known as deoxynivalenol (also called DON or vomitoxin). DON is a naturally occurring mycotoxin produced by several species of a particular type of mold. Potential human exposure to DON may occur from consumption of contaminated oats, corn, wheat, barley, rice, and other field grains.

NTP is an interagency program involving the National Institute of Environmental Health Sciences (NIEHS), part of the National Institutes of Health (NIH), U.S. Food and Drug Administration, and the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention. NTP is headquartered at NIEHS, and the NIEHS director serves as the NTP director.

NIEHS and NIOSH work closely to carry out NTP studies of the health effects of mold.

Additional Activities

NTP is currently working on several other activities, including:

- Developing methods that can more accurately and consistently determine the levels of fungal products in floor dust samples taken from water damaged buildings. This will allow researchers to begin looking at correlations between levels of exposure and biomarkers of disease, such as fungal-specific antibodies.
- In collaboration with Children's Mercy Hospitals and Clinics in Kansas City, Mo., NTP is working to characterize the diversity of fungi found in typical homes. Air and dust samples were collected from different rooms of homes participating in the Kansas City Safe and Healthy Homes Partnership project. The routine sampling included measuring air quality factors such as temperature, relative humidity, air circulation, and carbon dioxide concentration. Researchers have been able to extract DNA from the mold spores, to begin seeing what mold or fungi people are actually exposed to.[7] This information is also helping researchers develop a standardized immunoassay, a technique or test used to detect the presence or quantity of a substance.
- NTP is using new DNA-based tools, such as the Environmental Relative Moldiness Index (ERMI) developed by researchers at the U.S. Environmental Protection Agency with assistance from the U.S. Department of Housing and Urban Development, to help quantify mold contamination. ERMI allows researchers to better detect 36 different mold types from dust samples.[8]

More About NTP and NIEHS Research Efforts

In addition to the work being conducted through NTP, grantees supported through the NIEHS used ERMI to show that mold exposure during a critical window of development was associated with a three-fold greater risk for asthma later in childhood.[9]

As the lead NIH institute focusing on how environmental factors impact human health, NIEHS researchers are working to understand how exposures to mold and other environmental agents trigger diseases such as asthma, and how we can prevent, diagnose, and treat these diseases. Intramural researchers have shown that indoor exposure to certain molds, such as *Alternaria alternata*, is a risk factor for asthma.[10]

NTP is also working with NIEHS intramural researchers leading the Agricultural Health Study to assess the levels of fungal sensitization among farmers.[11]

Another example of NIEHS' efforts related to mold includes a public-private collaboration that brought together researchers from NIEHS and NTP, other government agencies, academia, and community partners, to support the Head-off Environmental Asthma in Louisiana (HEAL) study. HEAL began soon after Hurricane Katrina created an environmental disaster in 2005 that led to high levels of mold and other allergens, and disrupted health care for children with asthma. Using model asthma interventions, HEAL decreased the number of days children suffered with asthma symptoms by nearly half, from 6.5 days at enrollment to 3.6 days at the 12-month symptom assessment.[12,13,14]

Where can I find out more about mold?

National Institute of Environmental Health Sciences

Centers for Disease Control and Prevention

U.S. Department of Agriculture

U.S. Environmental Protection Agency

U.S. Food and Drug Administration

National Institute of Environmental Health Sciences

For more information on the National Institute of Environmental Health Sciences, go to **http://www.niehs.nih.gov/**

National Toxicology Program
U.S. Department of Health and Human Services

For more information on the National Toxicology Program, go to **http://ntp.niehs.nih.gov**

[1] *Storey E, Dangman KH, Schenck P, DeBernardo RL, Yang CS, Bracker A, Hodgson MJ. 2004. Guidance for clinicians on the recognition and management of health effects related to mold exposure and moisture indoors.*

[2] *NAS (National Academy of Sciences). 2004. Damp Indoor Spaces and Health. Washington, DC: The National Academies Press.*

[3] *WHO (World Health Organization). 2009. WHO guidelines for indoor air quality: dampness and mould. Germany: Druckpartner Moser.*

[4] *NTP (National Toxicology Program). 2006. NTP Concept Document: Mold.*

[5] *Weber RW. 2012. Allergen of the month—Stachybotrys chartarum. Ann Allergy Asthma Immunol 108(6):A9.*

[6] *CDC (Centers for Disease Control and Prevention). 2000. Update: Pulmonary Hemorrhage/Hemosiderosis Among Infants—Cleveland, Ohio, 1993-1996. MMWR 49(09):180–184.*

[7] *Rittenour W, Park JH, Cox-Ganser JM, Beezhold DH, Green BJ. 2012. Comparison of DNA extraction methodologies used for assessing fungal diversity via ITS sequencing. J Environ Monit 14(3):766-774.*

[8] *Vesper S, Wakefield J, Ashley P, Cox D, Dewalt G, Friedman W. 2011. Geographic distribution of Environmental Relative Moldiness Index molds in USA homes. J Environ Public Health; doi:10.1155/2011/242457 (Online 7 June 2011].*

[9] *Reponen T, Vesper S, Levin L, Johansson E, Ryan P, Burkle J, Grinshpun SA, Zheng S, Bernstein DI, Lockey J, Villareal M, Khurana Hershey GK, LeMasters G. 2011. High environmental relative moldiness index during infancy as a predictor of asthma at 7 years of age. Ann Allergy Asthma Immunol 107(2):120–126.*

[10] *Salo PM, Arbes SJ Jr, Sever M, Jaramillo R, Cohn RD, London SJ, Zeldin DC. 2006. Exposure to Alternaria alternata in US homes is associated with asthma symptoms. J Allergy Clin Immunol 118(4):892-898.*

[11] *Endres SM, Green BJ, Henneberger PK, Germolec DR, Bledsoe TA, Beezhold DH, London SJ, Alavanja MC, Beane Freeman LE, Hoppin JA. 2012. Fungal and atopic sensitization are low among farmers in the Agricultural Health Study. J Allergy Clin Immunol 130(1):267–270.*

[12] *Chulada PC, Kennedy S, Mvula MM, Jaffee K, Wildfire J, Thornton E, Cohn RD, Grimsley LF, Mitchell H, El-Dahr J, Sterling Y, Martin WJ, White L, Stephens KU, Lichtveld M. 2012. The Head-off Environmental Asthma in Louisiana (HEAL) study – methods and study population. Environ Health Perspect 120(11): 1592–1599.*

[13] *Grimsley LF, Chulada PC, Kennedy S, White L, Wildfire J, Cohn RD, Mitchell H, Thornton E, El-Dahr J, Mvula MM, Sterling Y, Martin WJ, Stephens KU, Lichtveld M. 2012. Indoor environmental exposures for children with asthma enrolled in the HEAL study, post-Katrina New Orleans. Environ Health Perspect 120(11): 1600–1606.*

[14] *Mitchell H, Cohn RD, Wildfire J, Thornton E, Kennedy S, El-Dahr JM, Chulada PC, Mvula MM, Grimsley LF, Lichtveld MY, White LE, Sterling YM, Stephens KU Sr, Martin WJ 2nd. Implementation of evidence-based asthma interventions in post-Katrina New Orleans: the Head-off Environmental Asthma in Louisiana (HEAL) study. Environ Health Perspect 120(11): 1607–1612.*