

Cracking the Mold Case: A Scientific Approach to Investigation & Control



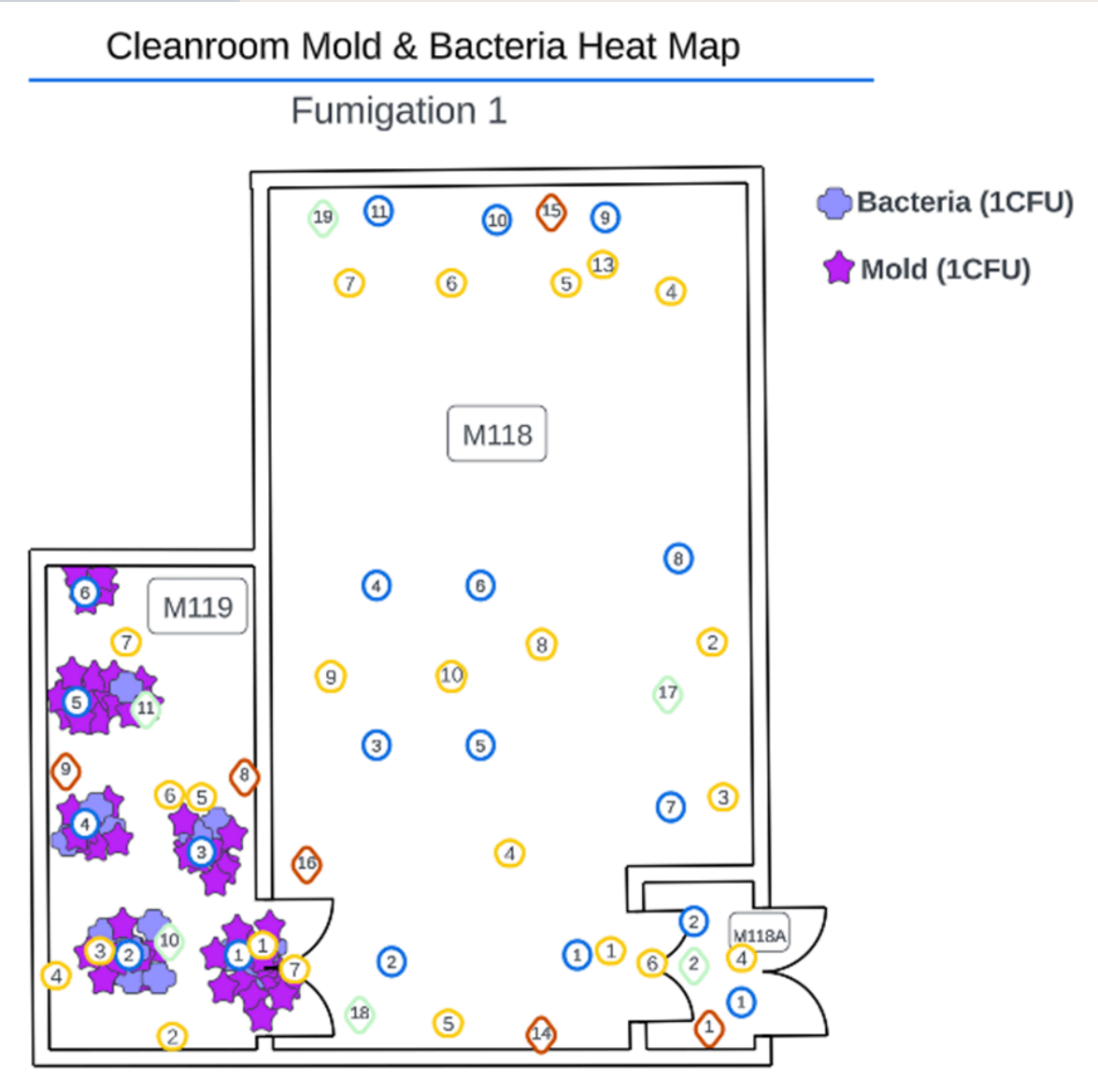
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Sources of Mold

Category	Example	Risks
Facility-related	HVAC, cold rooms, water leaks, structural cracks.	Provides persistent niches for mold proliferation; spores disseminate through airflow and structural breaches as well as material and personnel flows.
Material-related	Wood/cardboard, pallets, paper packaging.	Source for cellulous fungi which may be hard to kill.
Personnel-related	Gown reuse, hygiene lapses.	Acts as a transport vector for spores between uncontrolled and controlled areas.

Did remediation work? → trending required.
Before vs after remediation = objective proof.



Heat Maps & Data

- Overlay EM recoveries by room & sample type → allows visualization of likely ingress routes and areas of proliferation
- Review airflow data (smoke, DP mapping) → explain contamination hot spots
- Compare A/B states before & after gowning, cleaning, DP, or equipment changes

Common Gaps in Investigations

- ✓ CAPAs addressing symptoms, not root cause.
- ✓ Lack of clinical relevance assessment of the organism.
- ✓ No linkage of EM data to facility/process.
- ✓ Overemphasis on gowning & personnel while neglecting organism ID & source.

Premise & Importance
Inadequate mold investigations = recurring contamination.
EU Annex 1 (2022), §2.5 emphasizes need for science-based contamination control strategies and robust investigations.
Strong science-based investigations = stronger contamination control and continuous improvement.

Remediation efforts will remain ineffective without a thorough understanding of mold source, ingress pathways, environmental conditions supporting proliferation, and organism-specific resistance characteristics.



Personnel Flow
Gowning rooms, airlocks, and CNC → classified transitions.

Air intake / make-up air: poorly located intakes, damaged/loaded prefilters.

Wheel & Footborne Transport: Adhesive mats, carts/trolleys, footwear controls.

Cold rooms & refrigeration: door gaskets, condensate, wet insulation.

Material Transfer: Raw materials, pallets, pass-throughs, staging areas.

Utilities & water: drains, humidifiers, condensate pans/lines, leaks.

Building envelope: cracked caulk, wall/floor gaps, ceiling voids, door seals, leaks.

Ingress Points/Sources

Disinfectant Effectiveness

- Alcohols (IPA/EtOH)**
 - Effective against vegetative bacteria and some yeasts weak mold
 - Poor fungicidal activity and not sporicidal
 - Use for residue removal or after sporicide contact time
- Quaternary Ammonium (QACs)**
 - Effective against many vegetative bacteria
 - Some products have limited mold claims; not sporicidal
 - Check label; pair with an oxidizer for spores
- Peracetic Acid / Oxidizers**
 - Broad spectrum, sporicidal
 - Use periodically; frequent use can corrode surfaces
 - Base frequency on risk and EM trends
 - Not all oxidizers will kill all mold

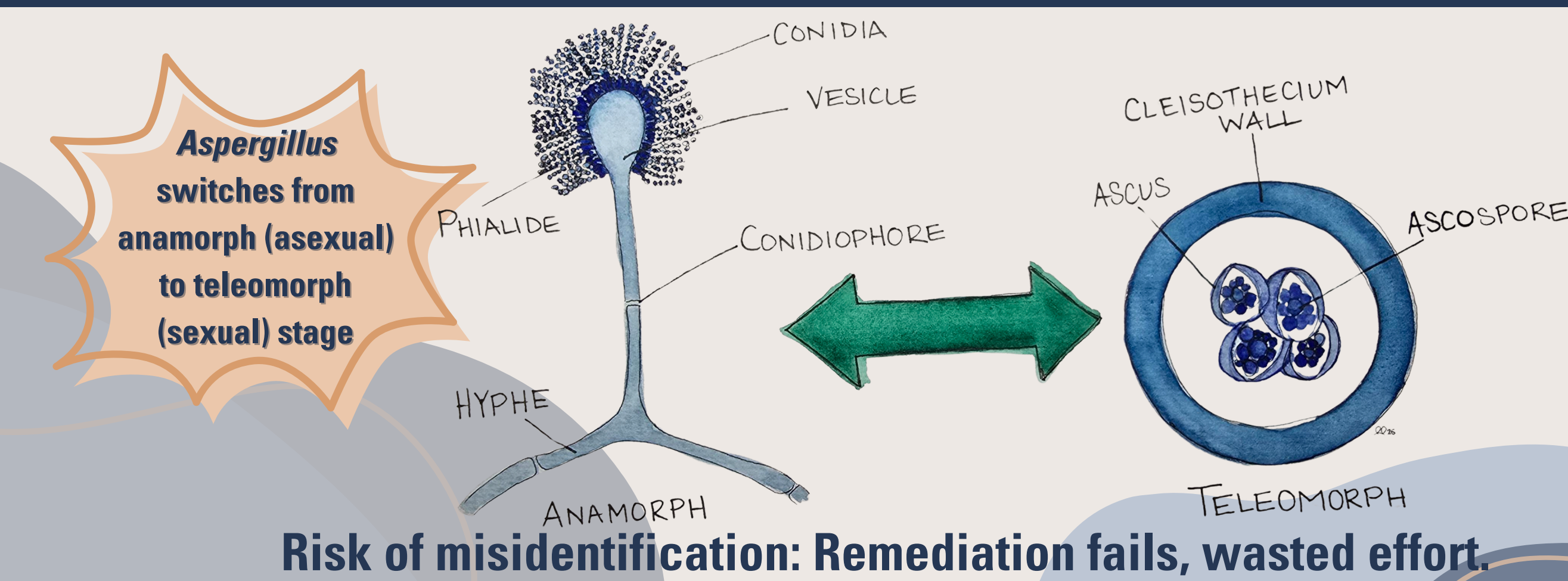


The Teleomorph Caution:
Some molds in their sexual stage show higher resistance. Understanding these organisms helps guide adjustments to contact times and air-cleaning mechanics.

Understanding the Organism: Data Talks; ID Snitches

ID accuracy = foundation of investigation.
Many mold have multiple sporulation states (anamorphs/teleomorphs/arthrospores/chlamydoconidia)

Example: *Aspergillus* species can switch forms = resistance to disinfectants.



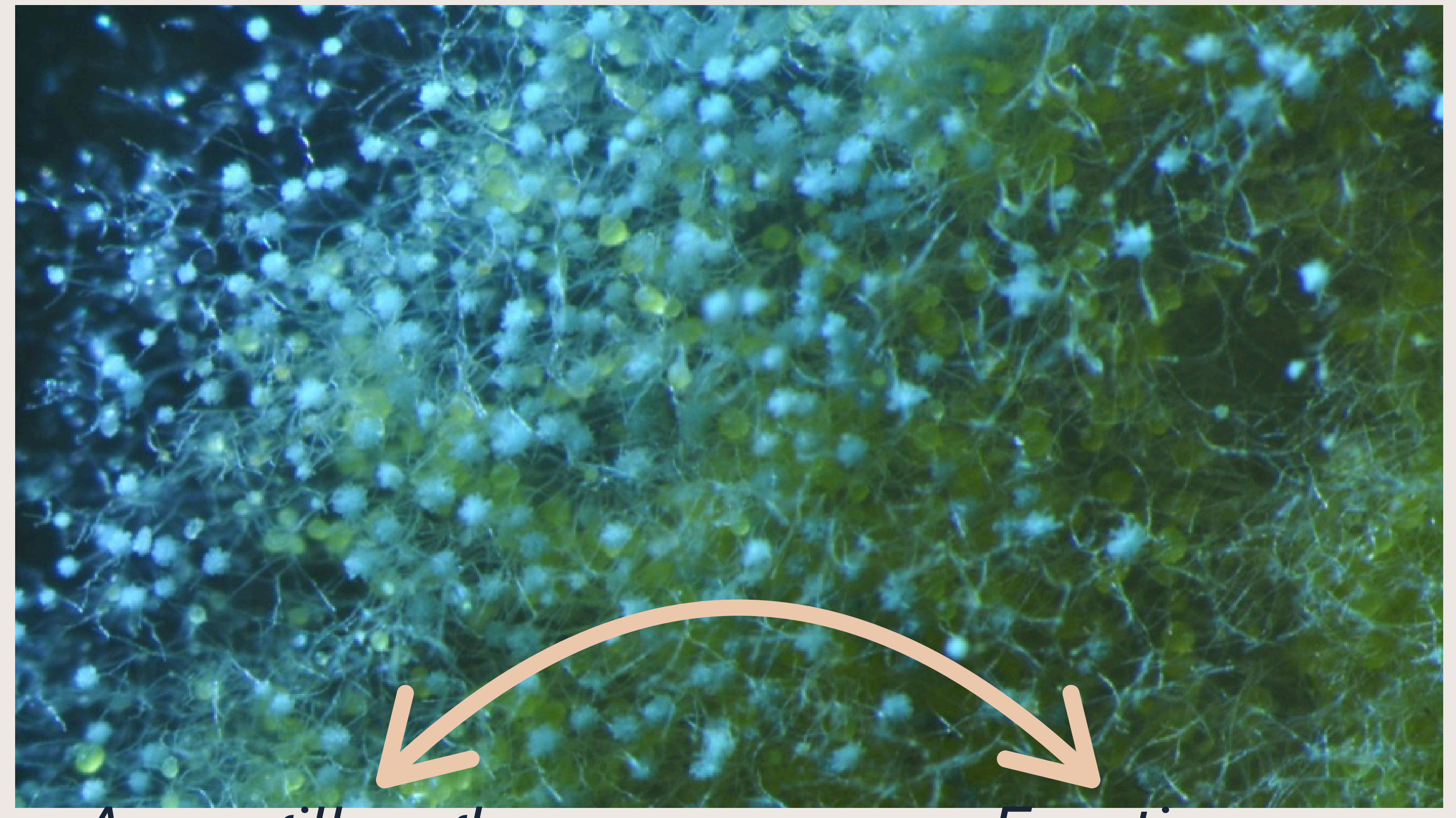
Risk of misidentification: Remediation fails, wasted effort.

Transport Mechanisms

- Personnel (primary transport risk)**
Personnel carry spores between areas.
- Wheels & floors**
Wheels and floors, if not cleaned become a vehicle for mold transport.
- Airborne mixing**
Deficient design/maintenance limit air mixing and cleaning, turning the room into a reservoir for mold.

Controls: Investigative smoke studies can identify mold transport through airflows

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Clinical Relevance

Understanding which organisms are critical versus incidental prevents over-reaction and supports risk-based decision making.

Genus	Clinical Risk
<i>Aspergillus</i>	Prevalent pulmonary aspergillosis, systemic infections
<i>Cladosporia</i>	Allergic asthma, sinusitis, hypersensitivity
<i>Candida</i>	Opportunistic pathogen, <i>Candida krusei</i> is a rapidly emerging pathogen
<i>Fusarium</i>	Known causative agent for keratitis (eye infections)
<i>Talaromyces</i>	Dimorphic fungus prevalent in immunocompromised patients
<i>Trichophyton</i>	Dermatophyte
<i>Alternaria</i>	Skin & respiratory infections, opportunistic pathogen
<i>Penicillium</i>	Opportunistic infections, respiratory allergen

Patient Safety Link
Fungal infections carry high mortality in immunocompromised patients (aspergillosis, mucormycosis). In ophthalmic and IV products, even minimal contamination can be catastrophic.

Table: Growth Conditions, High-Risk Zones, and Representative Genera

Condition	High-Risk Zone	Mold Genera	Notes
Moisture / Standing Water	HVAC drains, cold room condensate	<i>Aspergillus</i> , <i>Penicillium</i> , <i>Cladosporium</i>	Thrive on damp surfaces, drain biofilms
Organic Residues (dust, paper, cellulose)	Locker rooms, packaging storage, equipment crevices	<i>Alternaria</i> , <i>Chaetomium</i> , <i>Stachybotrys</i>	Cellulose-dependent molds; linked to paper/cardboard
Temperature Swings / Condensation	Cold rooms, poorly insulated walls	<i>Aspergillus</i> , <i>Cladosporium herbarum</i>	Favor repeated wet-dry cycling
Structural Gaps / Sealants	Cracks in caulking, refrigerator gaskets	<i>Phoma</i> , <i>Epicoccum</i> , <i>Cladosporium</i>	Persist in crevices; resistant to routine disinfectants
Low Humidity (xerophilic niches)	Dry storage rooms, HVAC dust, powders	<i>Aspergillus</i> , <i>Wallemia sebi</i>	Grow at water activity (aw) 0.65–0.80; resistant to desiccation

Remediation Gaps

- Failure to evaluate cleaning & disinfectant efficacy against facility isolates via EM trends.
- Ignoring difficult-to-clean surfaces (e.g., unsealed floors).
- Incomplete root cause analysis.

Continuous Improvement


- Routine review of mold index (species, niches, risks).
- Trending of EM results to evaluate effectiveness of cleaning and disinfectants against mold isolates.



Conclusion



Without the correct ID & a robust investigation, remediation fails.
Mold investigations are a continuous improvement cycle, not a one-time fix.



You cannot put all mold in the same basket