Consider Surrogate Allergens for that Unsolved IAQ Mystery
IAQ Problems are typically caused by

Gases and/or Particles

We will be discussing particles which can be observed by Microscopy
Microscopy and staining

Air and dust samples are treated with acid fuchsin stain

The stain colors proteins (among other things) pink

Pollen grains, mold spores and bacteria pick up stain

Skin scales and pet dander pick up stain

Inorganic particles and starch granules do not take up stain
Microscopy and staining

Unstained and stained pine pollen

Unstained and stained *Cladosporium* spores
“Surrogate Allergens” and Latex Allergy

Uncured latex used in gloves is “sticky” so interior must be treated

Cotton flock lining in glove
“Surrogate Allergens” and Latex Allergy

Latex surgical gloves and balloons were coated at the interior with powder.

Talc and then corn starch were used.

Starch on a glove is called “donning powder”
“Surrogate Allergens” and Latex Allergy

Corn starch granules do not pick up acid fuchsin stain

Corn starch granules (colorless) and skin scales (stained pink)
“Surrogate Allergens” and Latex Allergy

Corn starch granules in “donning powder” at the interior of gloves acquire allergenic latex proteins from the surfaces of the rubber gloves, and the aerosolized granules become surrogate allergens that can be inhaled and cause symptoms.

Inhaled latex allergen (Hev b 1). Poulos LM, O'Meara TJ, Hamilton RG, Tovey ER. J Allergy Clin Immunol. 2002 Apr;109(4):
Corn starch granules from home of cat owner using corn-based kitty litter

From a chair in house with cat

From a rug house with cat
“Surrogate Allergens”

What is pink-stained adhering material?

Corn starch granules from home of cat owner using corn-based kitty litter 1200x

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Other Surrogate Allergens Detected by Immuno-gold Labeling

Gold particle

Antibody

Antigens on soot

Soot particle

Antibodies are attached to gold nanoparticles
to detect antigens on soot particles
Gold nanoparticles stick to the soot surface and are detected by SEM
Soot as a “Surrogate Dog Allergen”

Gold nanoparticles are labeled with monoclonal antibodies anti-Can f1 and added to soot from air.

Backscatter electron micrographs of immunogold-labelled soot particles in airborne dust samples from home.

Airborne house dust particles and diesel exhaust particles as allergen carriers.
Ormstad, H. et al. 1998 Clinical and Experimental Allergy, 28: 702-708
“Surrogate Allergens”

• Pollen allergens observed on sub-micron soot particles
  Airborne house dust particles and diesel exhaust particles as allergen carriers. Ormstad, H. et al. 1998 Clinical and Experimental Allergy, 28: 702-708

• Cat allergens on soot

• Mold enzymes on substrate dust such as drywall?

• Microbial allergens and endotoxin on dust?
Starch granules leaking from pollen act as surrogate allergens.

Rain causes some pollen to burst, releasing starch particles that act as surrogate allergens.

“Thunderstorms have been linked to asthma epidemics, especially during the pollen seasons.”

Starch Granules with *Aspergillus* growth

Starch granules act as surrogate allergens.

Aspergillus conidiophore

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Do the Soot Particles have Allergens?

Soot-covered *Cladosporium* spores from a duct system

Soot and carbon particles are often seen in air samples from HVAC systems
Pet Allergy

There about 100 million dogs and cats in U.S.

From 15 percent to 30 percent of people with allergies have allergic reactions to cats and dogs.

Cat allergies are about twice as common as dog allergies.

Frequent exposure to birds can cause bird allergy.

Dogs can have asthma.

Source: AAFA
SURROGATE ALLERGENS

Skin scales from people and pets are keratin, an insoluble, non-allergenic protein.

Pet dander consists of keratin flakes with allergenic, water-soluble secretions of sebaceous glands.

Pet dander (cat, dog, bird, mouse, rat, etc.) is a surrogate allergen.

Many allergens are digestive enzymes, so they must be water soluble; they can be transferred to other particles by contact with water solutions.
Feathers and down can be large sources of bird bioaerosol ("bird bloom") which (along with other avian proteins) are irritating and/or allergenic.

Evaluating Allergic Responses to Bird Allergens. Lopata A, Schinkel M, Current Allergy & Clinical Immunology, June 2004, vol 17, No.2
Cockatiel Feather with Bird Bloom
Large numbers of keratin granules were in the air of the home. The client had hypersensitivity pneumonitis.
Bird Bioaerosol
(“Bird Bloom”)

Keratin granules
1-3 microns

From a quilt
1,000x

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A clinical study of hypersensitivity pneumonitis presumably caused by feather duvets.

Inase N, Ohtani Y, Sumi Y, Umino T, Usui Y, Miyake S, Yoshizawa Y.
Other studies:

High levels of bird antigen after 18 months in one home*.

HP from exposure to house dust with bird antigen from prior owner**.

HP from a feather duvet.*** “Duvet Lung”


Bird Bioaerosol (“Bird Bloom”)

in patients with extrinsic allergic alveolitis, (hypersensitivity pneumonitis) the results obtained in this study show that the antigens responsible for the disease are found in both pigeon serum and bloom extract.

Detection of specific antibodies to pigeon serum and bloom antigens by enzyme linked immunosorbent assay in pigeon breeder’s disease M J Rodrigo, M I Benavent, M J Cruz, M Rosell, C Murio, C Pascual, F Morel. Occup Environ Med 2000;57:159–164
The reddish stains on the concrete under and to the right of the main beam are mouse urine trails. Mice communicate through mouse urine trails. The trails are associated with odor and allergens. 

http://cen.acs.org/articles/89/i40/Mice-Urine-Powers-Social-Networking.html
Mouse-urine Trails associated with more frequent asthma symptoms in homes.

Mice

Mouse-urine trails contain mouse allergens on DUST.
Mouse hair and *Aspergillus* conidiophores and spores in mouse urine trail (wet dust!)
Is wool allergy real?

The evidence to date fails to support the notion that wool is an allergen, or that the wool fibre causes cutaneous allergic reactions (mediated by either type I or IV hypersensitivity). The papers implicating wool as the cause of cutaneous allergic reactions have important limitations that counter their findings.

Debunking the Myth of Wool Allergy: Reviewing the Evidence for Immune and Non-immune Cutaneous Reactions.
Wool Bioaerosol ("dander") Can Be an Irritant

Wool Fiber shedding cuticle

Skin scale

Wool cuticle and cortex particles in an air sample

Wool cuticle and cortex strands

Wool cuticle and cortex particles in an air sample

Respirable wool cuticle particulates
Why Does Damp Wool Stink

Wool comes from sheep skin

Anything soluble on the animal’s skin can be deposited under the cuticle and eventually between the cortex fibers

Sheep sweat, urine, etc. can be in the hairs

When damp some of the odor chemicals are released to the surface

Allergens and/or irritants can be on the surface of the wool cuticle particles
Wool Moth Fecal Pellets

Pellet Color Depends on Fiber Color

Missing surface spherules 8000x SEM

Surface of Wool Moth Fecal Spherule with “adhesive” 30,000x SEM

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Refrigerators are not always full of edibles.

Refrigerator bioaerosol sources

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Wet and Moldy Blower Cabinet

Moisture from a leaking AC condensate tray.

2019 IAQA Annual Meeting
The water in furnace humidifier trays is always contaminated with organisms: bacteria, mold or actinomycetes. Most of the debris in the tray, however, is minerals that form from evaporation of water.
Sub-micron particles

Moldy A/C coil

Condensate pan in winter

Micron-sized rust

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Hyphae Embedded in Dried Bioslime

The dust in the condensate pan must be coated with byproducts of microbial growth!
Scanning Electron Micrograph of *Cladosporium* mold growing on Aluminum A/C fin

AC - Sample
MAG: 2000 x  HV: 20.0 kV  WD: 24.9 mm

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Subtilisin

In late 1960’s Proctor and Gamble (P&G) started adding a protein enzyme (subtilisin) to detergents to improve blood-stain removal during laundering.

Up to 50% of factory workers became sensitized to the enzyme, many suffering from occupational asthma due to exposure to the aerosolized enzyme.

Since that time, P&G has maintained that consumers do not become sensitized to the enzyme as a result of home exposure.

Studies have shown that less than 1% of consumers are allergic to the enzyme.
Enzymes in Detergents

Subtilisin is a protease

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Lint may have laundry chemicals
Residual Protease Activity on Laundry Lint From Tide wash

Washed towels in cold water

Dried on air fluff

Collected lint

Protease residue on lint

Sent to lint to Dr. David Corry, Baylor College of Medicine

Private Communication, D. Corry, 4/14
Conclusions

In many IAQ investigations, you may not find the “smoking gun”; testing for all common allergens may be negative but you must believe the sufferer.

If only a very few occupants are suffering symptoms that might be related to allergen exposure, the cause could be surrogate allergen exposure.

Since there are no easy ways to test for surrogate allergens, elimination/cleaning of possible sources is suggested.
If you would like to receive our quarterly IAQ IQ newsletter please leave a business card with your email or email me at Jeff@MayIndoorAir.com
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