

Damp Indoor Spaces and Health



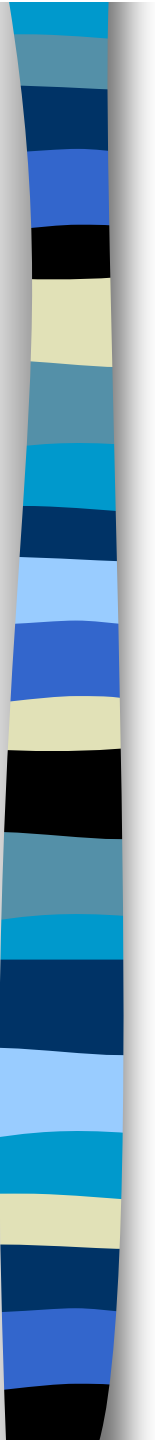
John J Ouellette MD
Retired Clinical Professor
of Medicine UW Madison



Today's Program

- Indoor and outdoor pollution
- Indoor pollution as it relates to newer homes-time weighted exposure
- The principle indoor pollutants
- Wet homes as a major cause of indoor pollution
- The major bio-aerosols and how they effect our health
- 50% of all dwellings will be replaced in the next 25 years

Green Green Beautiful Green





Today's Task

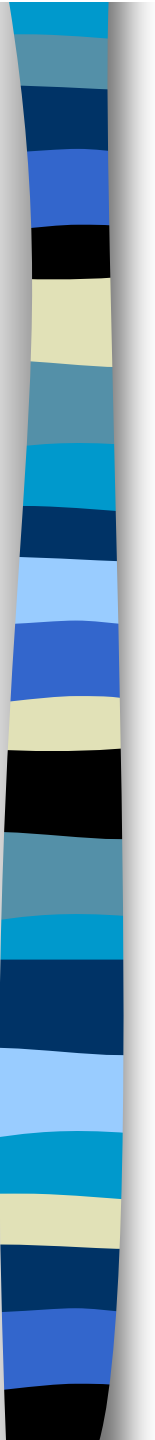
- Green Buildings are key in the preservation of Energy and our other natural resources
- Energy efficiency is a key ingredient in the production of green buildings-but there is good news and bad news
- Energy efficiency in the past frequently led to bad IAQ situations
- The good news is that new technology can prevent the poor IAQ situations seen in the past
- CO₂ - Carbon -- Carbon Sequestration



Indoor and Outdoor Pollution

- Global – greenhouse effect, global warming, ozone loss, ocean dumping, nuclear waste, use of fossil fuels
- Regional – acid rain, destruction of ground level ozone, polluted rivers, destruction of forest
- Local- air pollution, water pollution, hazardous waste, odors, noise and many others
- Household-combination of indoor and outdoor

The View from My College Window





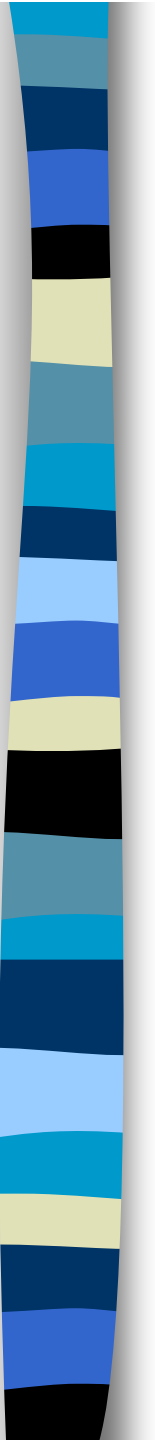
About your speaker

- Internal medicine/allergy
- Indoor air quality – expert witness
- Building science
- Air pollution committees for Academy of Allergy
- Worked with the State Department of Energy
- Worked and lectured with such organizations such as Affordable Comfort, National Association of Home Builders, UW Extension, others
- State Medical Society environmental and occupational committee member 12 years
- President of the Wisconsin Walnut Council

The First Tunbridge House



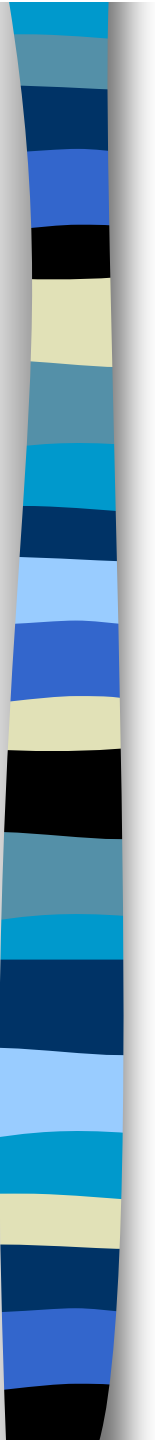
The Ouellette farm from across the valley



Susan Susanka Would be Proud of
this one



Herd of Jersey Cows



Pine Trees Planted in 1950 as Part of an FFA Project



The “King” – of the Certified Forest



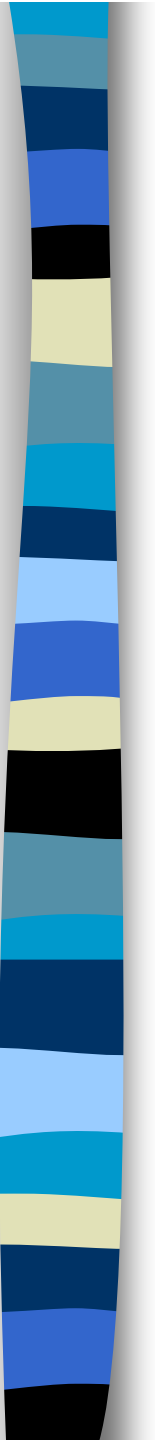
Indian Grass - Biofuel



Hybred Aspen - Biofuel



The Manager of the Sustainable Woodland



How it all began

**Energy
Efficiency**

EE

**Indoor Air
Quality**

IAQ

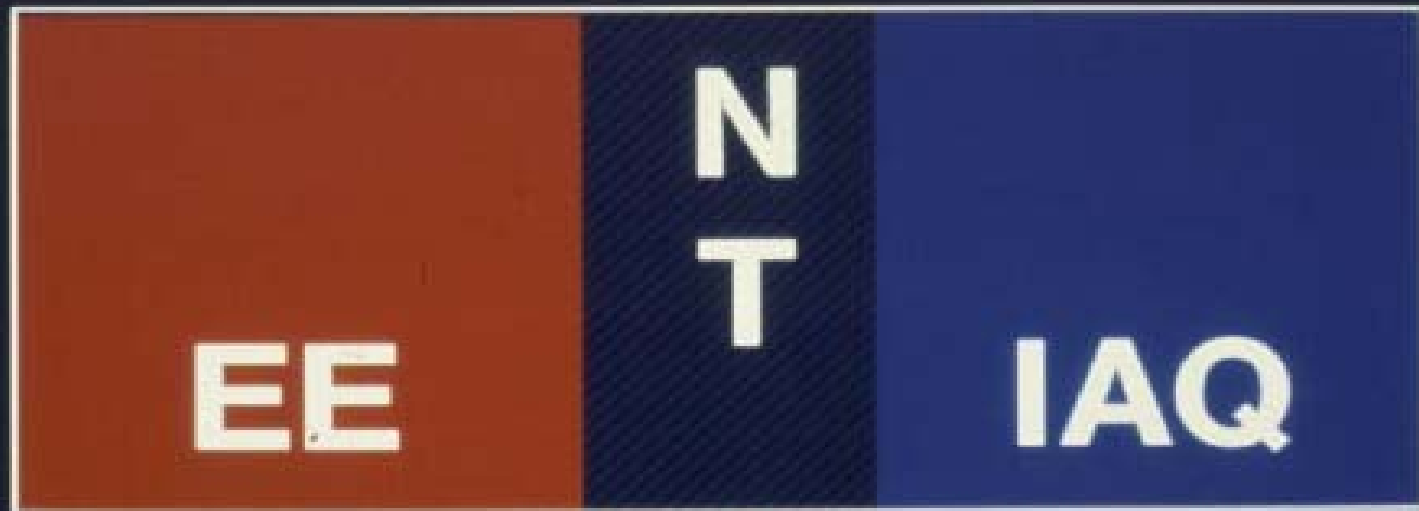
**When the cost of energy was
very low and the supply was "infinite."**

How it all began



Energy Efficiency over-ran Indoor Air Quality
After the energy embargo of 1973,
new home construction had no regard
for indoor air quality.

How it all began-think green



NEW TECHNOLOGY

New technology has allowed us to combine energy efficiency and indoor quality for comfort and health.



1986 Tri-State Home Task Force

- 5000 manufactured homes scattered over Wisconsin-Minnesota-Michigan
- Many of these homes developed wet problems with health problems
- Vapor barrier on the cold side of wall enclosure
- Task force studied health and structural problems

Tri-state-study



Tri-state-study





Litigation of Tri-State Homes

- The task force concluded that there were structural and health problems
- A group of the home owners started litigation regarding the health problems
- A case by case law suite netted 5-6 million dollars that was divided among those with health problems
- A total of 558 occupants of the homes received a medical evaluation



Science Has Come Home !

- Building Science researchers have learned a lot about how to make homes **PERFORM** better
- More healthful, durable with less maintenance, less costly to run, with greater comfort

**Anatomy
of Human
Body**

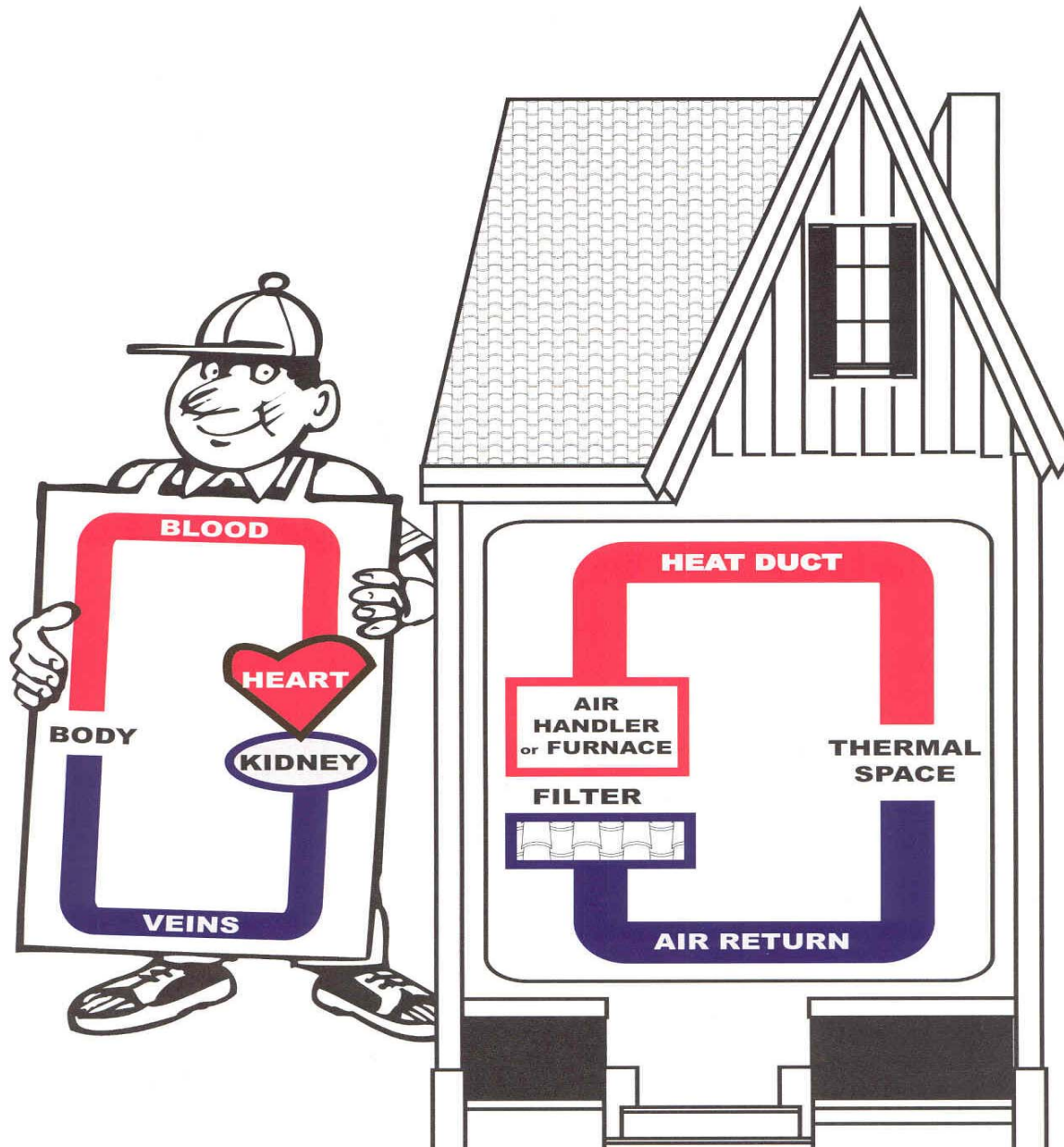
**Physiology
Whole Body
Concept**

**Control
Mechanisms**
Temp,
Fluids,
Etc.

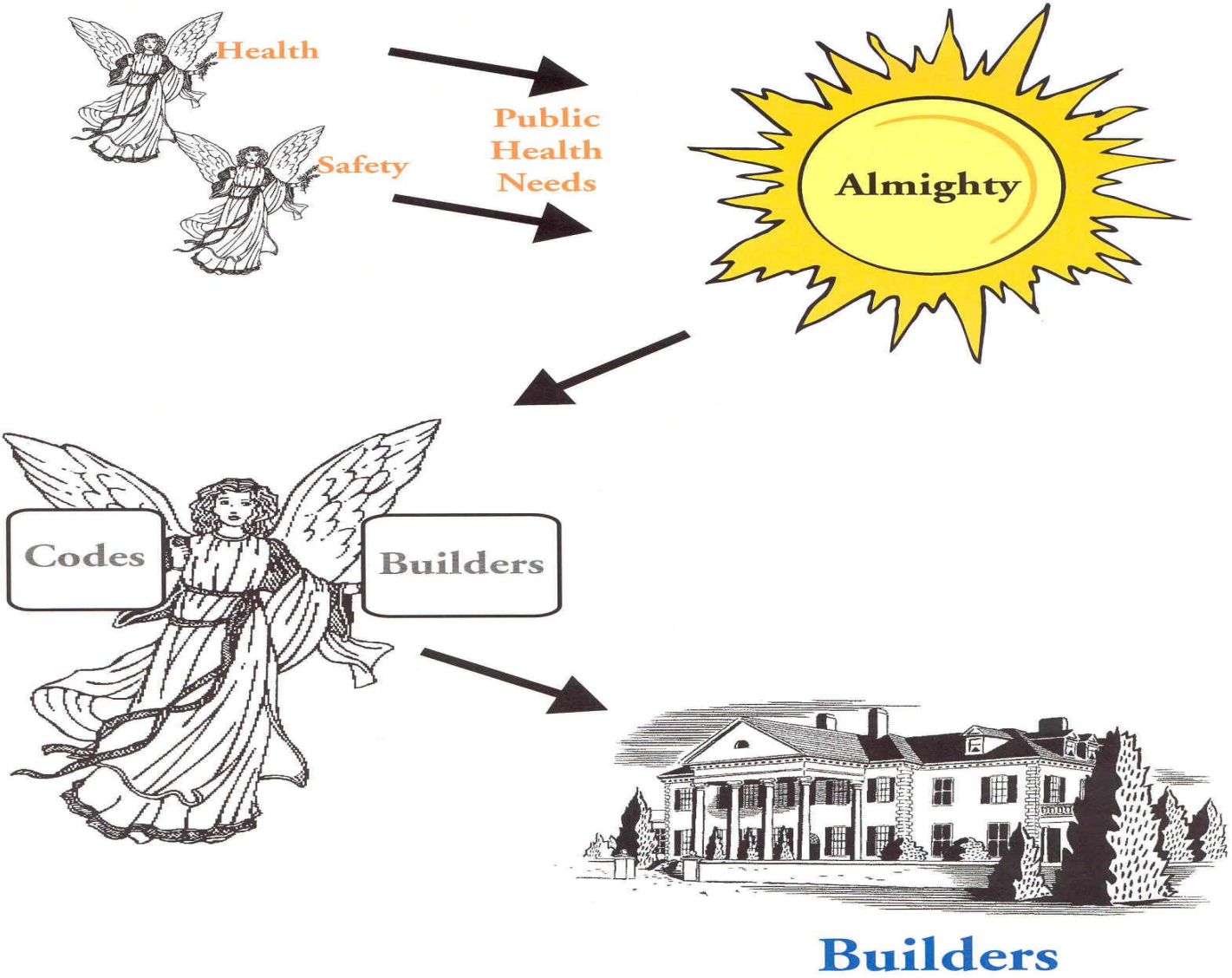
**Structure
of the
House**

**Performance
Whole House
Concept**

**Control
Systems**
Temperature,
Humidity,
Ventilation,
Etc.



Public Health Issues & Building Codes



Whole House Concept

- View the house as a total unit
- All parts and functions of the building are related
- Air with pollutants may move through out the entire structure
- Time weighted exposures affects all occupants of the conditioned space

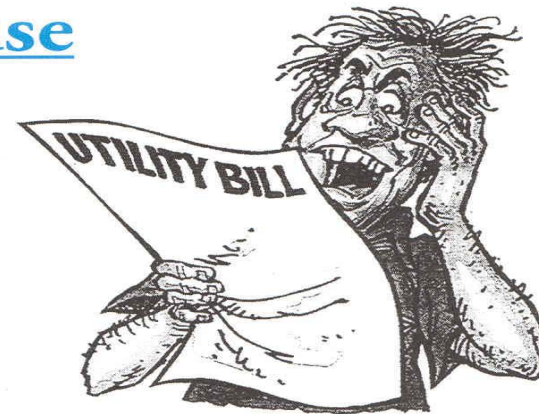
Desirable House

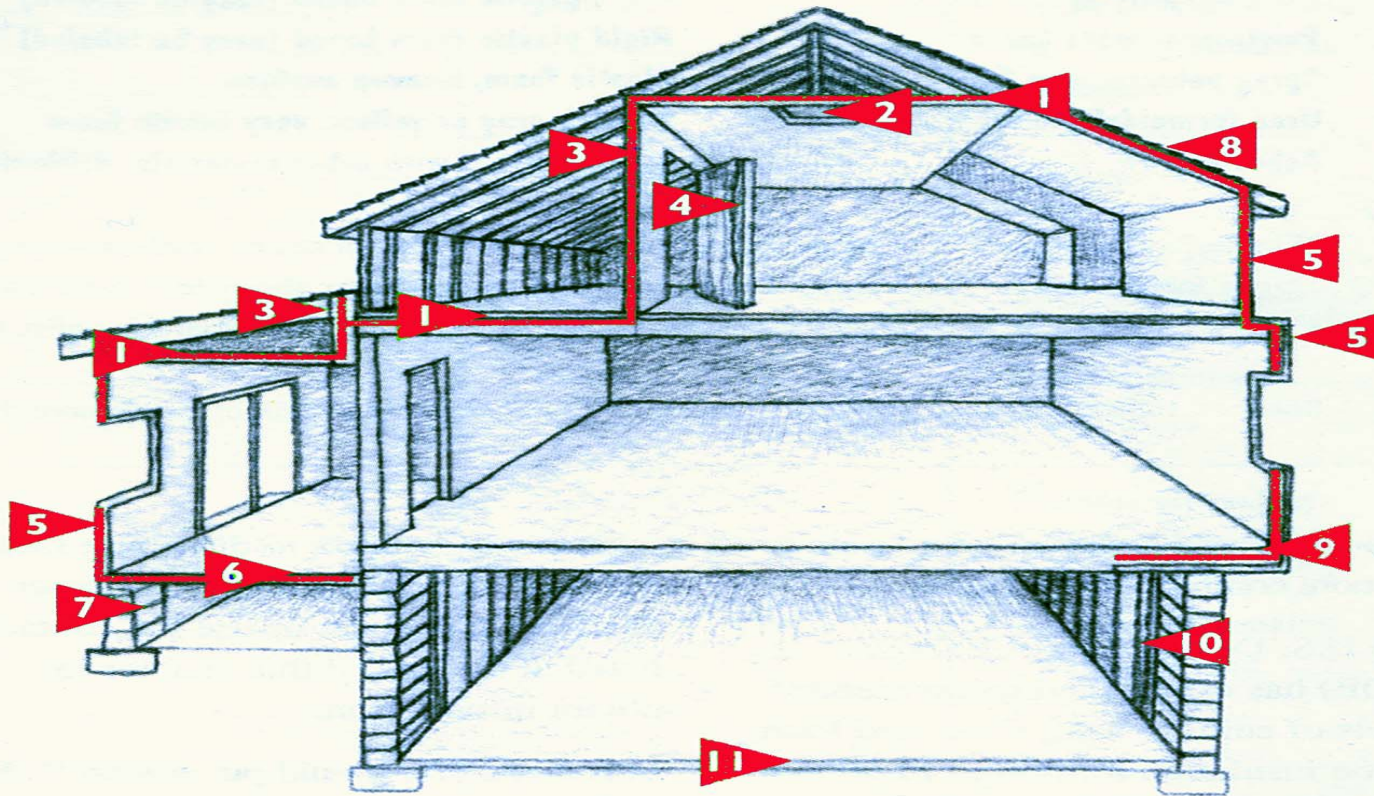
- Durable
- Energy Efficient
- Comfortable
- Healthy
- Good Investment
- Money flows to equity



Undesirable House

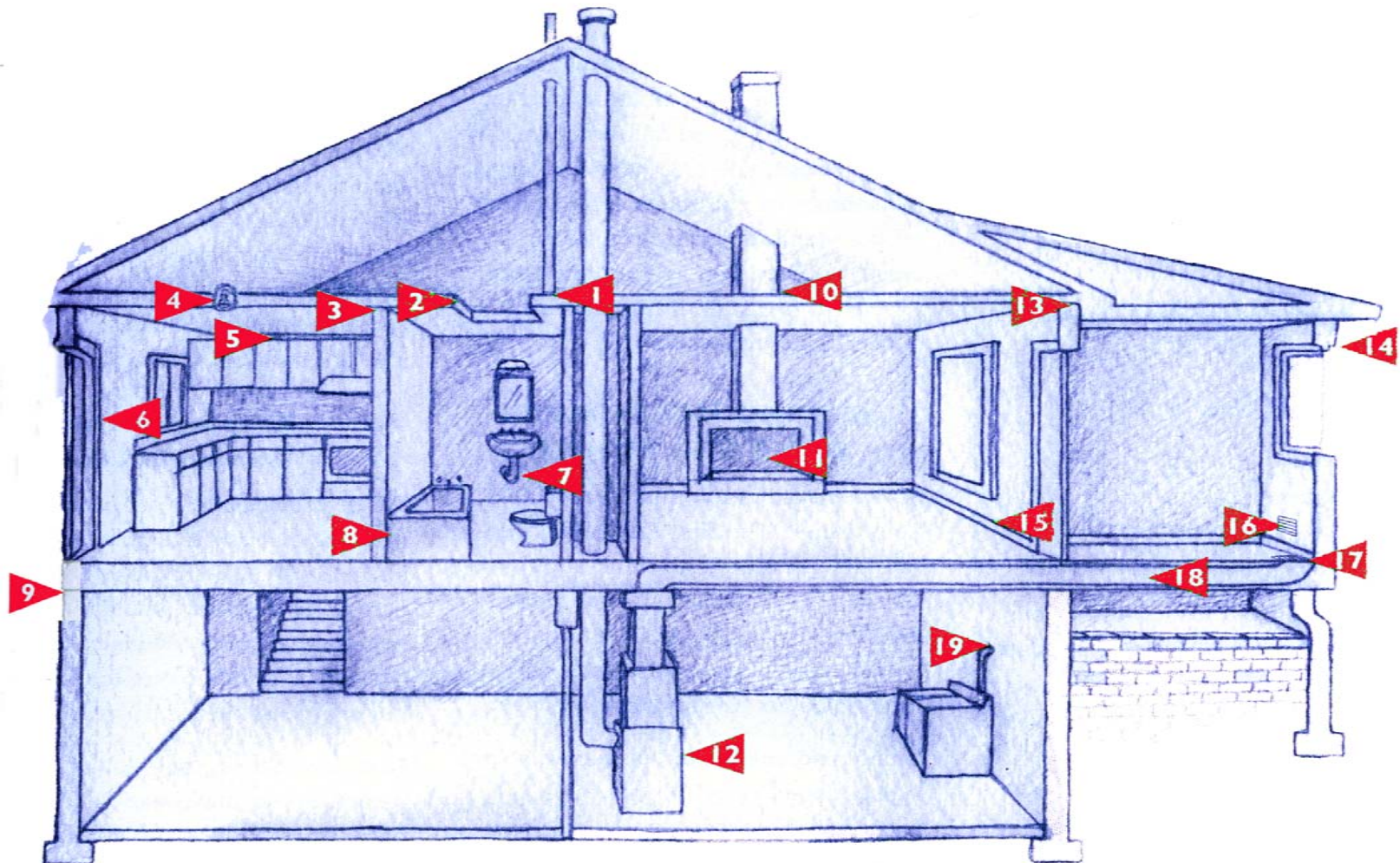
- Non-Durable
- Energy Inefficient
- Uncomfortable
- Unhealthy
- Poor Investment
- Money Flows to upkeep and maintenance





- 1** Ceiling between house and attic
- 2** Attic hatch
- 3** Wall between house and attic
- 4** Attic access door
- 5** Exterior wall
- 6** Floor above vented crawlspace or unheated garage

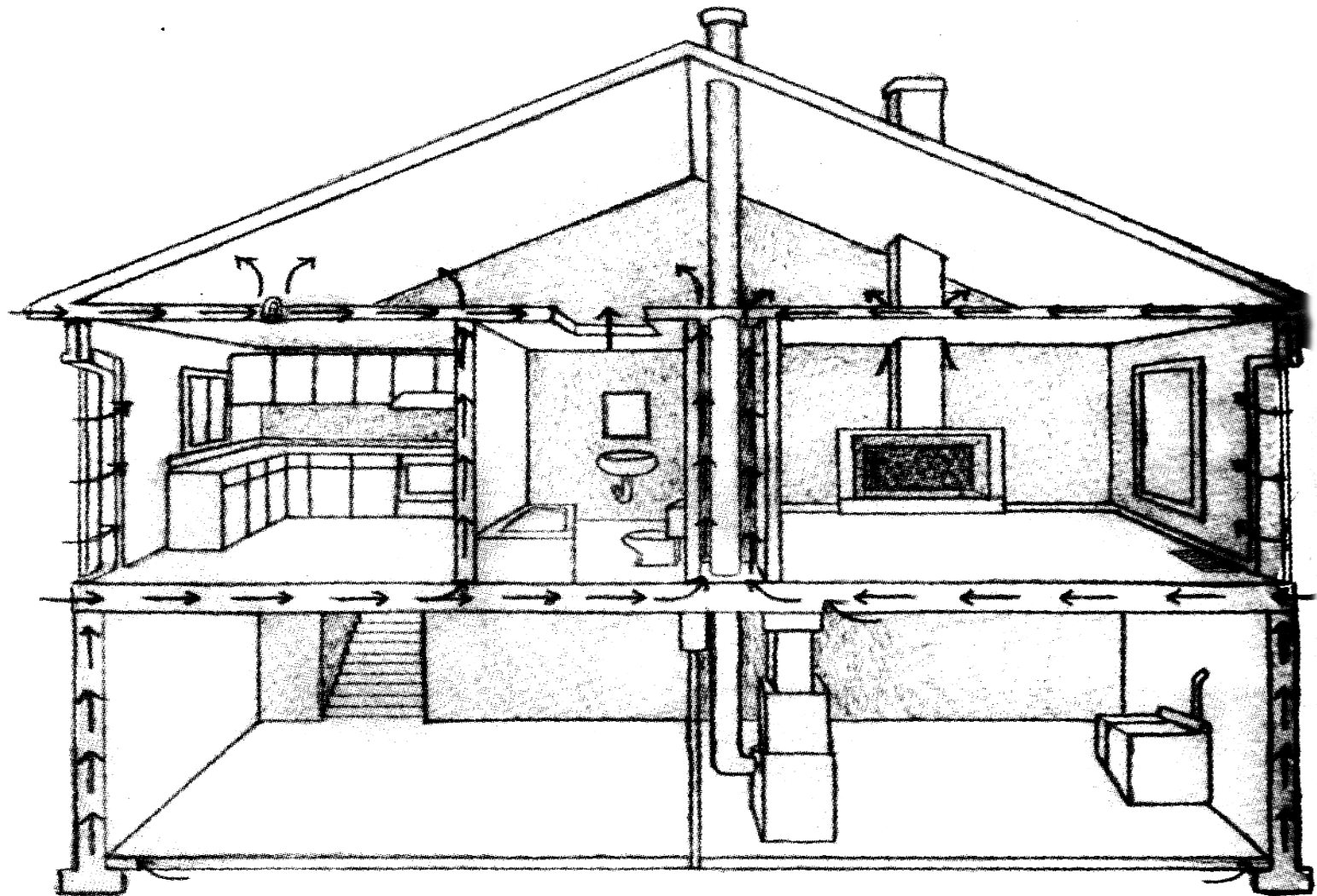
- 7** Foundation wall of unvented crawlspace
- 8** Sloped or cathedral ceiling
- 9** Portion of floor cantilevered beyond wall below
- 10** Foundation wall in conditioned basement
- 11** Floor of conditioned basement



- 1** Around plumbing vent stack
- 2** Attic hatch
- 3** Tops of interior walls
- 4** Recessed light
- 5** Behind built-in cabinets
- 6** Around door
- 7** Plumbing penetrations

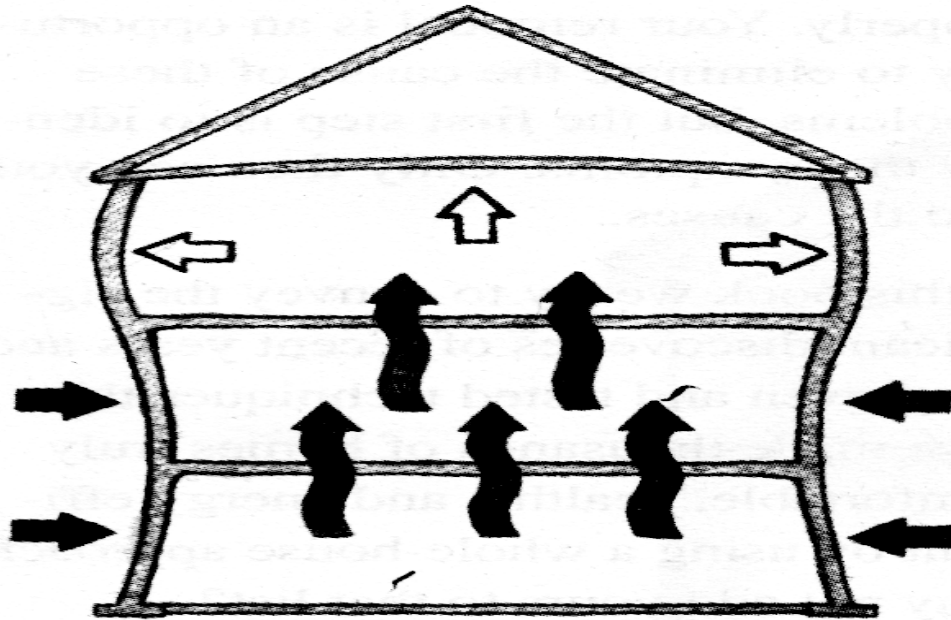
- 8** Around bathtub
- 9** Sill plate
- 10** Around chimneys and flues
- 11** Fireplace damper
- 12** Furnace or air conditioner air handler box

- 13** Where additions join house
- 14** Around window
- 15** Behind baseboards
- 16** Around electrical sockets
- 17** Around duct boot and register
- 18** Ducts
- 19** Around dryer vent

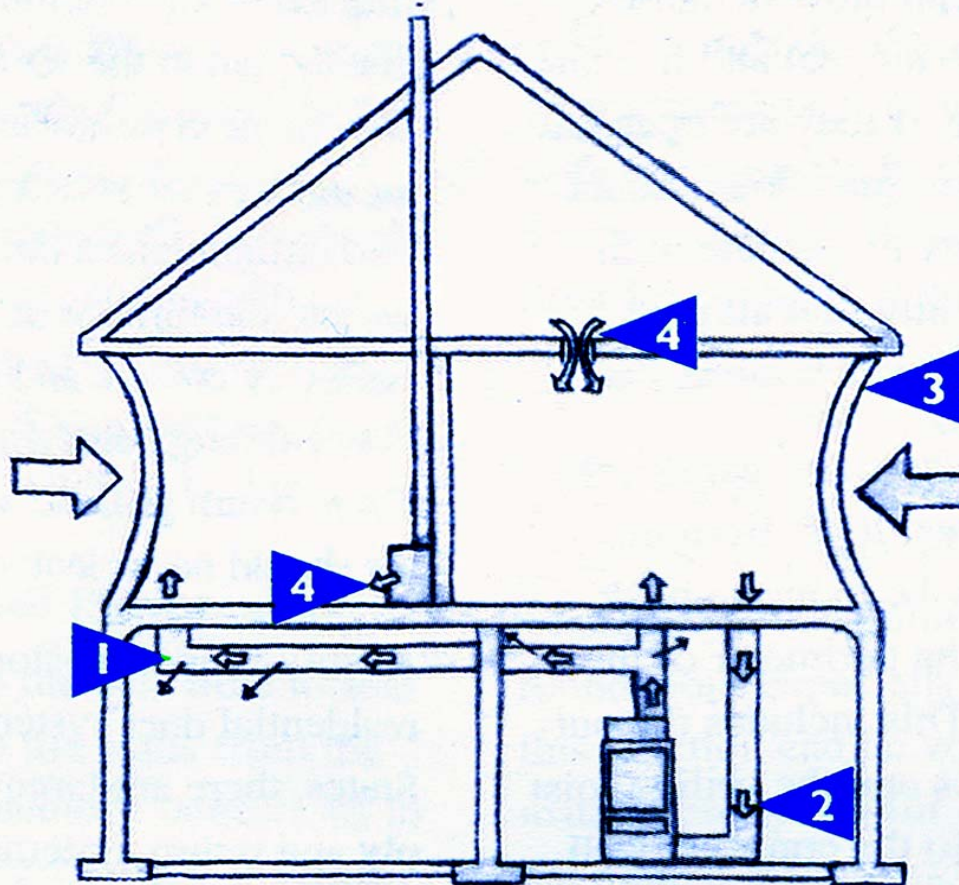


Air travels through your house in unexpected ways. The wall, ceiling, and floor cavities often serve as passageways where moisture and odors also travel. When holes made for plumbing, lights, and electrical wires are not sealed, air moves in and out freely, causing your home to become uncomfortable and driving up your utility bills.

Air Movement Is Dynamic

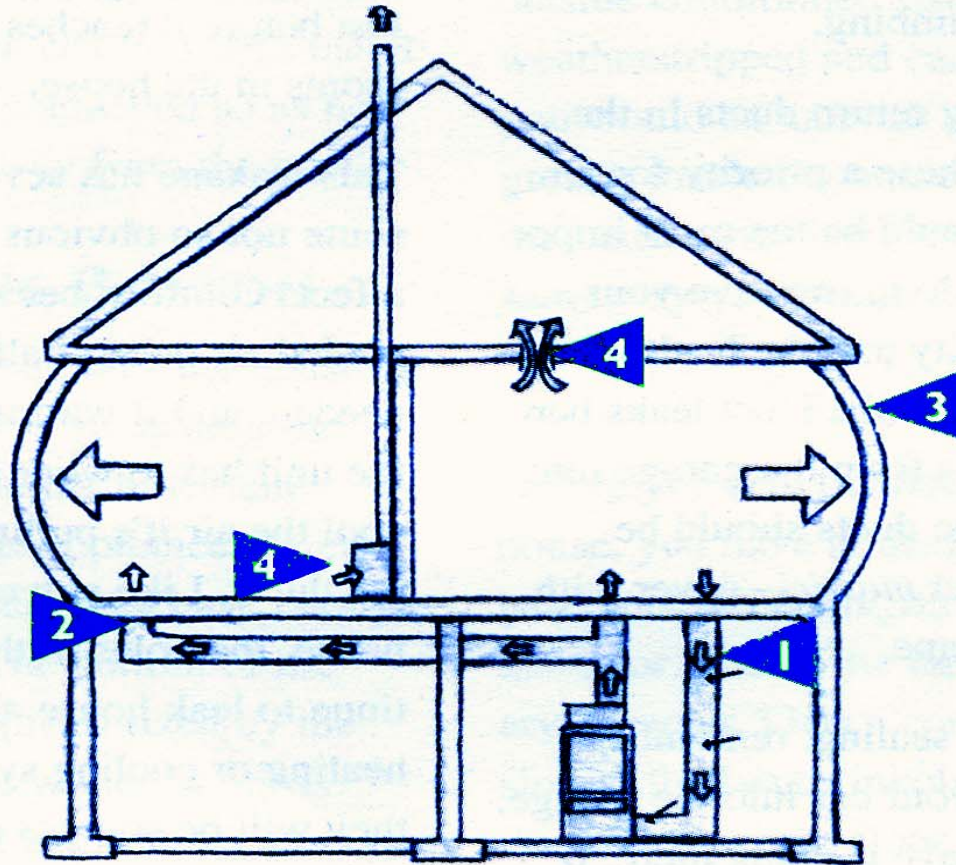


Heat and pressure differences cause a dynamic in the house known as the stack effect. Hot air inside will rise, putting pressure on the top of the house, where this air will force its way outdoors. At the bottom of the house the lower pressure pulls outside air indoors. In winter, this makes your heater work harder and creates drafts.



Depressurized house

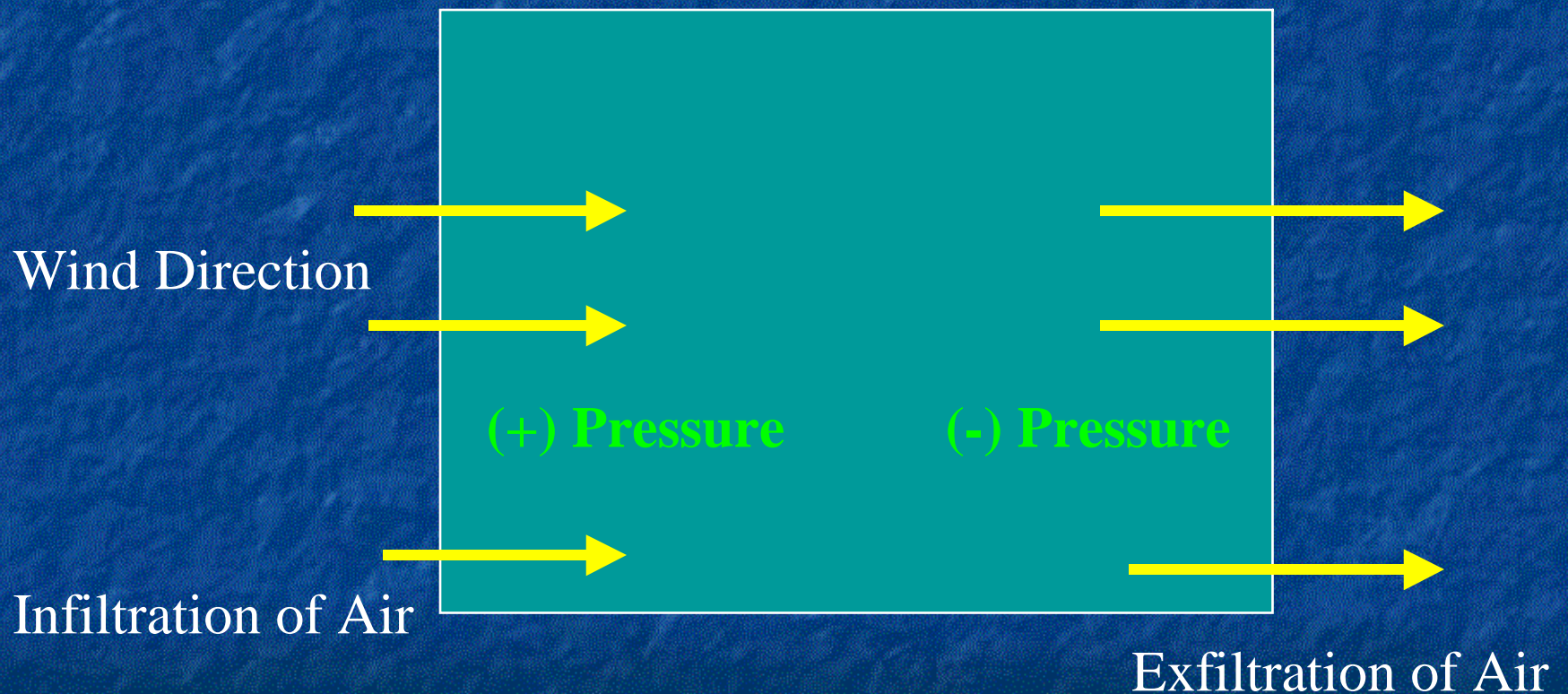
- 1** Supply ducts leak air outside living space
- 2** Return takes more air from house than leaky supply ducts replace
- 3** House is depressurized
- 4** Air leaks in through holes in house air barrier



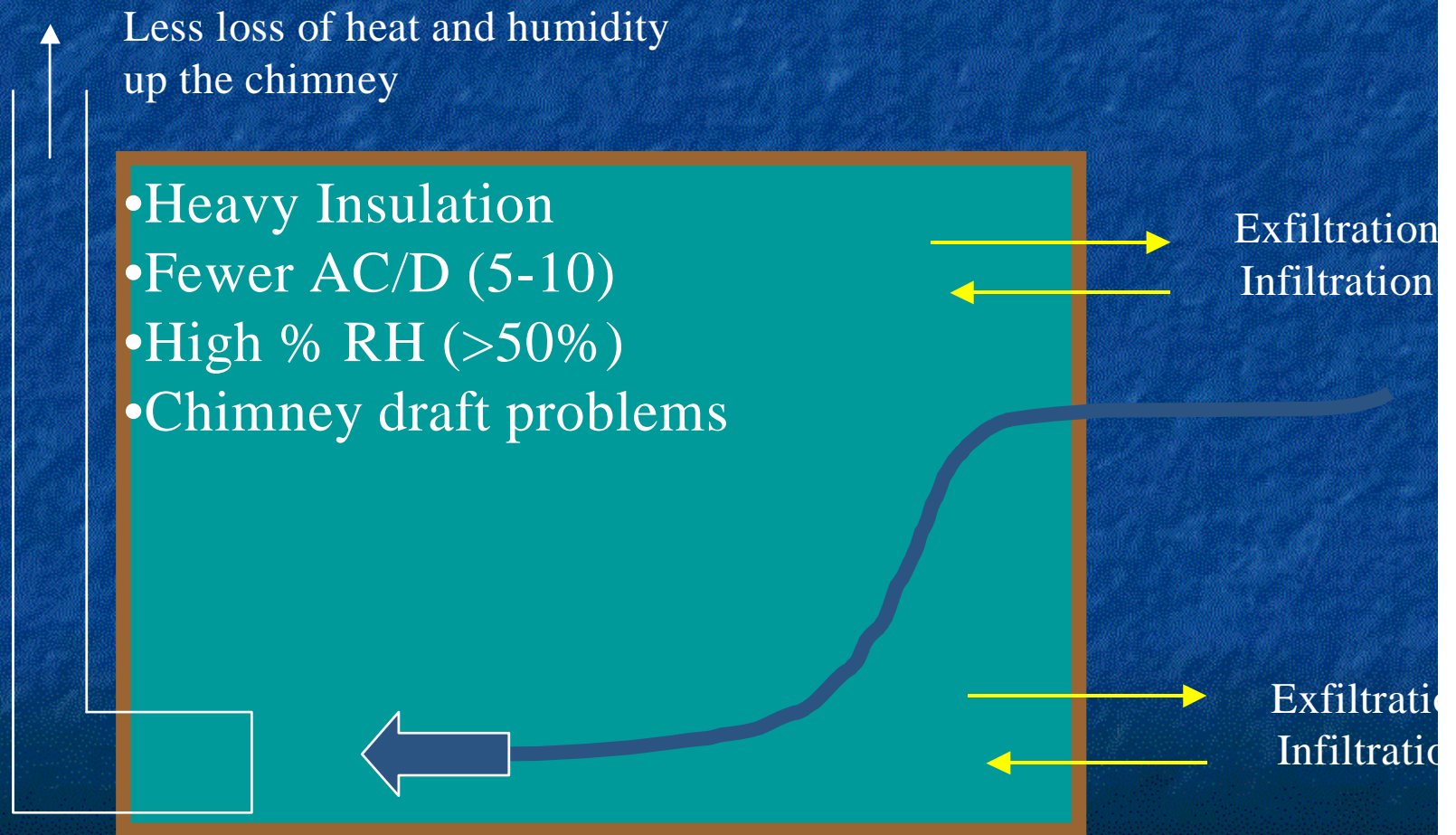
Pressurized house

- | | |
|---|---|
| <p>1 Return duct leaks take air from basement, instead of house</p> | <p>3 House is pressurized</p> <p>4 Air leaks out through holes in house air barrier</p> |
| <p>2 Supply ducts add more air to the house than leaky return ducts remove</p> | |

Effect of Wind on Air Movement and Pressure in the House



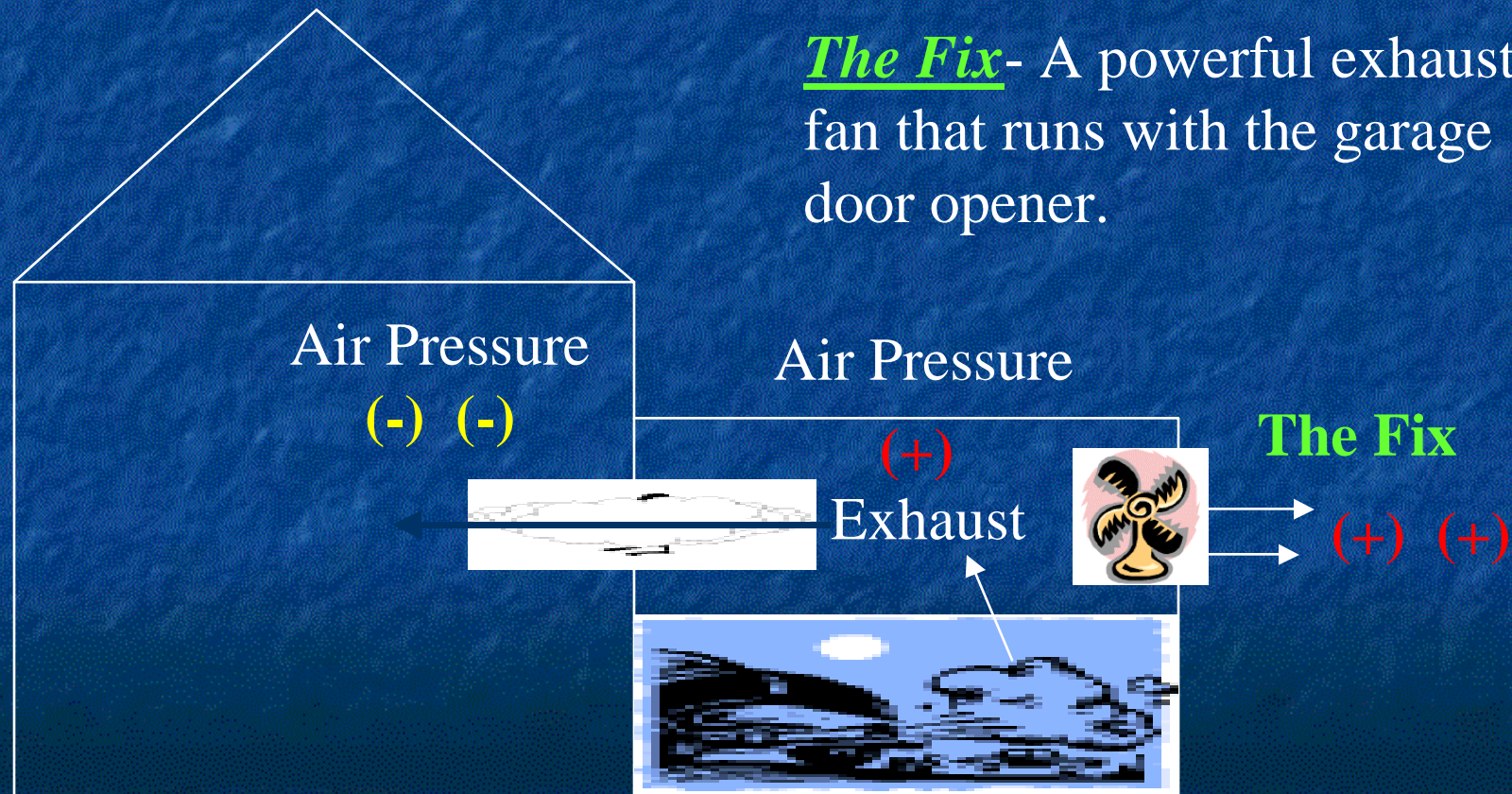
Air Dynamics of a Well Insulated House with a Furnace and Chimney



Movement of Combustion Products from garage into the House

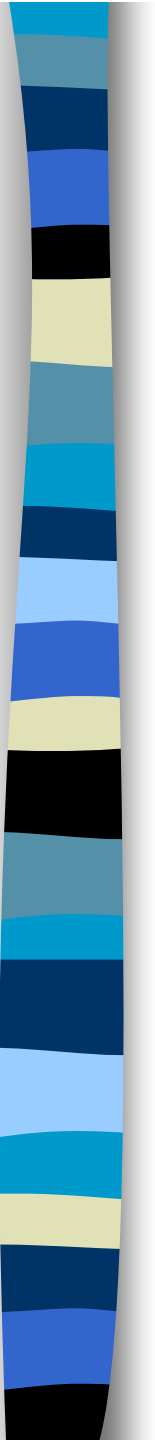
Gasoline or Diesel combustion products flow into house from positive (+) to negative (-) pressure.

The Fix - A powerful exhaust fan that runs with the garage door opener.



The four “P”s of pollution

- People
- Pollutants
- Pathways
- Pressures





The House Is A System

- EVERY CHANGE made in materials, technique, design, or appliances, affects the house system in either a positive or a negative way.
- A lack of good information and training in building science, leads to unintended and often misunderstood IAQ and building performance failures



Characteristics of Many Older Buildings

- Leaky and Drafty
- Poorly Insulated
- High Energy Use
- Uncomfortable
- Natural Ventilation
- Materials get wet & can often dry
- Lasted a long time



Characteristics of Most Newer Buildings

- Tighter construction
- Higher insulation levels
- Lower energy use
- BUT-poor ventilation
- **MOISTURE FAILURES**
- Indoor air quality problems



Characteristics of High Performance Buildings

- Very tight construction
- Carefully insulated
- Low energy use
- High comfort level
- Mechanical ventilation
- Good IAQ
- Reduced moisture problems
- Durable and low maintenance
- Affordable to own...1-2% of the total cost



Keys to A Functional Building and Fantastic Air Quality

- Air tight shell-The American Lung Association agrees that an air tight “continuously sealed” shell is where good IAQ starts
- This is what is done in microchip clean and surgical operating suites-
- Air tight, then ventilate and filter humidity controlled fresh air



Keys to a Functional building

- Fresh air ventilation
- You can never build houses too airtight
- It is possible to under ventilate them
- **IF YOU BUILD TIGHT, YOU MUST VENTILATE IT RIGHT !!**



High Performance Homes

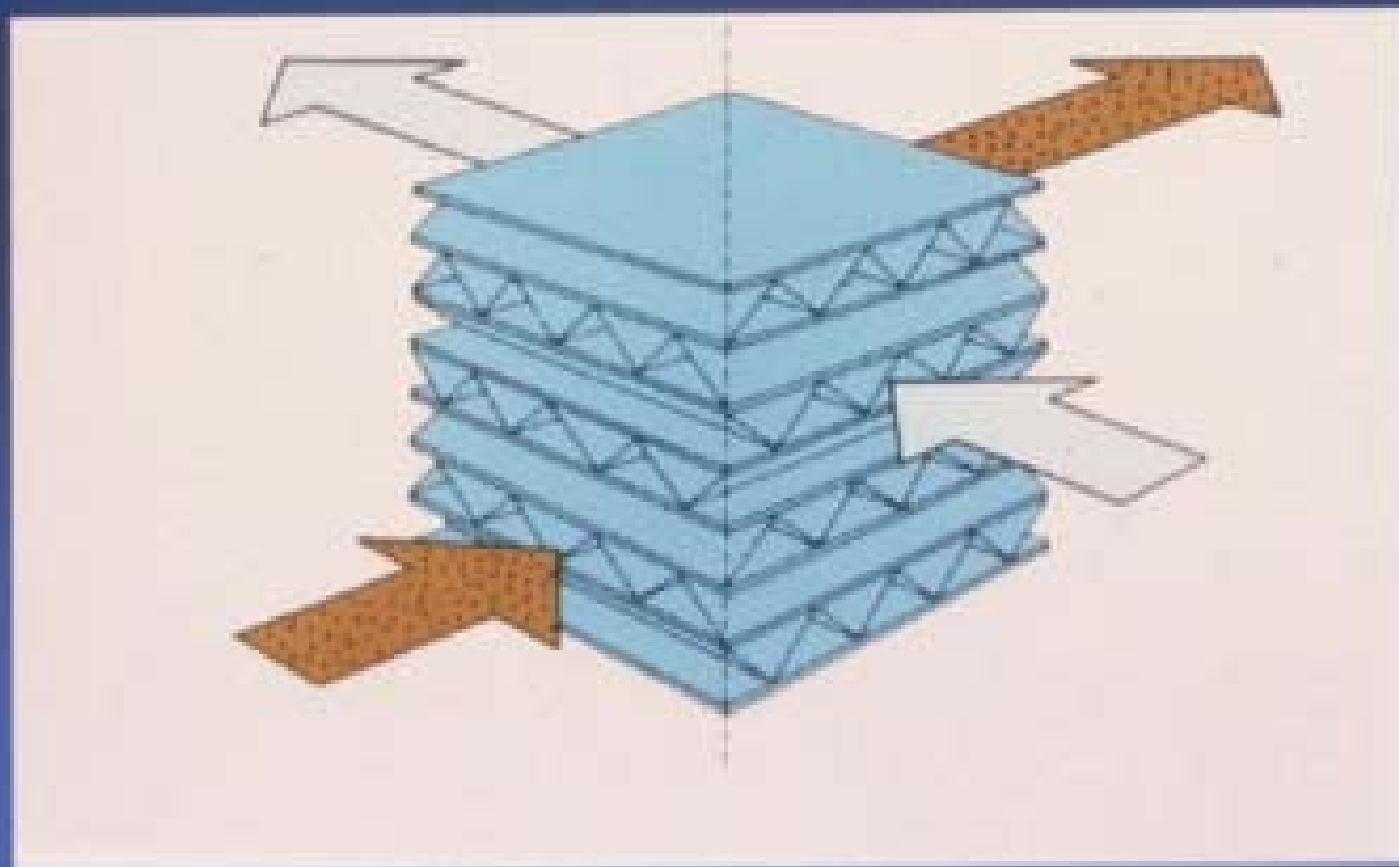
- CARB- Consortium for Advanced Residential Buildings
- CARB'S new builders challenge-2012
- EPA's Energy Star Qualified Homes
- DOE's Building for America's programs
- Green Building Program with their silver, gold and platinum certification
- The consumer buy in
- **AN OUNCE OF PREVENTION IS WORTH A POUND OF CURE**

Air to Air Heat Exchanger

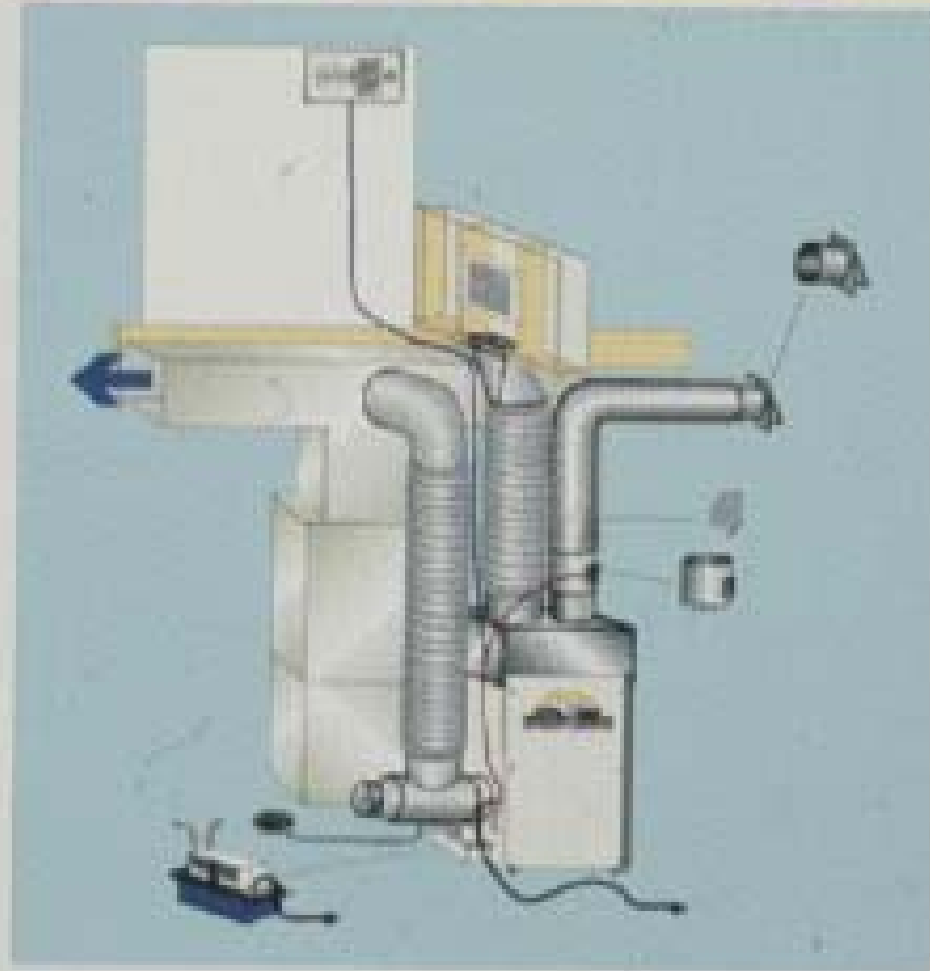


Today's Homes Require Additional Ventilation

The NewAire Heat Exchanger
Provides Critical Ventilation at a Low Cost



Basement



Essentials of Healthy and Comfortable Indoor Air

- ventilation-air changes/day
- water content of air -%RH
- comfortable even temperature
- air movement-air mixing
- all indoor air filtered
- remove pollution sources
- dilute air pollutants with ventilation

Concern for IAQ-Incubator Effect

- 89% time spent inside homes
- ventilation reduced
- synthetic building materials
- Pollutants concentrated
- time weighted exposure
- multiple pollutants-to include water
- victims are the elderly, the children , the disabled and the unsuspecting

Indoor/Outdoor Exposures

- A very elaborate calculation – states that the indoor/outdoor Exposure is 22 times greater indoors than outdoors
- Indoor contribution > 95%

Americans as Indoor Creatures

■ Indoors	89%
■ Transit	6%
■ Outdoors	5%



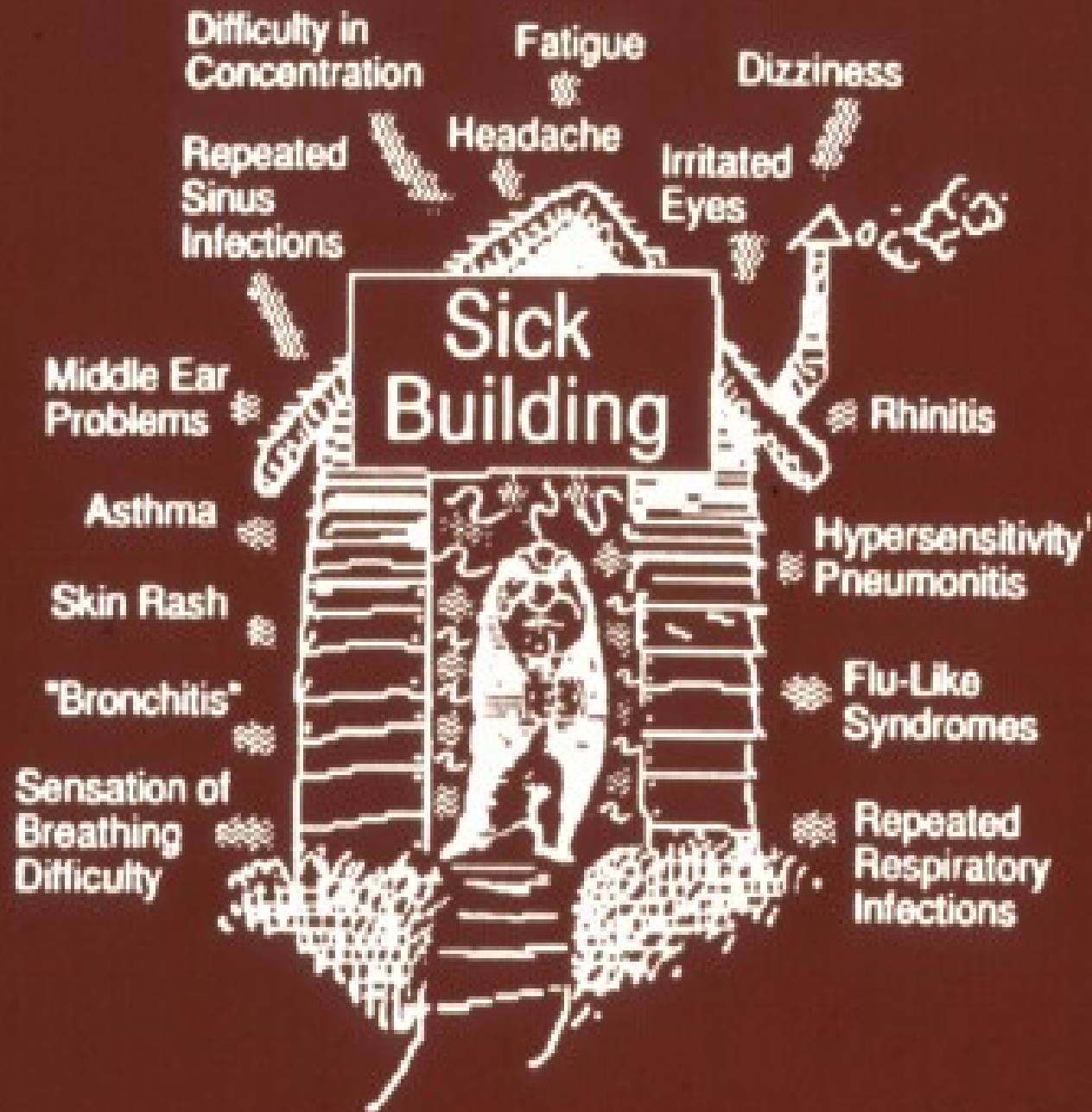
Childhood Diseases

- Asthma – 160%
- Childhood cancers – 33%
- Testicular cancer in young men
- Cook stoves in developing countries



National Productivity

- Study of office worker productivity by Fiske and Rosenfeld
- 43 to 258 billion dollars/year (IAQ)
- Article (cover story) in Business Week (June 5, 2000)



Case Report

A 42 year old woman moved into a reconditioned, manufactured house in 1992. The house recently had a new roof, a new subflooring and many windows replaced.

The woman and her 2 daughters had frequent URI's, medical providers visits and multiple antibiotics. None of them had significant URI's prior to moving into this house.

Special Studies:

1. RH 85%
2. 5 Indoor Molds with 2000-7000 CFU's
3. CO level of 15ppm

They moved out of the house in 1998 and since that time they have had many fewer URI's.

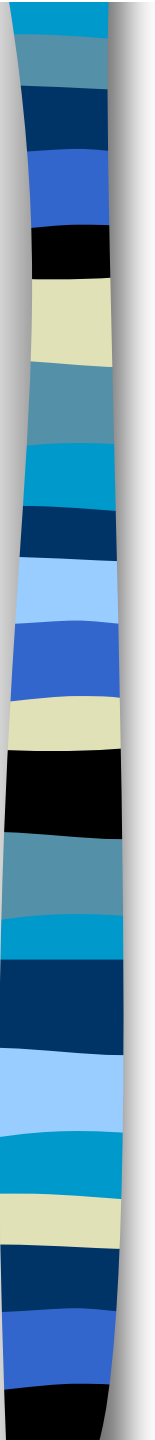
Air Pollutants

Microbes

- Bacteria
- Viruses
- Mold
- Thermophylic
- Actinomyces

Allergens

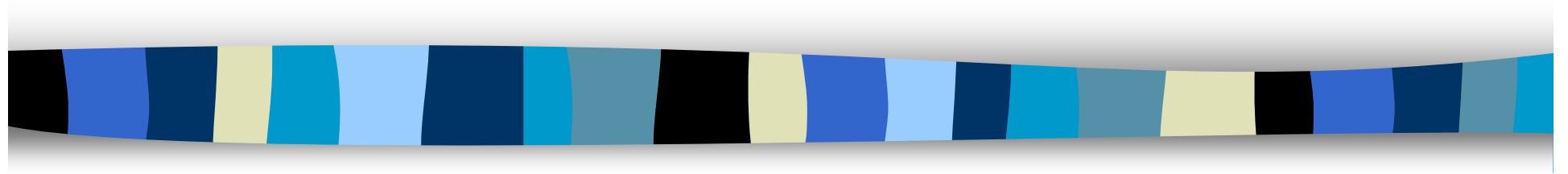
- Pollens
- Mold
- Dust mites
- Insects
- Pets
- Rodents





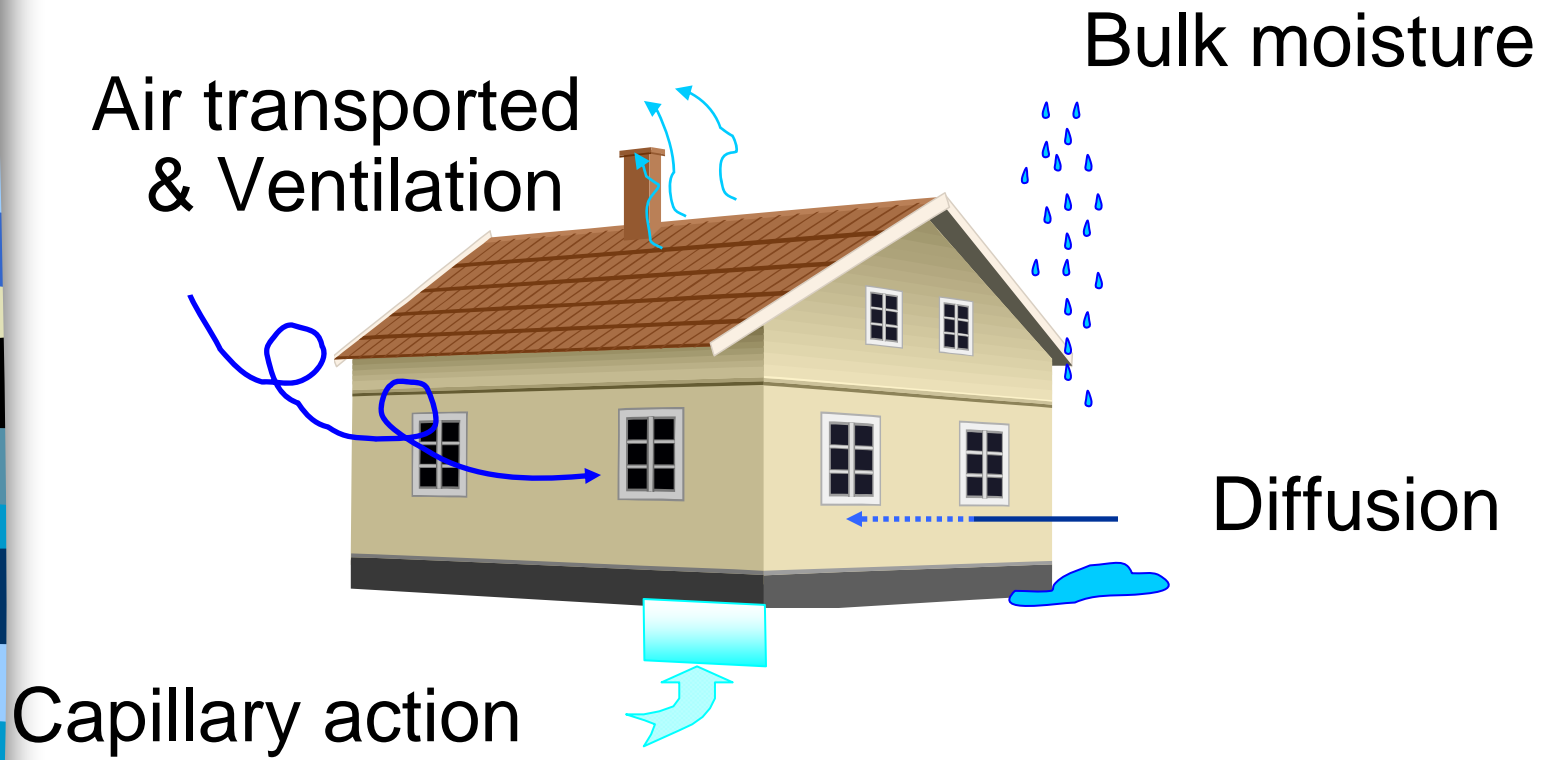
Air Pollutants-inorganic

- Combustion products
 - Gasoline
 - Diesel (DEP)
 - Wood
 - Cigarette
 - Other fuels
- Gases
 - NO_2 , CO , CO_2 , SO_2
- Volatile organic compounds
 - Formaldehyde and others
- Ozone
- Particulates
- Lead, Asbestos
- Radon

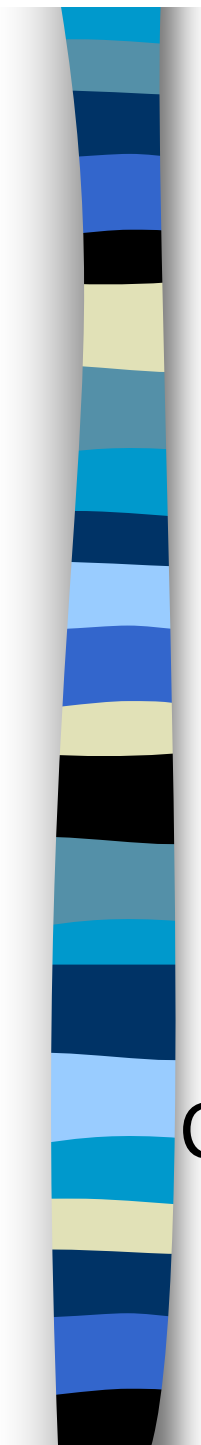


**MOISTURE IS THE MOTHER OF
MOST BIOLOGICAL EVILS**

All buildings are affected by...



Moisture Transfer



Monitoring Humidity Levels

- Simple Hygrometer



Monitoring Humidity Levels

- Hobo Data Loggers





MOLD

- Mold has attracted a great deal of attention in the past 25 years.
- Groups of people are “polarized” regarding the significance of mold
- Overreaction on both sides
- Lawyers have discovered that “mold is gold”
- Hysteria reigns supreme

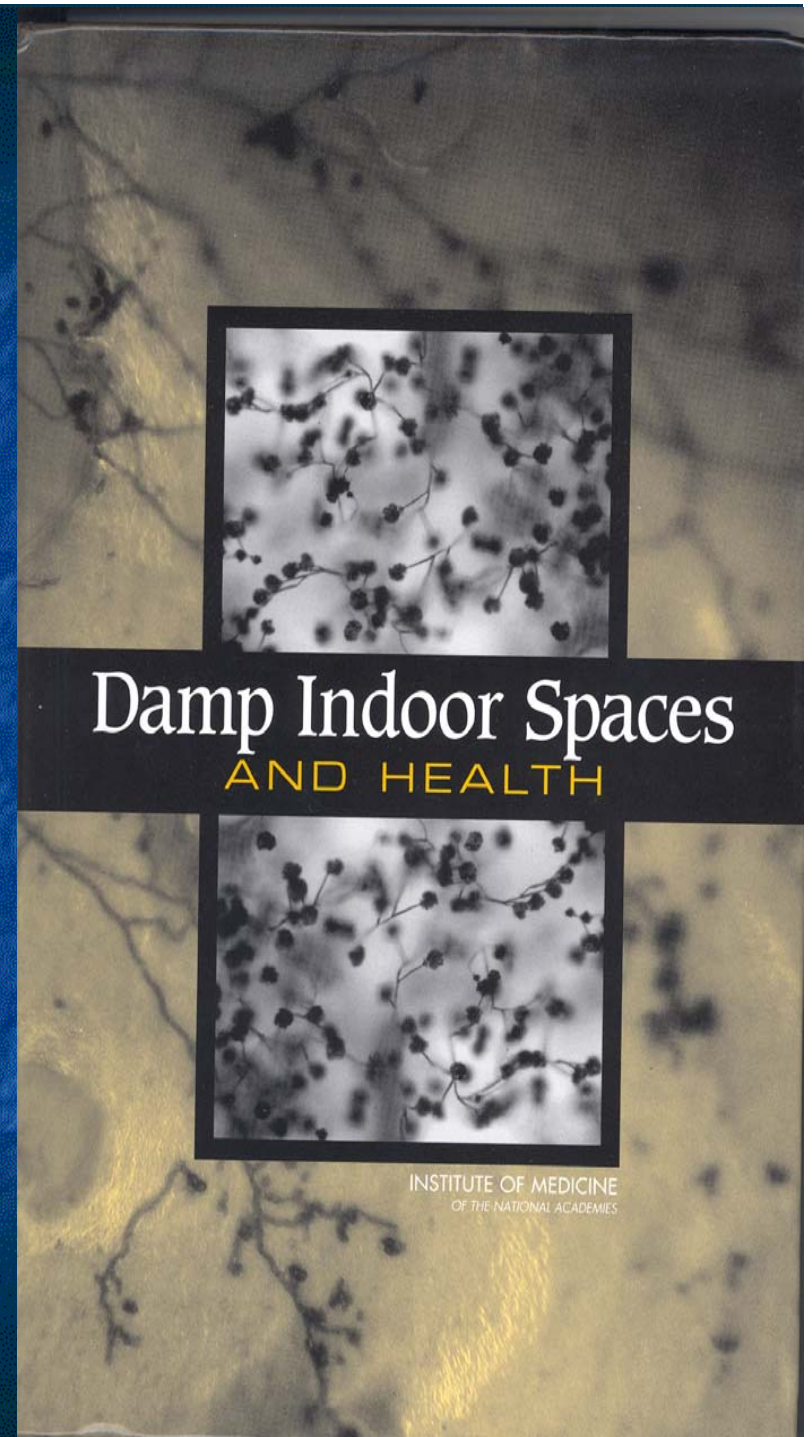
Edited by Dr Noreen
Clark

Institute of Medicine

The National
Academies Press

2004

Less than \$50.00





What is a Damp Space?

Very broad definition

Visible water

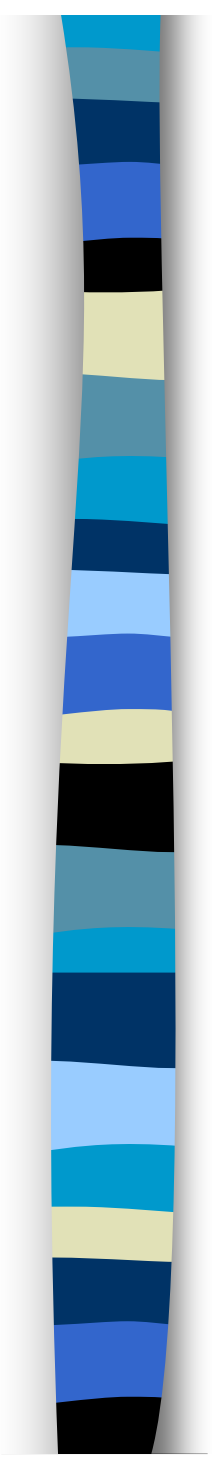
Water damage

Damp spots

Water leaks

Flooding

Mold



Questions to Help Identify Mold Exposure or Water Intrusion

1. Has the home been flooded?
2. Is there any water-damaged wood or cardboard in the house?
3. Has there been a roof or plumbing leak?
4. Have occupants seen any mold?
5. Have occupants noticed a musty smell?



Damp Indoor Spaces And Health

- Edited by Dr Noreen Clark
- University of Michigan school of Public Health
- A committee was convened in 2002 and the book was published in 2004
- “On the basis of its review of the scientific papers-excessive indoor dampness is a public health problem”



Summary of Findings Regarding the Association Between Health Outcomes and Exposure to Damp Indoor Environments

- Sufficient Evidence of a Causal Relationship NONE
- Sufficient Evidence of an Association---Upper respiratory tract symptom-cough-Wheeze-Asthma symptoms in sensitized asthmatic persons
- "Damp Indoor Spaces"



Findings Regarding the Association Between Health Outcomes and Exposure to Damp Indoor Environments

- Limited or Suggestive Evidence of an Association
Dyspnea-Lower respiratory illness in otherwise-healthy children
- Asthma development
- “Damp Indoor Spaces”



Inadequate or Insufficient Evidence to Determine Whether an Association Exists

- Airflow obstruction-Mucous Membrane Irritation Syndrome-COPD-Inhalation Fevers (non-occupation)-Lower Respiratory Illness in otherwise-healthy adults-Acute Idiopathic Pulmonary Hemorrhage in infants
- Skin symptoms, GI Problems, Fatigue, Neuropsychiatric Symptoms, Cancer, Reproductive effects, Rheumatologic and other immune disease
- “Damp Indoor Spaces”



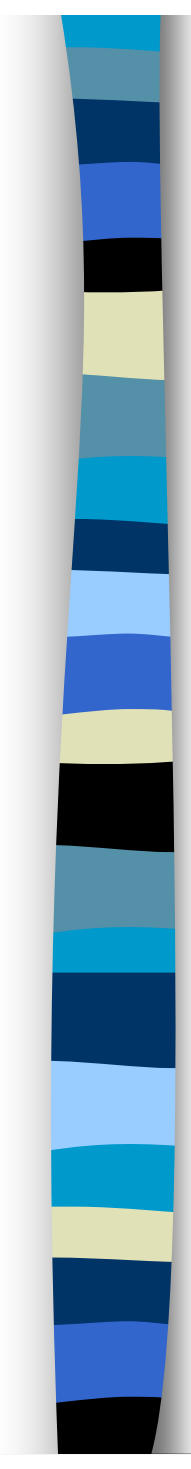
Summary of Findings Regarding the Health Outcomes and the Presence of Mold or Other Agents in Damp Indoor Environments

- Sufficient Evidence of a causal Relationship—NONE
- Sufficient Evidence of an Association-nose and throat sx's, Asthma sx's in a sensitized person, Cough, Wheeze, Hypersensitivity pneumonitis
- Limited or Suggestive Evidence of an Association-Lower respiratory illness in otherwise-healthy children
- Inadequate or Insufficient Evidence-The same list as the damp house environment
- "Damp Indoor Spaces"



There is Much in the Literature to Support the Relationship of Damp buildings and Illness

- The European literature has lead the way when looking at damp or wet building causes of disease
- The key words are damp or wet buildings, respiratory disease, disease in general, mold or fungi, mycotoxins, endotoxins, particulates, VOC's, indoor pollutants, building related illness, sick building syndrome, ergosterol, and beta glucans
- Many of the studies have gotten better since the Damp Indoor Spaces and Health publication came out in 2004



Hydrophilic fungi and ergosterol associated with respiratory illness in a water-damaged building -- -- Environmental Health Perspective, 2008 Jan;116(1);45-50

Park JJ, Cox-Ganser JM, Kreiss K, White SK, Rao CY

- Our findings extend the 2004 conclusions of the Institute of Medicine
- Mold levels in dust were associated with new-onset asthma in this damp indoor environment



Moisture damage and childhood asthma: a
population-based incident case-control study
European Respiratory Journal

Pekkanen J, Hyvariened A, Haverinen-shaughnessy
U, Korppi M, Putus T, Nevalainen A.

- The present results, using standardised assessment of exposure and asthma, suggest that moisture damage and mould growth in the main living quarters are associated with the development of asthma in early childhood



Major Bio-aerosols or Factor “X”

- Mold and multiple by-products of mold
- Gram-negative Bacteria/endotoxin
- Dust Mites to include fecal proteases
- Break down products of water damaged buildings

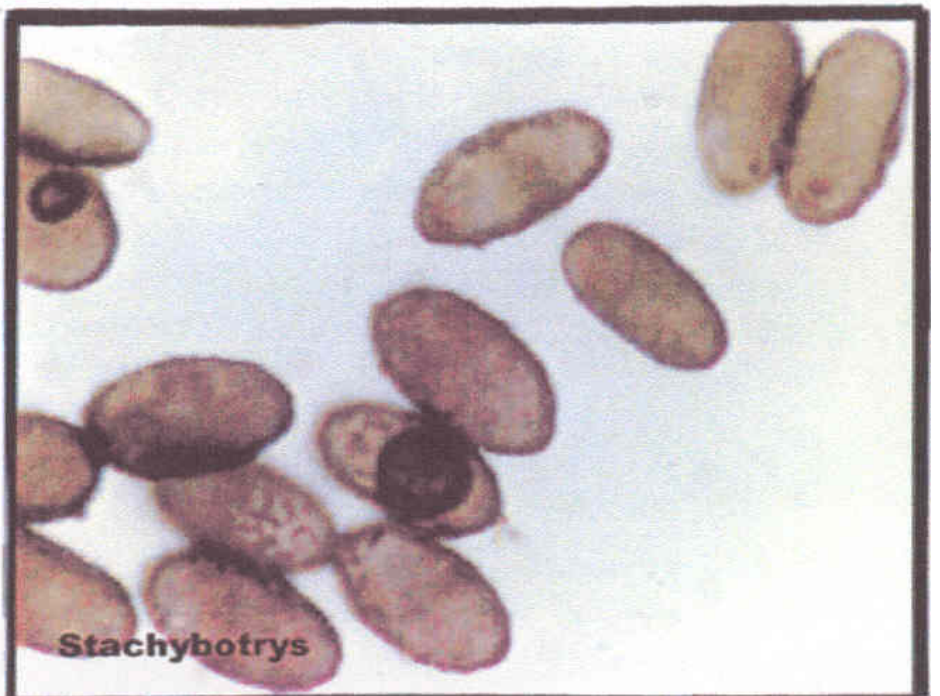
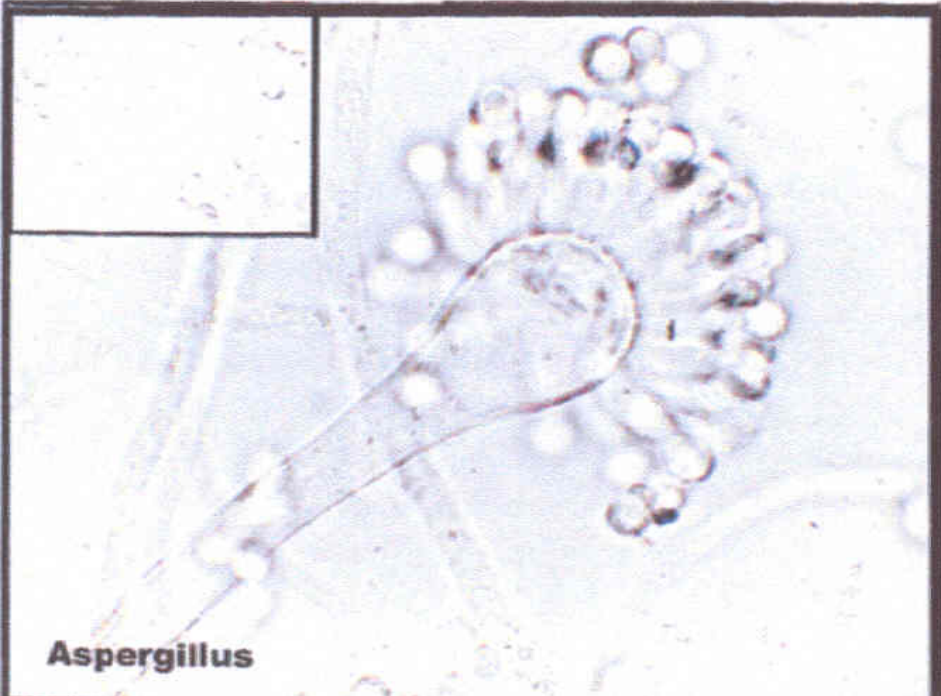
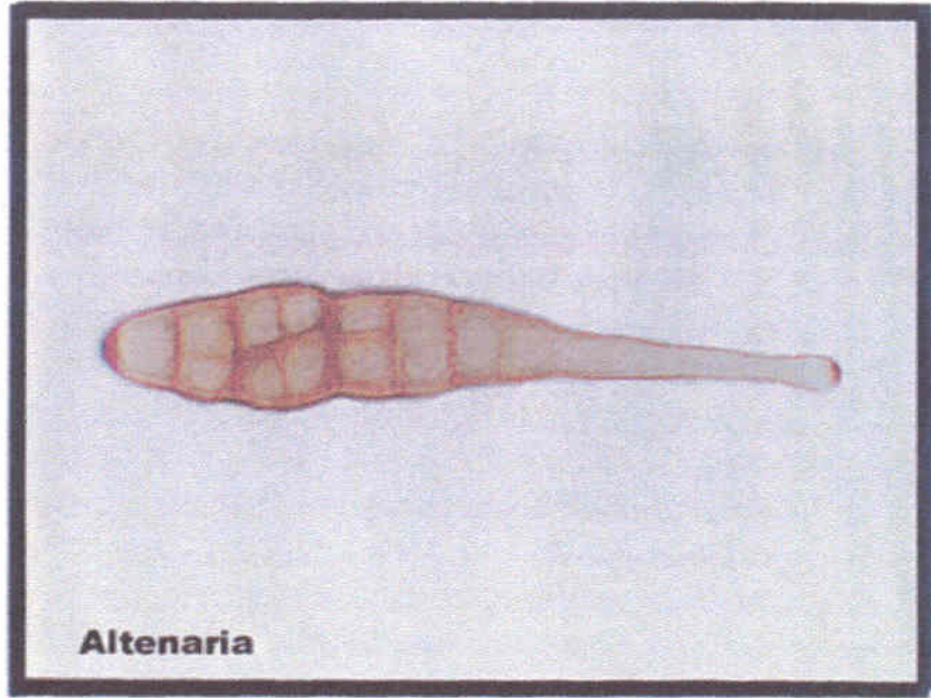
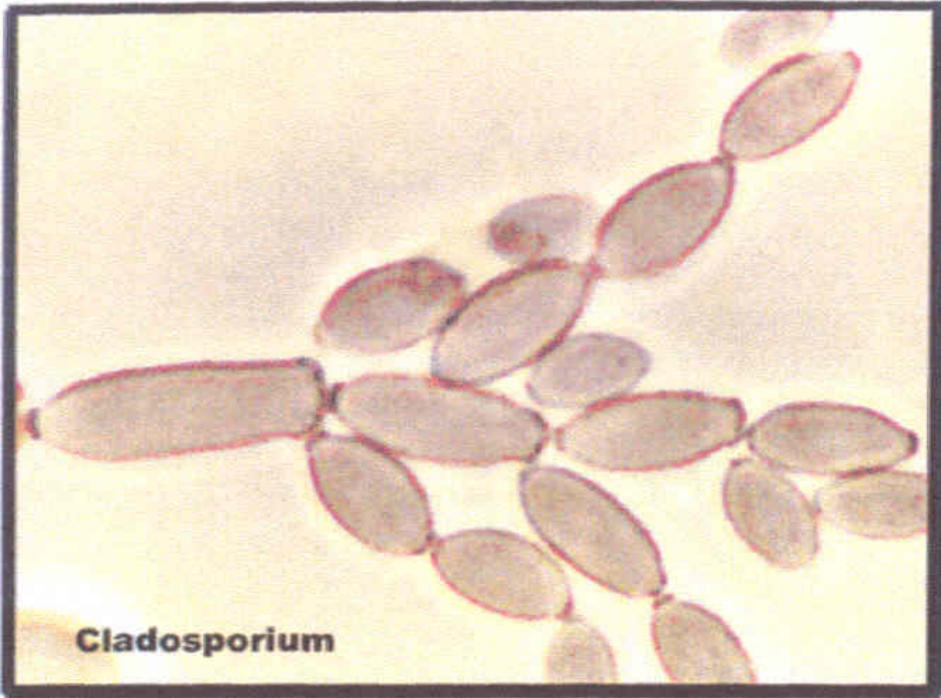


The Witch's Brew-Multivariable of all the Biomass-Factor "X"

- Microbes
- Changing seasons
- Temperature
- Available food and water
- Interaction with other microbes and all other pollutants

Examples of Buildings in Europe







Mold Growth

- The molds do not have any internal digestive system so that the enzymes are released into the area where the mold is growing and are available for digestion of the materials at hand
- These enzymes contain proteases that have the ability to digest many types of materials
- An array of alcohols, voc's and other material. are formed by the action of the digestive process
- Toxins or mycotoxins are formed as part of the growth or metabolic process (secondary metabolic products)
- Spores are produced to propagate future growth and generation of the colony-and are not produced all of the time

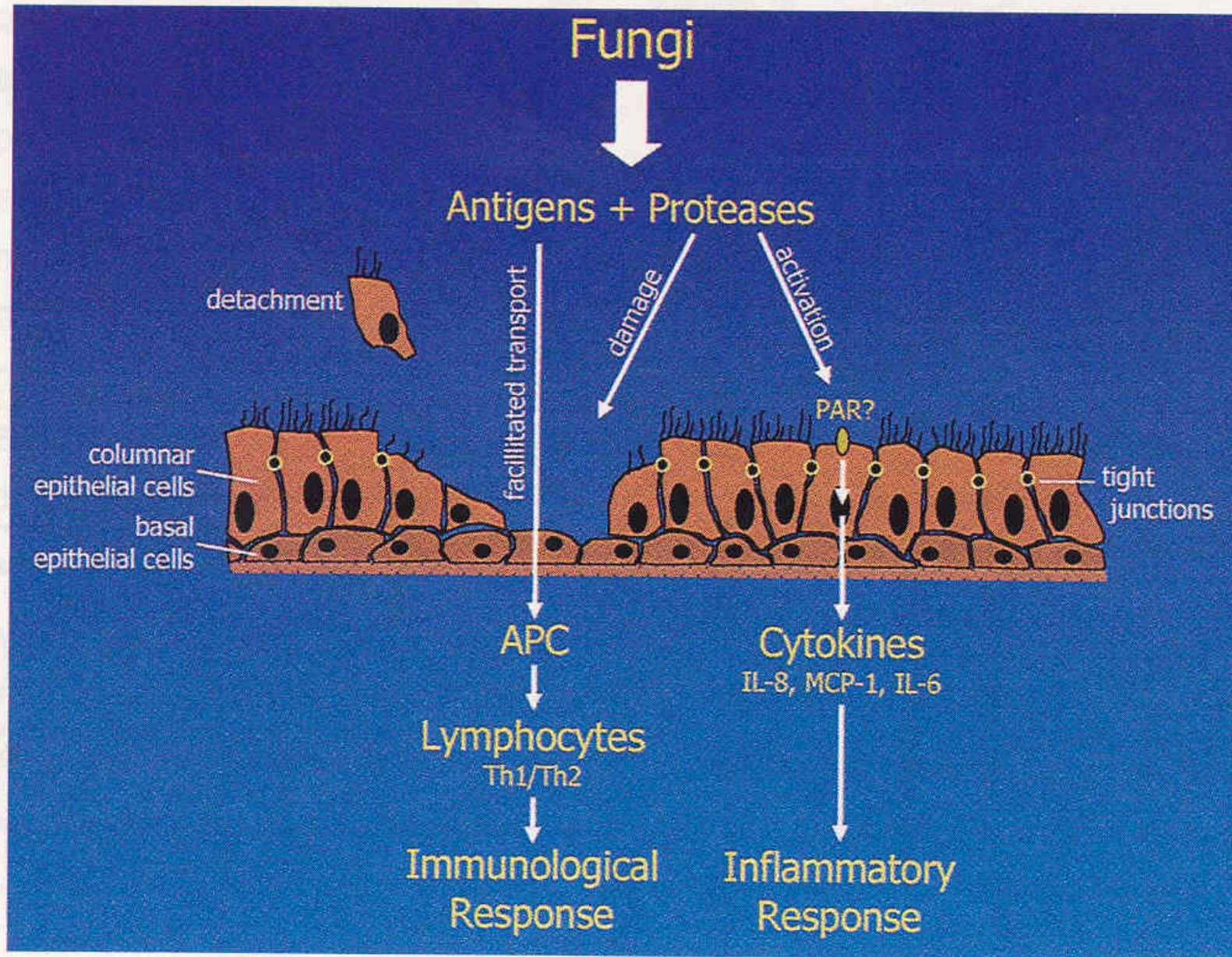


FIG 4. Interaction of fungal proteases with epithelial cells. Cell damage and cytokine release are shown concomitantly with the proposed effects on the inflammatory response and facilitation of the immune response. APC, Antigen-presenting cells; MCP-1, monocyte chemotactic protein-1.

One Tract-One Disease-Nose to the Alveoli

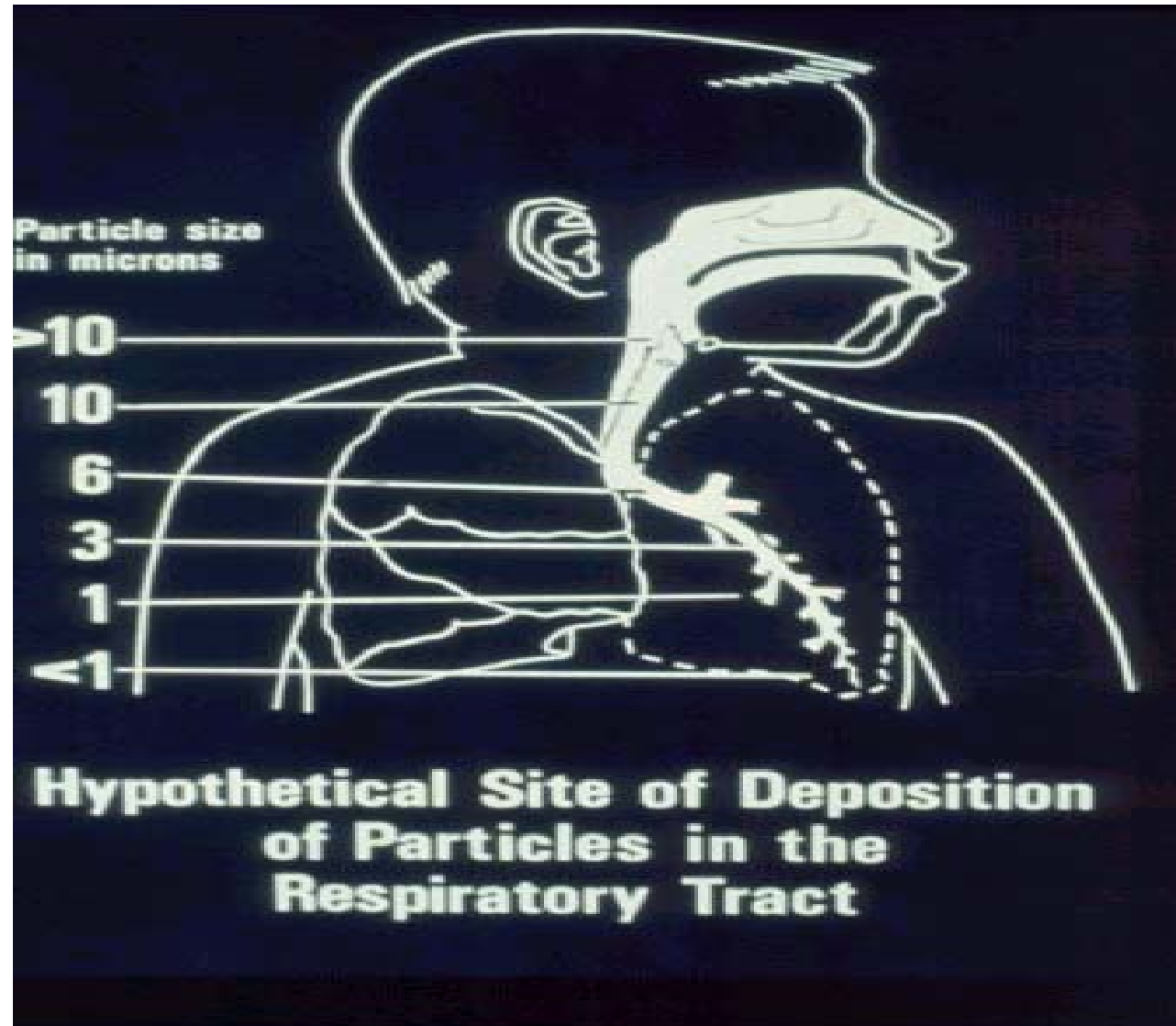




The Respiratory tract-First Line of Defense Against the World

- Most common target for environmental agents
- 8-9000 liters of air is breathed in one day
- Serves as the direct interface with the outside world
- The lungs play multiple roles
 - supplier of oxygen-rids the body of CO₂
 - remover of waste and toxins – anti-oxidents
 - Glutathione-s-transferase GST
 - defender against hostile intruders

Particulate Movement in the Tracheobronchial Tree

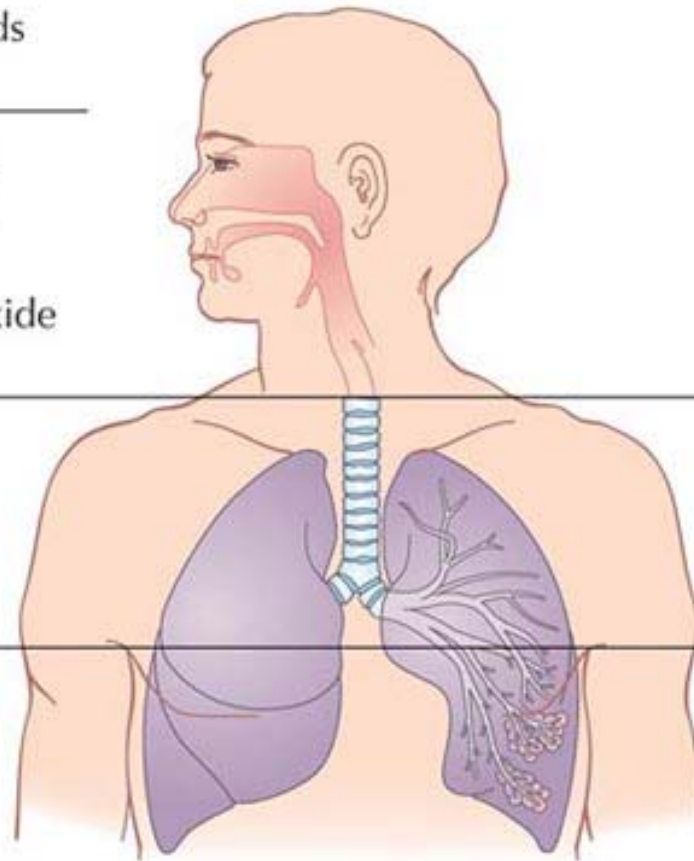


Water solubility and site of initial impact of airborne irritants

Water solubility	Initial level of impact	Compounds
High	Eyes Nose Pharynx Larynx	Aldehydes Ammonia Chlorine Sulfur dioxide

Medium	Trachea Bronchi	Ozone
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Low	Bronchioles Alveoli	Nitrogen dioxide Phosgene
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Respiratory Tract Inflammation

- Infection or Invasion
- Allergy
- Bacterial endotoxin effect
- Innate immunity
- Protease-activated innate immunity
- Irritant particulates, VOCs
- Toxic



Mold- Mechanism of Disease

- Direct Invasion of Tissues
 - Healthy people
 - Immuno compromised people
 - HIV
 - Post Transplant
 - Cancer
 - Diabetes
 - Other



Mold- Mechanism of Disease

- Classic Allergic Rhinitis and Asthma
 - IgE Antibodies to spores
 - IgE Antibodies to mold proteases
 - Other
- Allergic Fungal Sinusitis
- Allergic Broncho-Pulmonary Aspergillosis (ABPA)



Hypersensitivity Pneumonitis-Allergic Alveolitis

- Inflammation of the air sacs or alveoli
- Caused by a host of fungal bioaerosols
- Materials penetrate deep into the lungs- smaller particles
- IgG antibody identified by diffusion type of reaction
- Will become a disabling disease if subject is not totally removed from the antigen source



Humidifier Disease

- Hypersensitivity condition related to contaminated humidifiers
- Fever, Chills, interstitial pneumonia
- Leads to pulmonary failure and possible death
- **HUMIDIFIERS NEED TO BE KEPT CLEAN !!!**



Irritant Effect

- Pot-Pouri of material manufactured by the growing mold colony or the on-going metabolic processes
- Voc's particulates alcohols aldehydes beta 1- 3 glucans-ergasterol
- Enzymes – tryptases- peptidases
- Small hyphal particles with ??
- Others-dependng on the mold substrate temperature water activity



Mold-Mechanism of Disease

■ Mycotoxins

- Mycotoxins are metabolites of active growing molds
- Wide spread effect on many tissues
- These toxins can be: nephrotoxic, hepatotoxic, neurotoxic, and effect other organ system
- No human studies have been done



Mechanism of Disease-Bacteria

- Direct Infections or invasion of tissue
 - Legionnaire's Disease
 - Anthrax
 - Others
- Injury to tissue with out invasion
 - Gram positive with exotoxin
 - Gram negative with endotoxin
 - Mixed with both toxins
 - Bacteria growing outside the host producing toxins with direct effect on the host as it contacts the toxin



Endotoxins

- Lipopolysaccharide
- Produced by gram negative bacteria
- Grow in high moisture area
- Gram negative bacteria growing in standing water will produce endotoxins-this may cause the sick building syndrome
- Drs Reed and Milton reported on occupational endotoxin condition at two industrial sites



Symptoms caused from endotoxin exposure

- “Flu like” symptoms
- Ache all over
- Headache
- Fever and chills
- Fatigue
- Respiratory inflammation
- Cough and wheeze

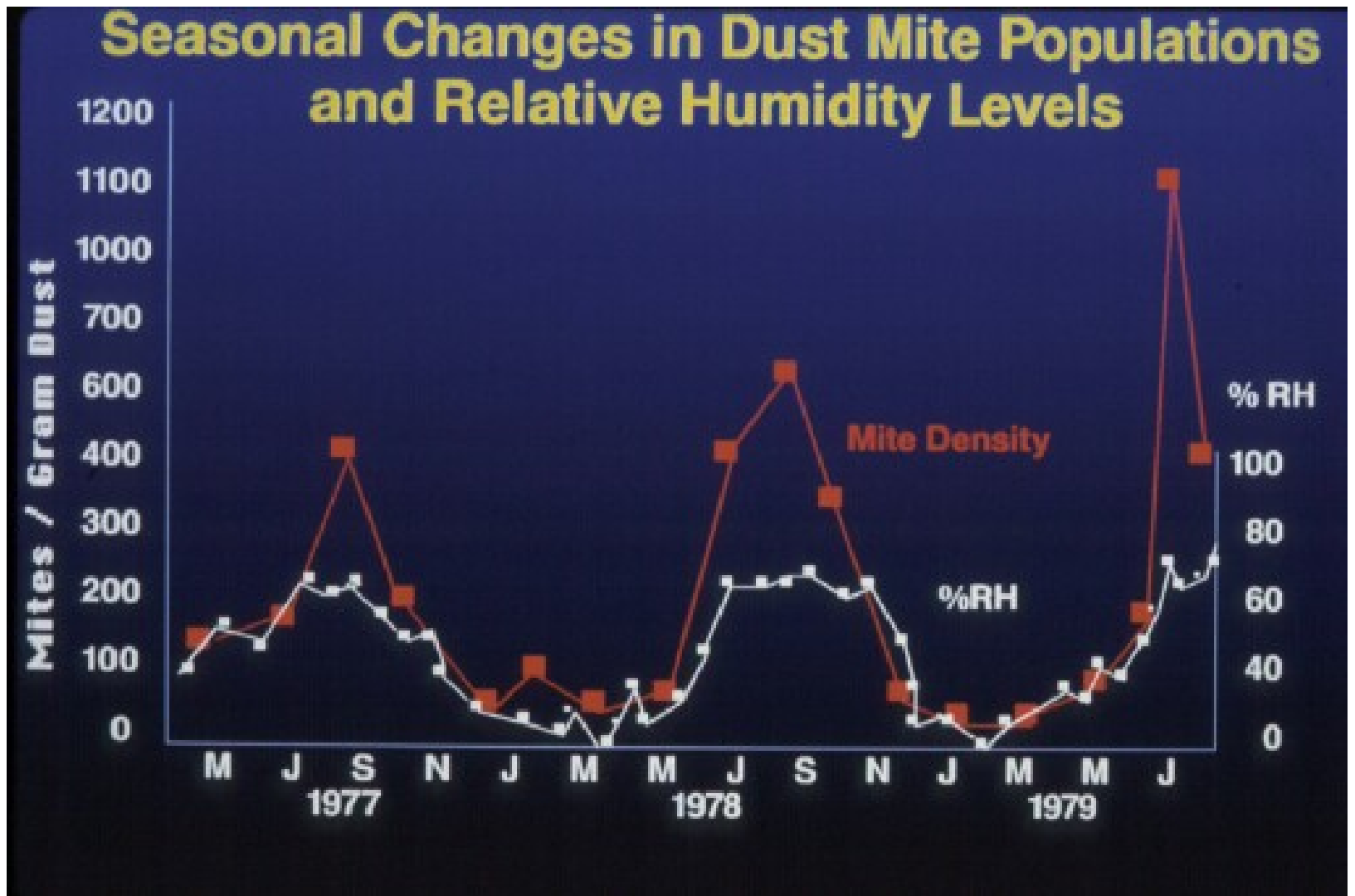
Dust Mites

Dermatophagoides
(×455)

Dust mites are found on mattress surfaces and in pillows, bedding, soft furnishings and soft children's toys. They feed on human skin scales, which are abundant. In one day, a person sheds enough skin scales to feed a mite for months. Since mites need fluid, which they get from the air, humid climates support the population of dust mites.

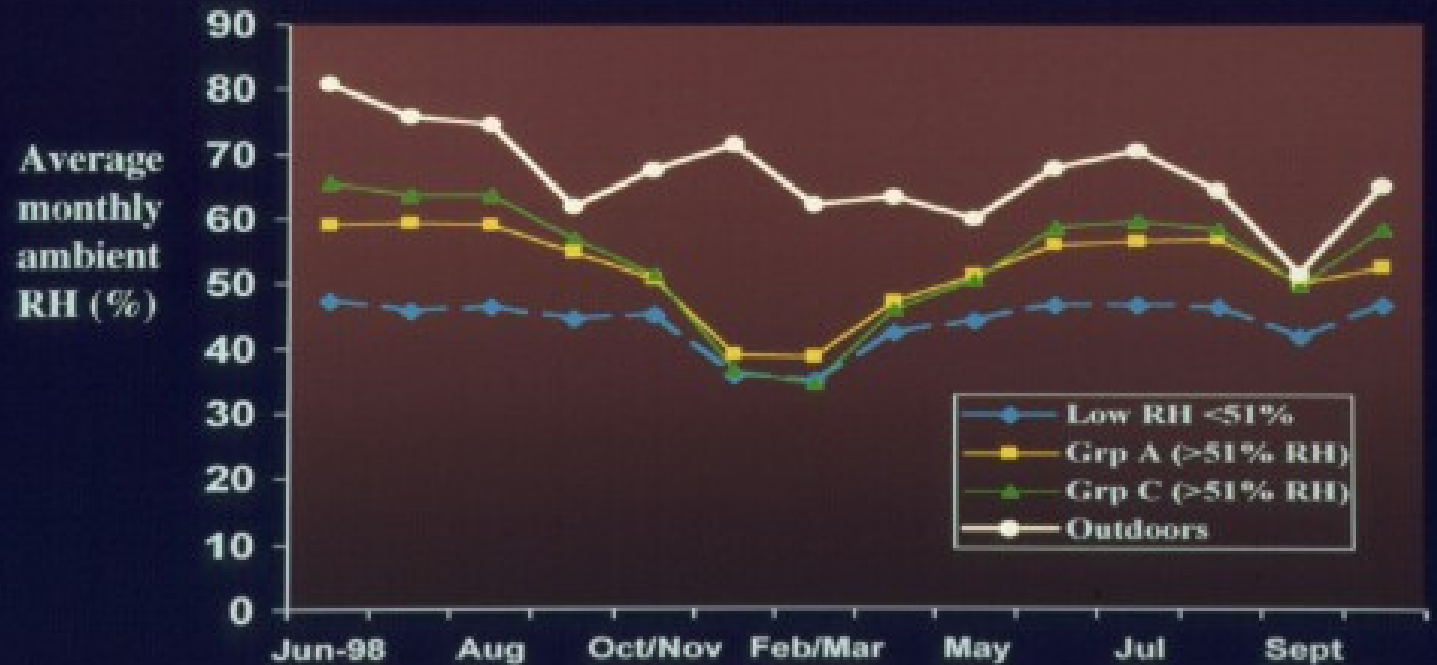


RH Effect on Mite Production



The effect of %RH on Mite Production- Dayton Study

Average monthly ambient relative humidity in homes for the 3 groups vs. outdoors



The Effect of %RH on Mite Growth-Dayton Study

Average live mites for all 3 sites (BRF, FRF and Couch) per gram of dust.





Dust Mites-Mechanism of Disease

- Allergic or IgE type of reaction from the antigen located on the fecal pellet
- Innate immune or irritant reaction from fecal proteases
- Endotoxin reaction from fecal pellet



Environmental Indices of Building-related Health Risk

- Mold air counts do not predict risk
- Dampness is the risk factor, but is a marker of causative agents
- Assess dampness by observation, not expensive measurement
- Hidden dampness still a challenge
- Kkreiss@cdc.gov



Take Home Points

- Dampness-related illness is preventive opportunity
- Observation of dampness-related conditions is sufficient to recommend removal from exposure and remediation
- Clinical and public health action necessary without knowing measurable cause
- Kkreiss@cdc.gov



Summary

- The world's population is increasing along with the need for more energy
- The need for healthy affordable housing is also increasing
- Healthy buildings are possible with the application of newer technology and good building science--- GO GREEN
- Johnouellette@sbcglobal.net
- www.buildingscience.com