

HEALTHY LIVING IN TIGHT, COMPACT HOMES

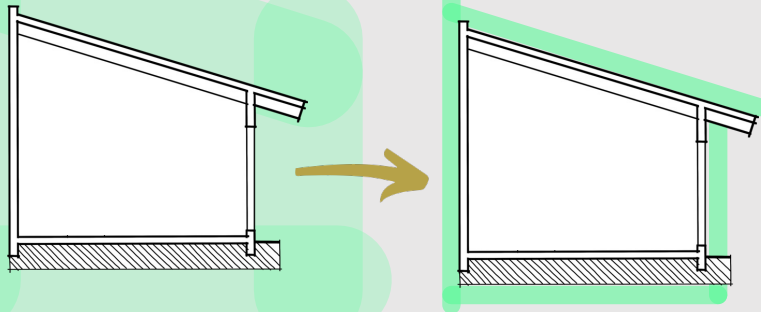
A firsthand, holistic,
cross-disciplinary view

Westford Symposium XXVIII

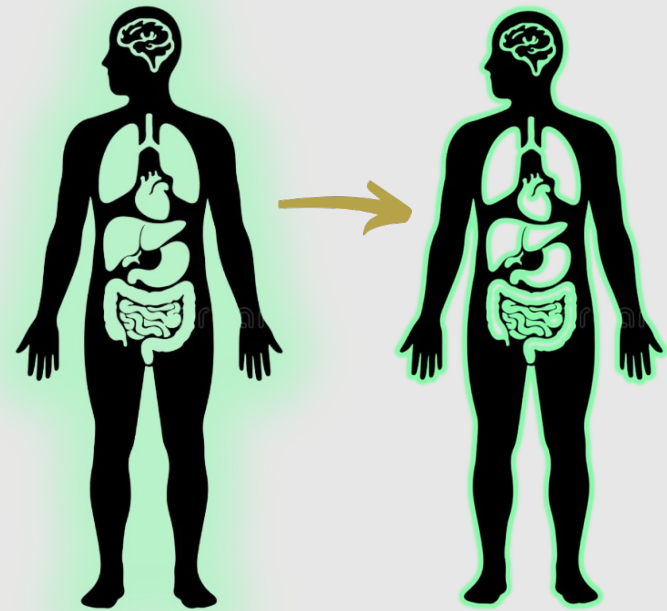
03 AUG. 2026 →



ENVIRONMENTAL SEPARATION ENVIRONMENTAL HEALTH



Precision Design



Precision Health



Ashley Murphree, P.E.

Alchemech Engineering

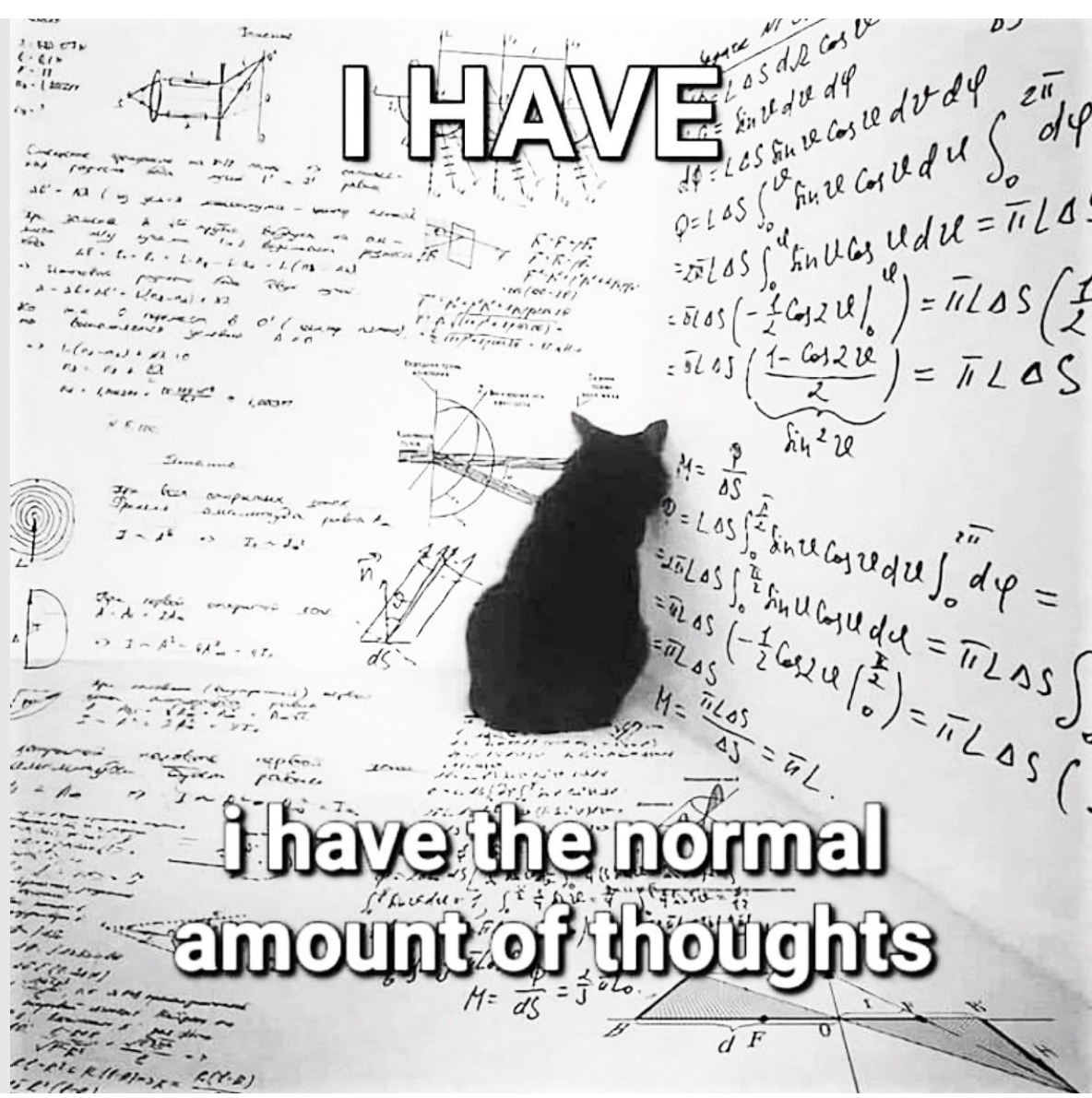
ashley@alchemech.com

My Street Cred. :

- Mechanical P.E. - Residential
- Building Science Consultant
- Passive House Certified Tradesperson
- Former Co-Founder of Good Bones Design Build
- “Chronic complex illness patient”
- Clare Kelway, BS DIHom HHP BCHN®
- Student of Dr. Bruce Hoffman

I HAVE

i have the normal
amount of thoughts









5 Passive Principles

CONTINUOUS, TBF INSULATION



TRIPLE PANE



AIR TIGHT



ERV WITH FILTERS



Variable perm air-tight membrane - no cold steel condensation!

Natural Materials



**The elemental difference
between**

the Machine

and the Garden

**is that
one is driven by a force
which must be introduced
from without,**

**the other grown by an
energy which originates
from within itself.**

James Carse

Finite & Infinite Games



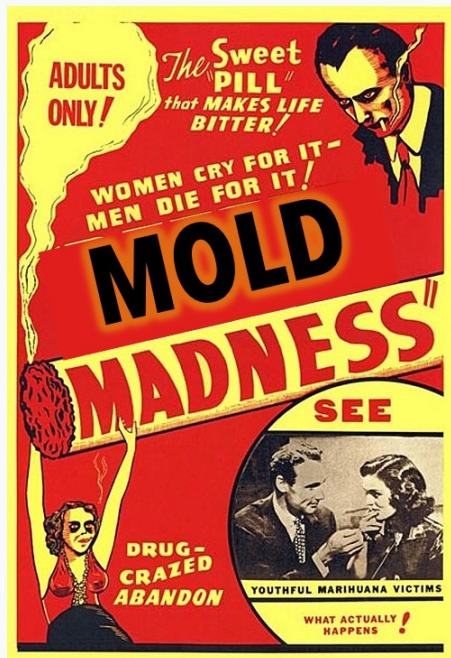
**Oh, the
irony...**



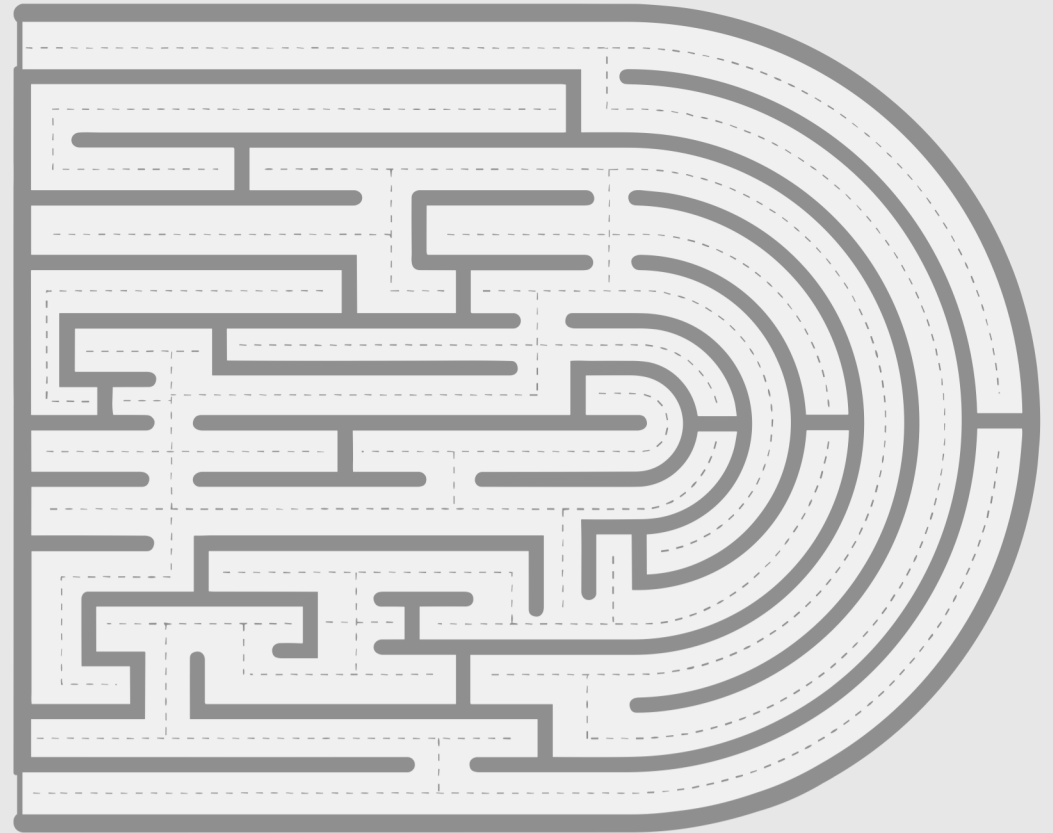
**“I think you
have mold”**



MOLD MADNESS



1972 theatrical release poster



High Consequence

Standards & Guidelines



Small Particle Cleaning 101

Following a Mold Exposure
and/or Mold Remediation

For households with diagnosed
or probable mold-related illness
iseai.org/resources



IICRC®

Institute of Inspection Cleaning
and Restoration Certification

ANSI/IICRC S520 & S500



- **ANSI/IICRC S520** – Standard and Reference Guide for Professional Mold Remediation
- **ANSI/IICRC S500** – Standard for Professional Water Damage Restoration
- **EPA – Mold Remediation in Schools and Commercial Buildings**
- **EPA – A Brief Guide to Mold, Moisture, and Your Home**
- **NYC DOHMH** – Guidelines on Assessment and Remediation of Fungi in Indoor Environments
- **ACGIH** – Bioaerosols: Assessment and Control
- **AIHA** – Recognition, Evaluation, and Control of Indoor Mold
- **ISEAI Remediation Guidance**

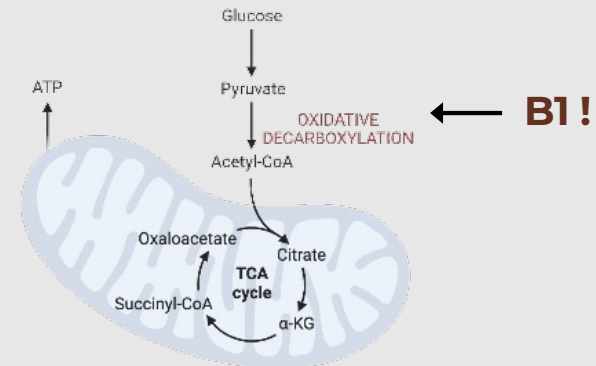
ISEAI - Small Particle for CIRS



Reductionism Caution

MANY CAUSES→

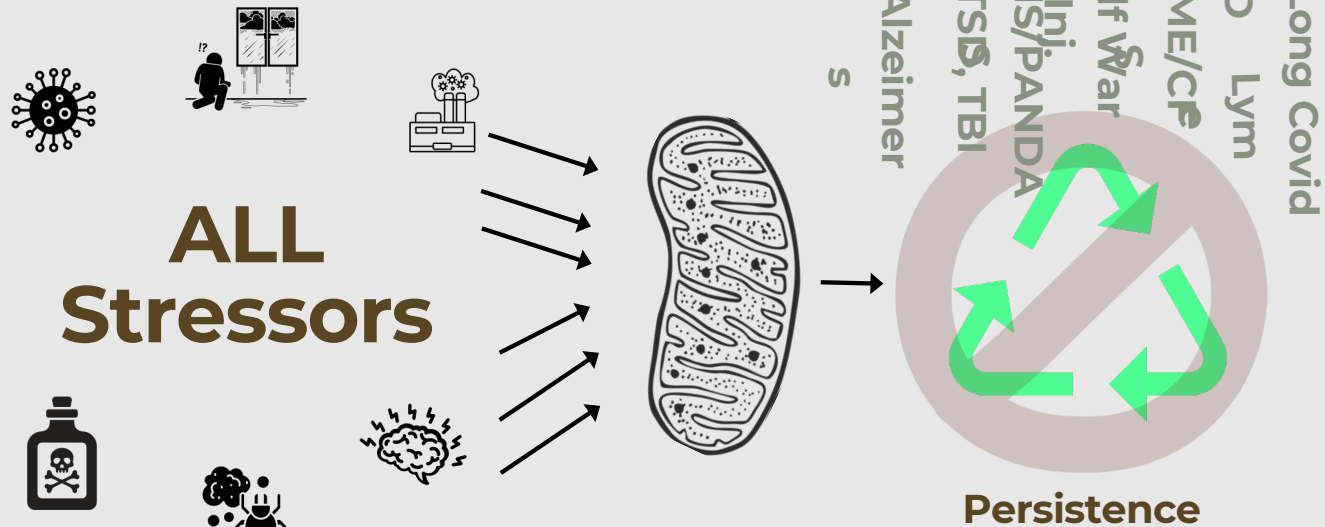
- Primary - Allergic disease & gut illness
- Severe dust mite allergy
- Cedar
- Feather
- Also mold, but not here



Created in BioRender.com bio

WHAT ACTUALLY HEALED→

- Nutrient replenishment
- Gut repair
- Meditation
- a trigger-free home, secondary



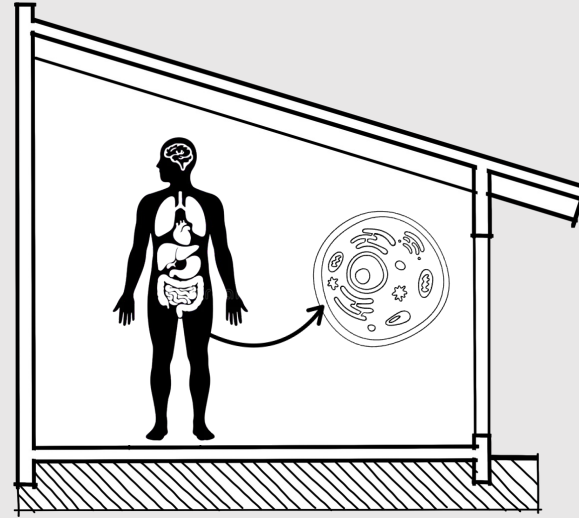
The Cell Danger Response



Dr. Robert Naviaux



@redpenblackpen
n



Cell Biology For Building Scientists

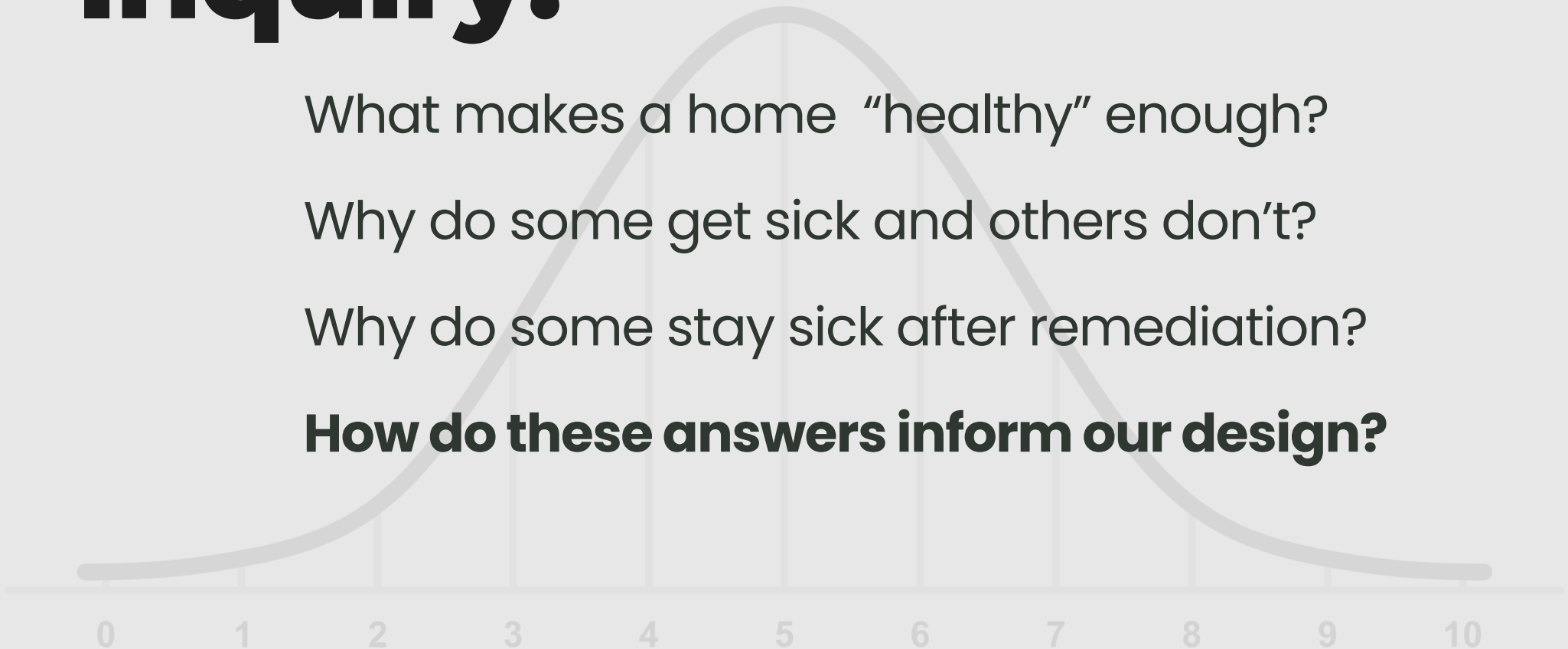
Inquiry:

What makes a home “healthy” enough?

Why do some get sick and others don't?

Why do some stay sick after remediation?

How do these answers inform our design?



Lesson 1:

Control Boundaries

**Conservation of
Mass & Energy**

***Caveat : This is a wildly reductionist approach,
but it's an entry point!**

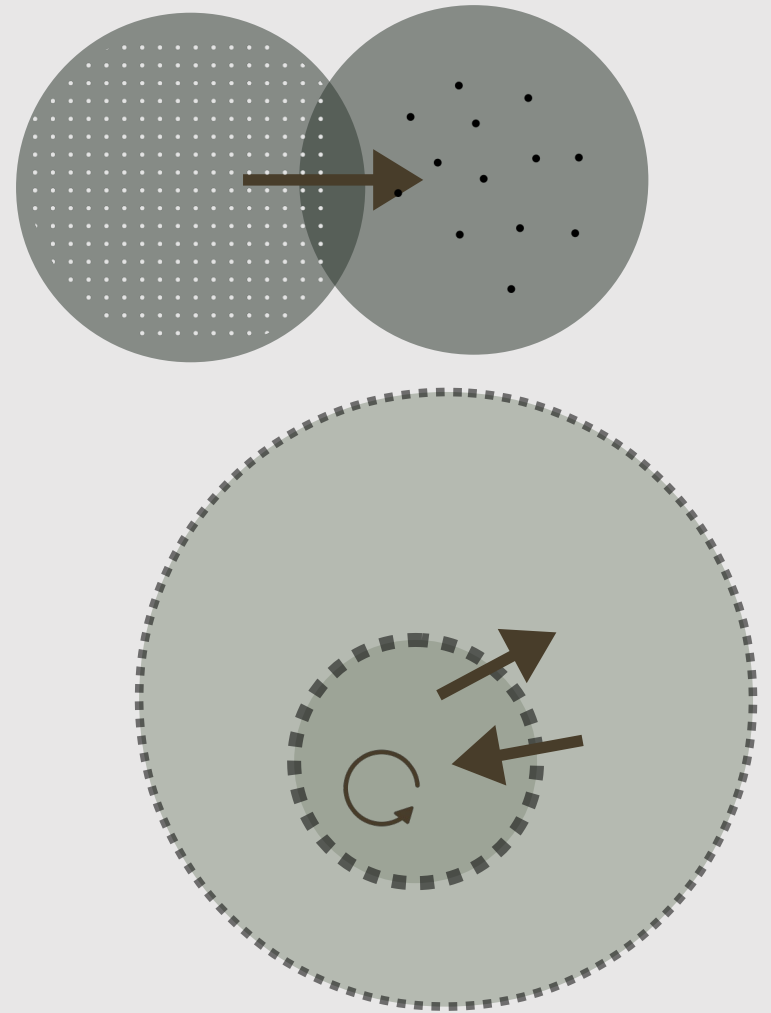
System Control Boundary



Define in/out .
Systems within systems.

Membrane:

A selective barrier.
Environmental separation.
Passage of some things, restraint of others.
A location of concentration differential gradient.



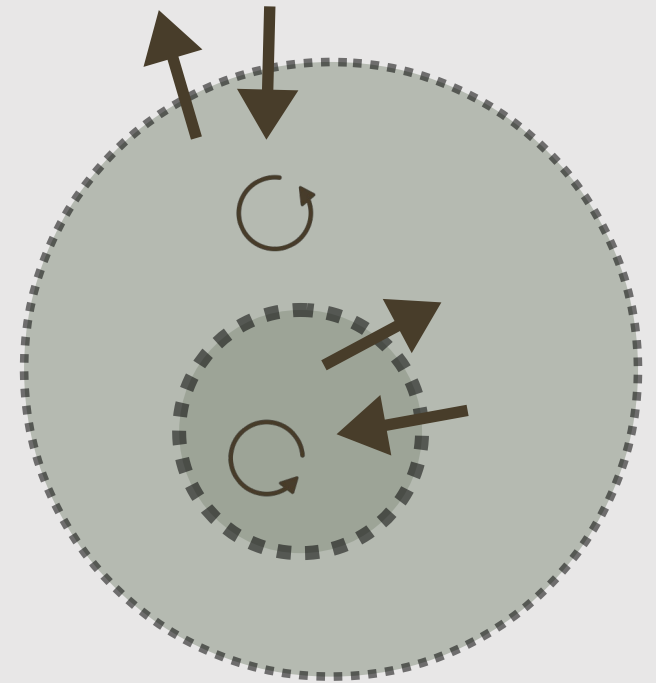
Conservation of Mass & Energy

Flows across boundaries.

Internal source generation & removal.

Accumulation & depletion.

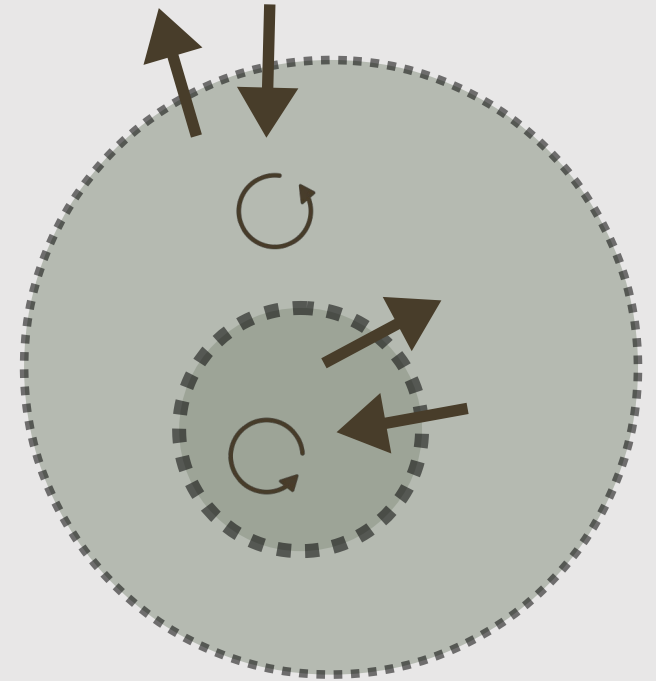
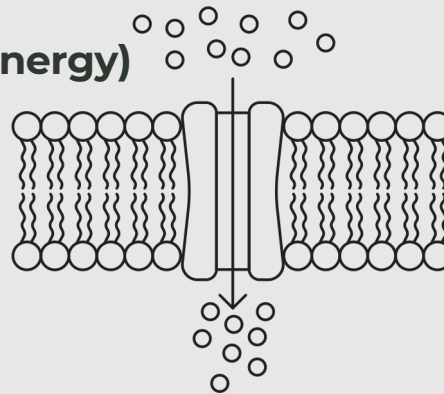
Non-linear interactions.



Membrane Transport

Passive diffusion
Facilitated diffusion

Active transport (pump using ATP energy)



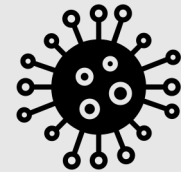
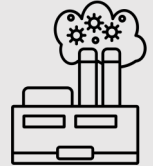
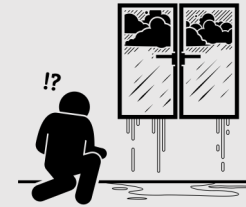
Sources & Damage Functions

Source ->

Path ->

Force ->

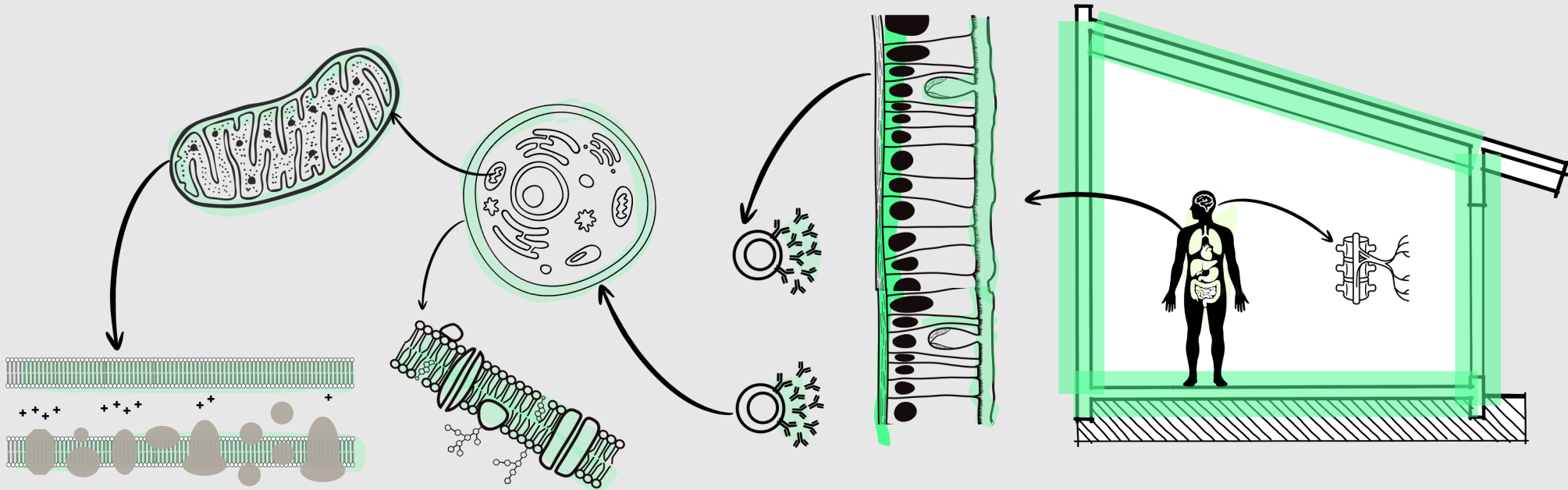
Something sensitive to damage



Lesson 2:

**The “Perfect Occupant”
“Damage Functions”**

Membranes & The “perfect occupant”



Layer 1: Building Enclosure

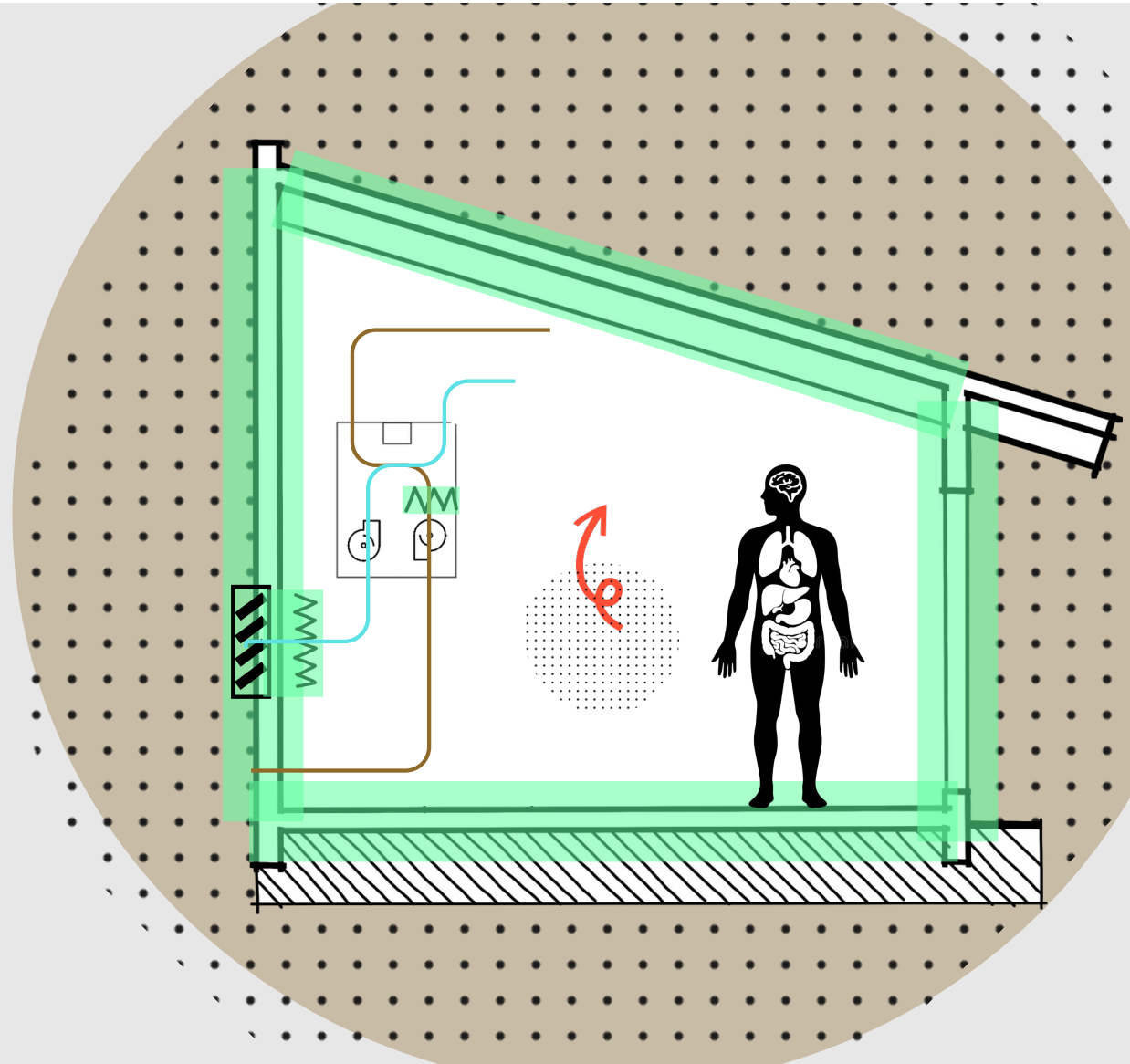
Sources, Damage Functions

OUTSIDE

- Water & Moisture
- Pollutants, Allergens
- Heat
- Soil gas

INSIDE - "INDOOR ECOLOGY"

- Cooking Fumes
- PM
- Gas appliance
- Fungus
- Bacteria
- Mites, dander, allergens
- Material off-gas, VOCs, Chem



Layer 2: Microbiome & Epithelia

Sources, Damage Functions

“OUTSIDE”

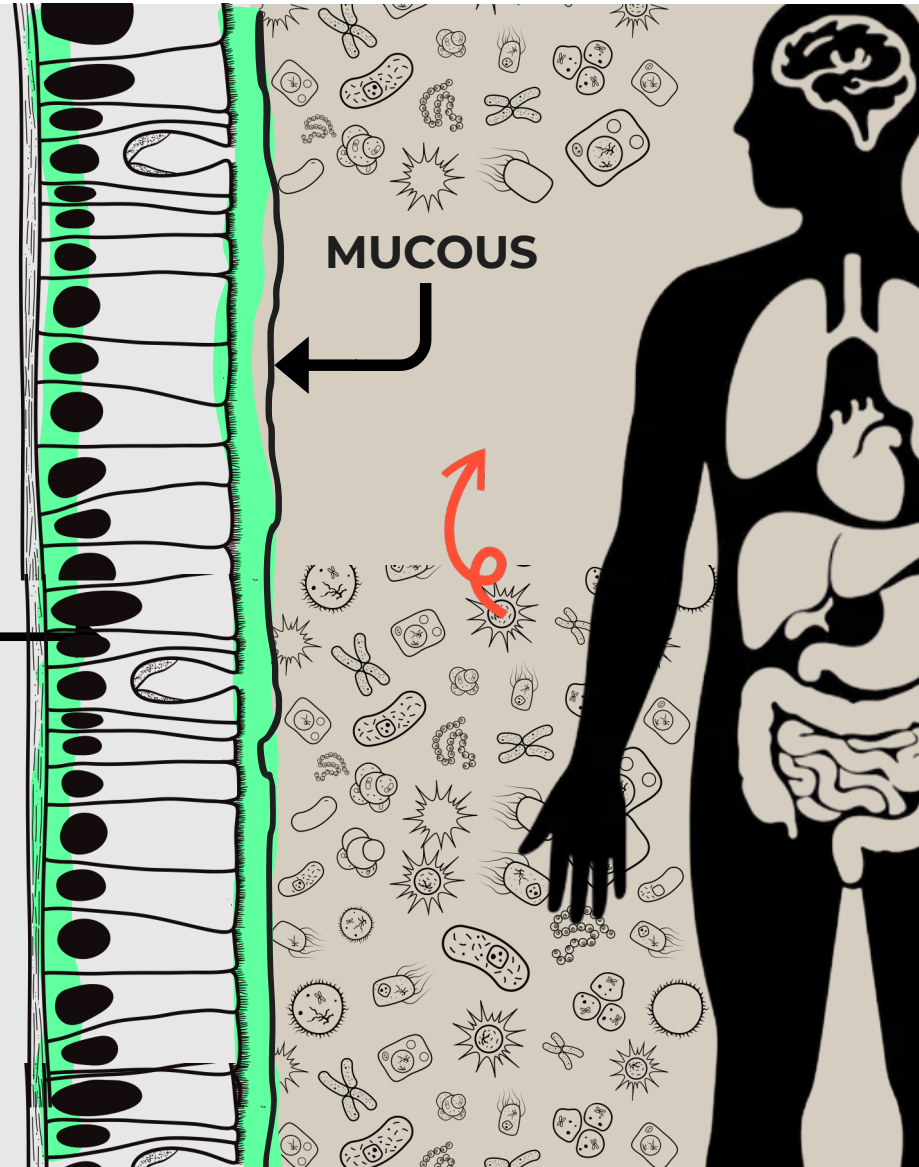
- Microbiome - **(+) or (-) source gen.**
- Virus, bacteria, PM, VOCs
- Endotoxins, LPS
- Harmful proteases - **“Digests” holes into barrier**
 - Dust Mite, cockroach
 - Fungal exposure
 - Detergent enzymes

“INSIDE”

- Immune - inflammation disrupts
- Clearance impaired?
 - Genetic
 - Functional

TIGHT
JUCTIONS

MUCOUS



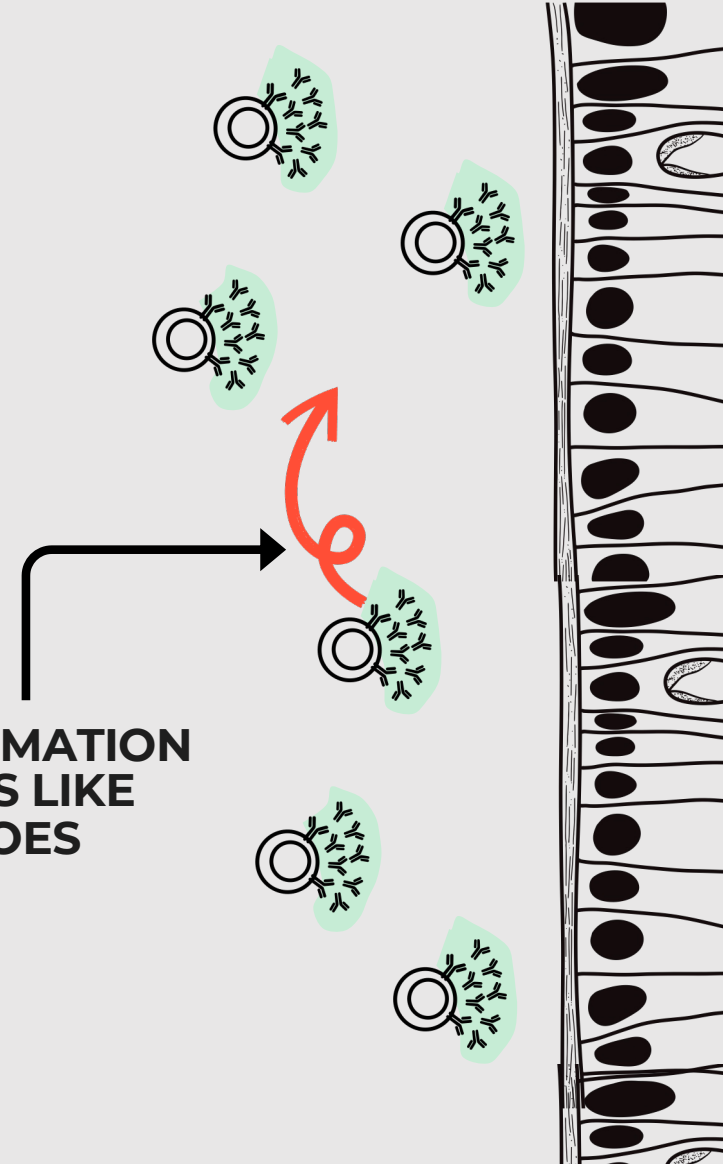
Layer 3: Immune Cells

Sources, Damage Functions

INSIDE

- Innate & Adaptive immune system
 - Genetic factors
- Mast Cells
- Non-linear effect - Once sensitized
 - TILT, Dr. Claudia Miller
 - MCS
 - MCAS
 - Mold

INFLAMMATION
SIGNALS LIKE
DOMINOES



Layer 4: Cell Membrane

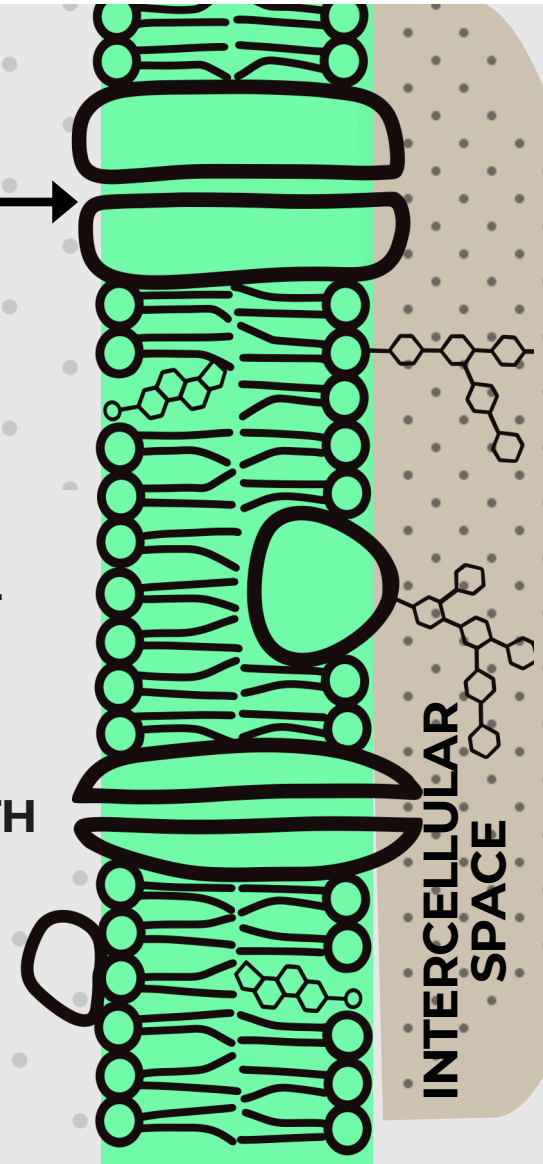
Functions & Damage Functions

- Complex!
- “Gates” with “Lock + Keys”
- Signals received--> Effects/ actions taken
- Leaky water balloon
- Reactive oxygen degrades, like corrosion
- Toxin loading



LIPID BI-LAYER
WITH INTEGRAL
MEMBRANE
PROTEINS:

“BUTTER
SANDWICH WITH
OLIVES”



Layer 5: Mitochondria Membranes

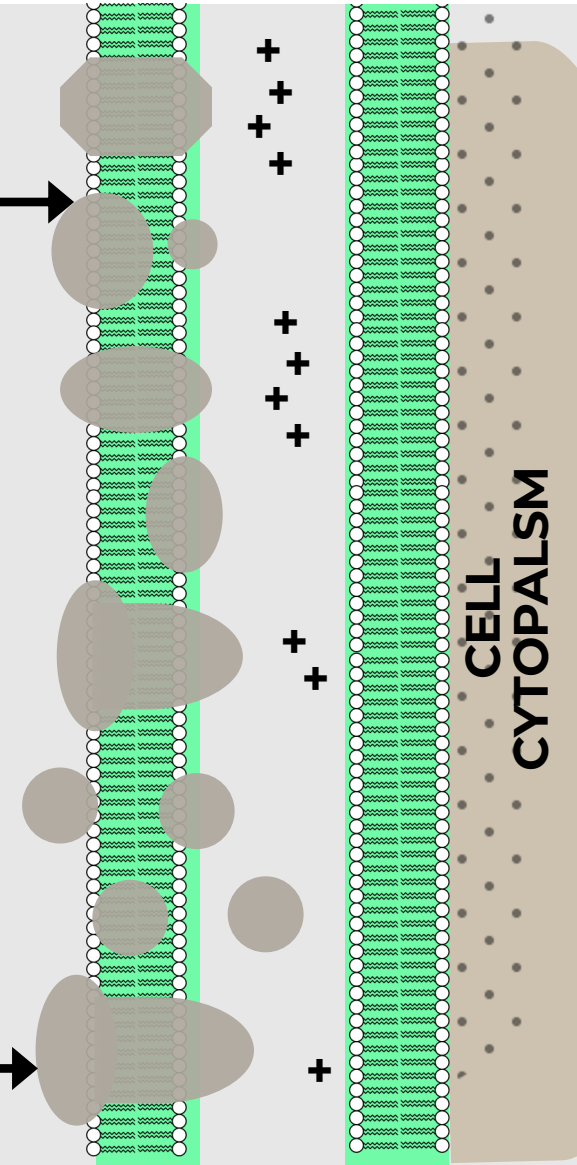
Functions

- Sentinel
- Carbon (glucose) + O₂ → CO₂ + H₂O + Energy
- Battery storage
- REDOX - oxidation/antioxidant
- + much more



DOUBLE LIPID
BILAYER

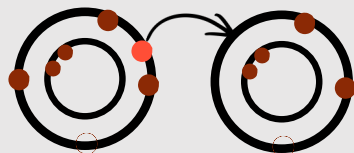
ELECTRON
TRANSPORT
CHAIN



Cellular Respiration

A chemical power plant. ATP!

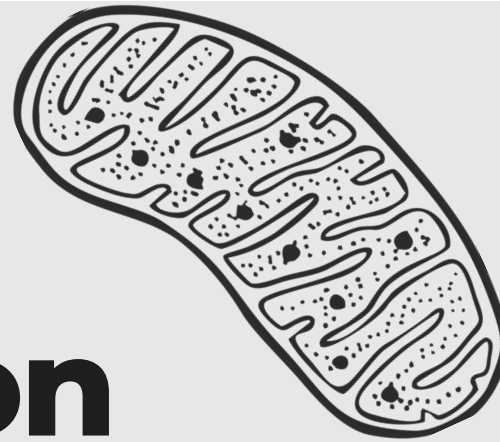
- REDOX
 - An efficient “Clean burn” engine
 - Imbalance → oxidation/corrosion



ANTIOXIDANT STABILIZE



OXIDANT DE-STABILIZE



DOUBLE LIPID
BILAYER

ELECTRON
TRANSPORT
CHAIN

ATP

CELL
CYTOSOL

The Cell Danger Response



Mitochondria sense “danger”

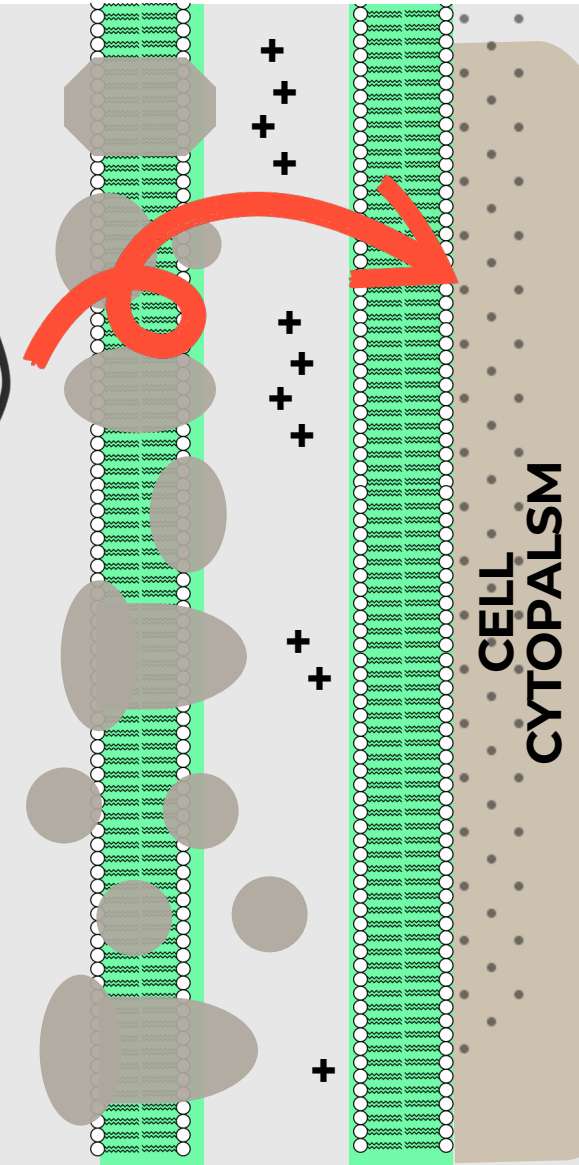
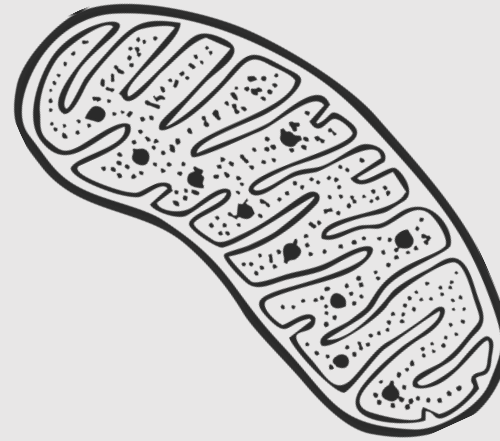


ATP stops



Harden membranes like a fortress
Release “DAMPs”

Trigger immune (mast) cells another time



Chronic symptoms “stuck” when mitochondria do not get “safe & clear” signal.

Reinjury

Persistent exposures

Inadequate nutrients, energy, circadian anchors



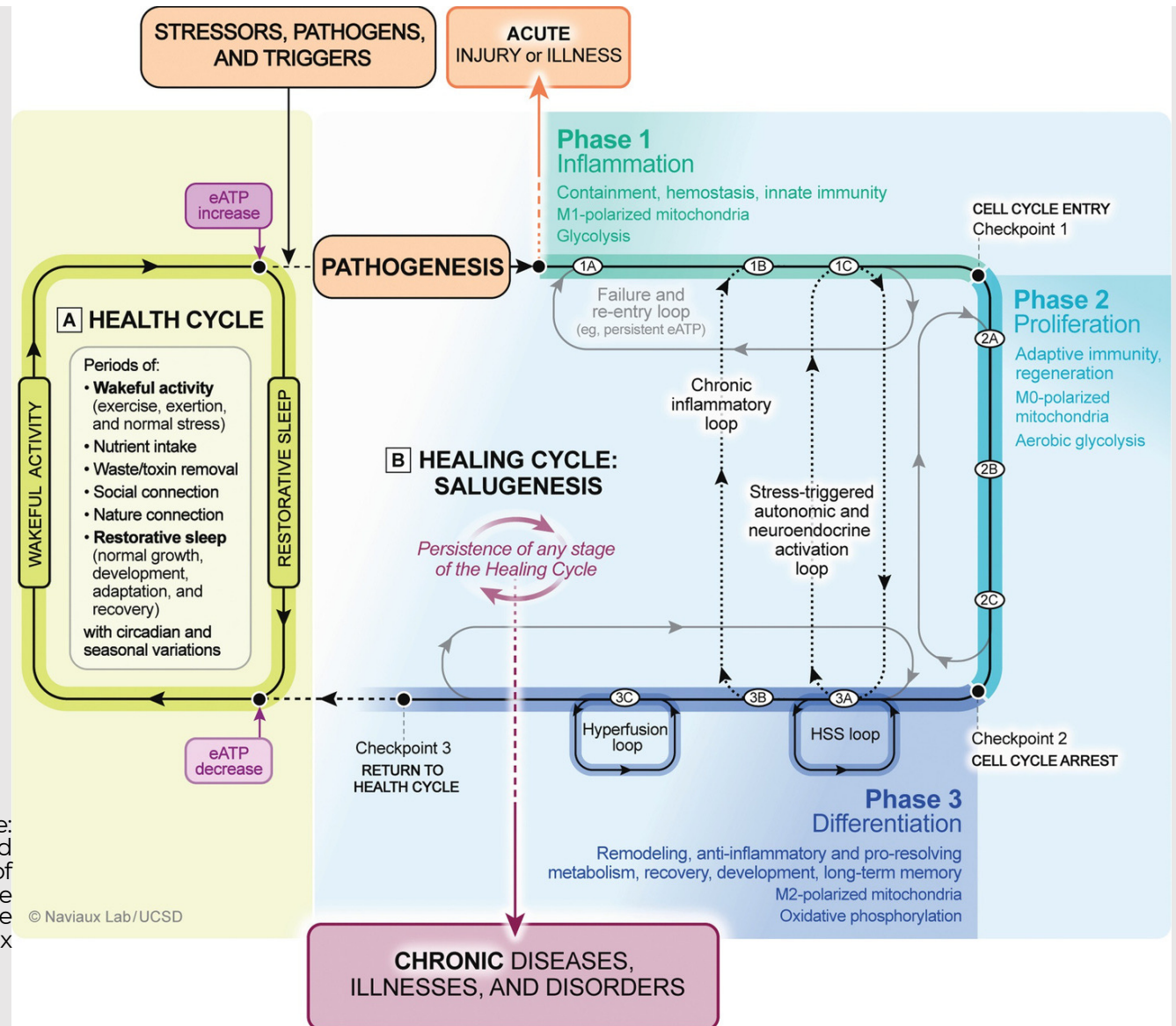
Phases of CDR:

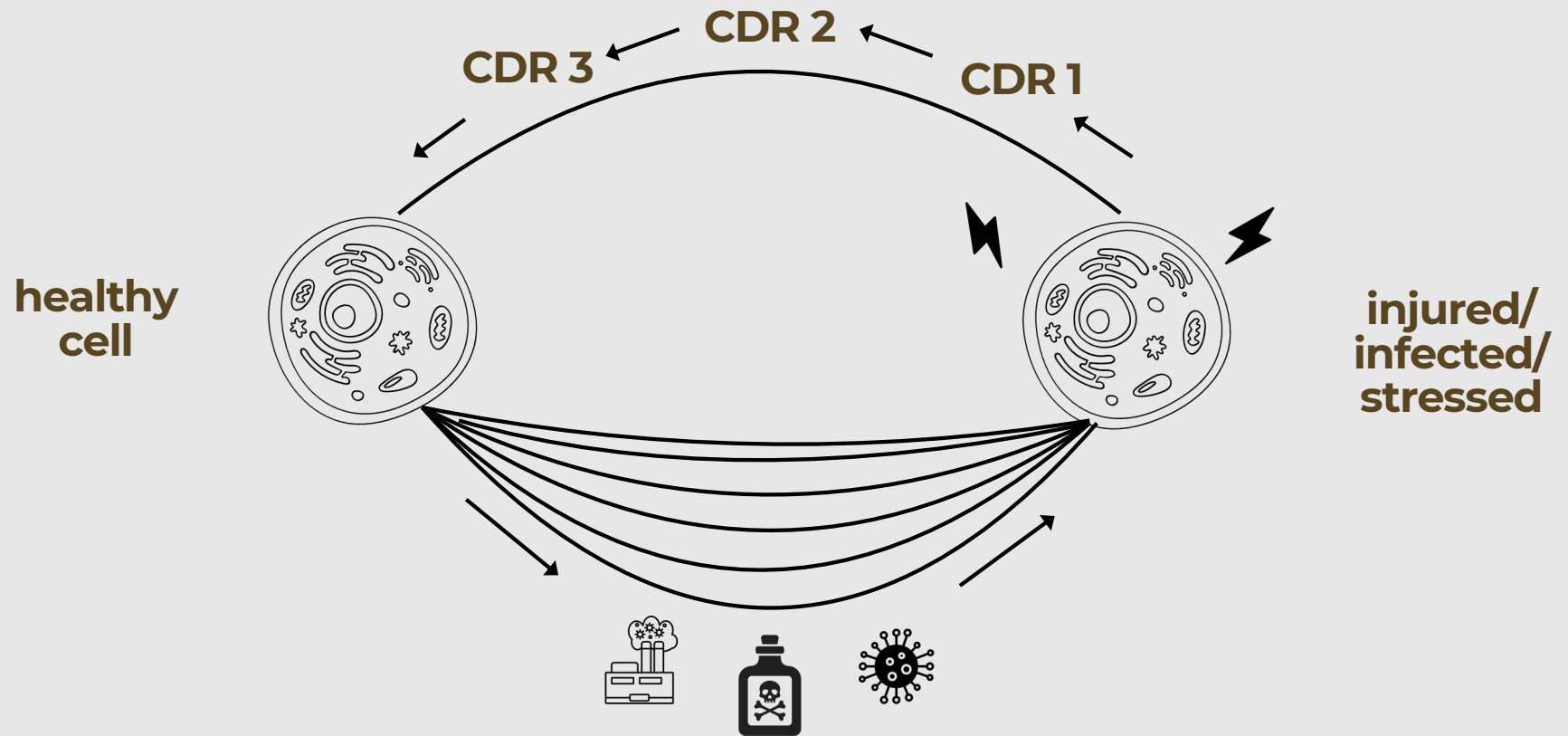
CDR 1: Inflammation = containment

CDR 2: Grow/repair new tissue

CDR 3: Connect back to the organ system & communication

Source:
Mitochondrial and
metabolic features of
salugenesis and the
healing cycle
- Dr. Naviaux



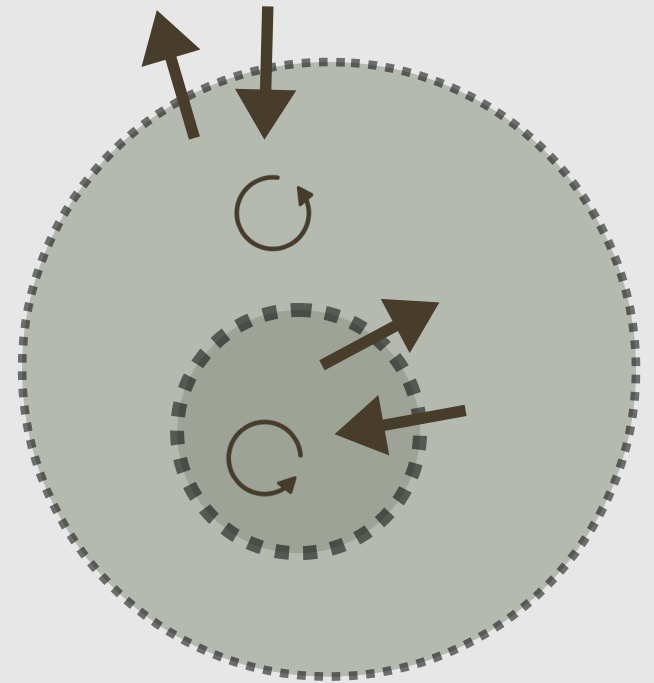


**Many paths to damage.
Only one path back to health.**

Silent Spring

**Membrane integrity
& “Reserve capacity”
is quietly shrinking.**

Changing climate... rising sea level...
Sensitized occupants ?



Layer 0: Nervous System

Sources, Damage Functions

LIMBIC

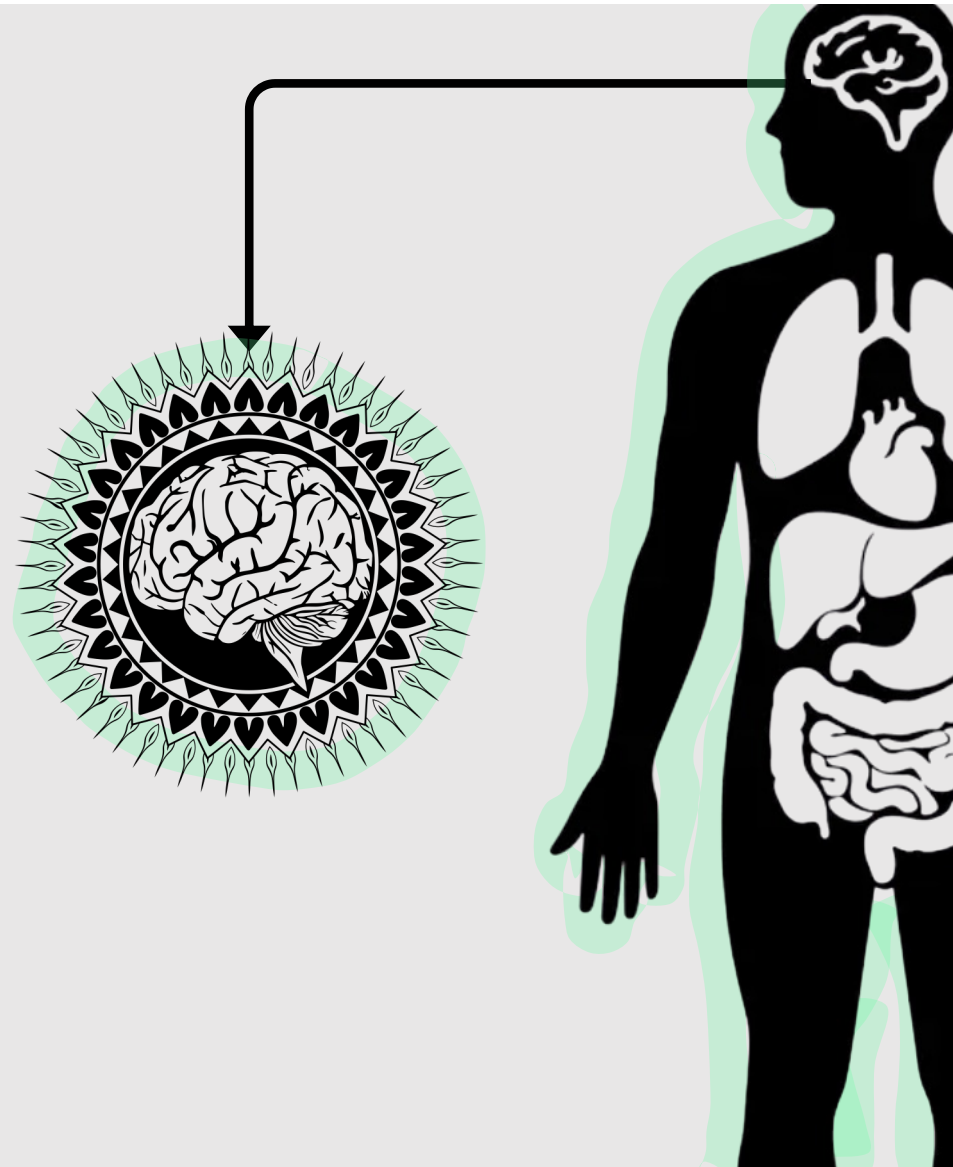
- Amygdala : Fear
- “Fight/Flight” → Sensitized

VAGAL

- “Rest & Digest” dysfunction

AUTONOMIC

- Automated functions (blood pressure, etc.) misfire



Lesson 3:

Homeostasis

We can't efficiency our way to dry

But can we efficiency our way to
homeostasis?

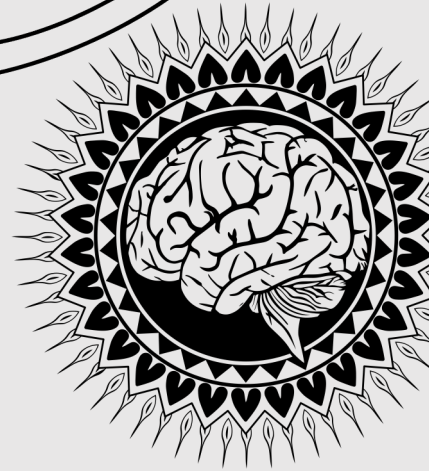
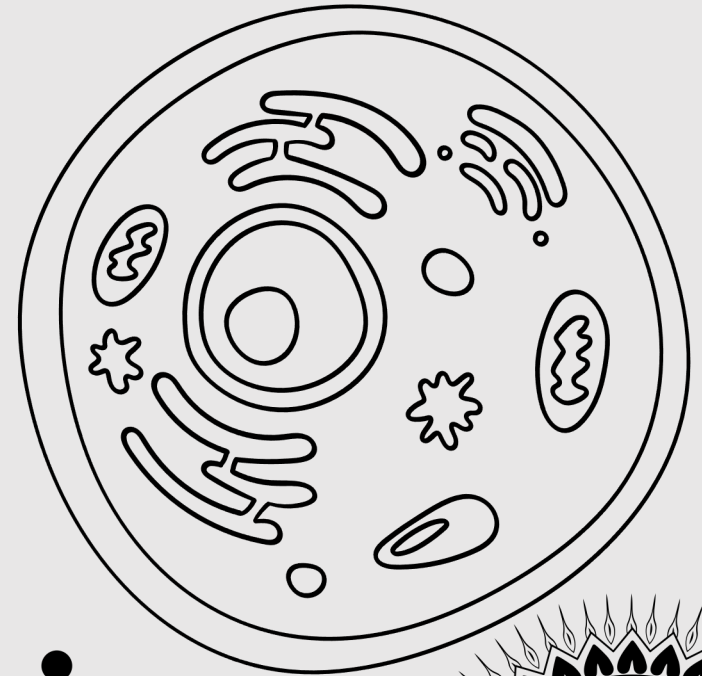
Homeostasis

Restore mitochondrial power plant

Remove triggers
long enough to “reboot”
sensitization.

Restore “health cycles”

New research
opportunity!

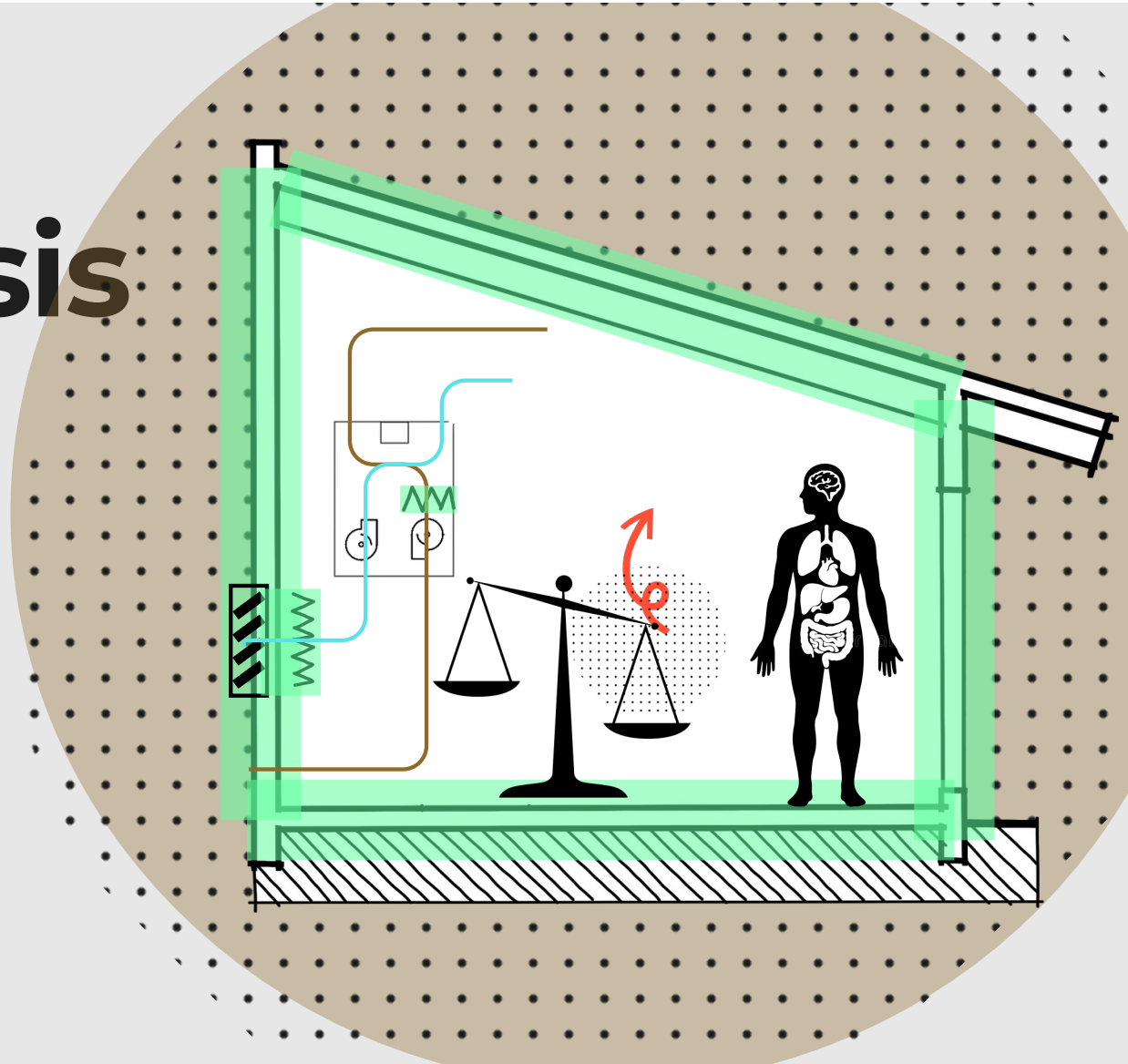


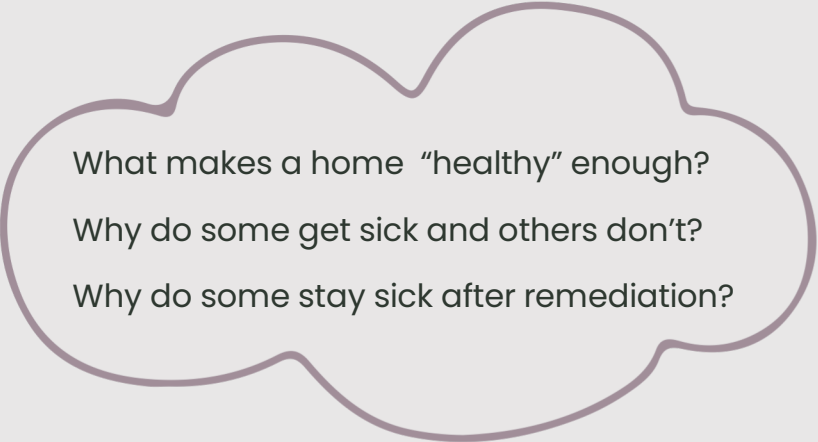
Homeostasis

Outdoor sources:
well controlled

Indoor sources:
Unpredictable

Mechanical or Passive
capacity for indoor
source management?
Often missing





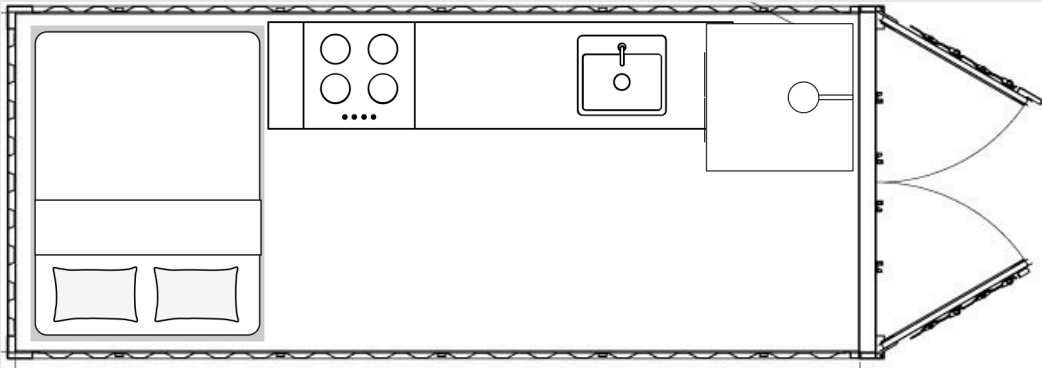
What makes a home “healthy” enough?
Why do some get sick and others don’t?
Why do some stay sick after remediation?

BIOLOGY RECAP

- **Health = strong “bioenergetics”, not just mold-free**
- **Leaky membranes → responses are non-linear & resource intensive**
- **“Perfect Occupant” is quietly becoming sensitized.**
 - **Use this research – collab. with clinicians to repair ALL membrane levels**
- **Goal: homeostasis – restore mitochondrial power plant**
 - **Remove triggers (& avoid hysteria)**
- **Research building design for “health cycles”**

BIOLOGY → BUILDING SCIENCE

How does this information inform
our design?

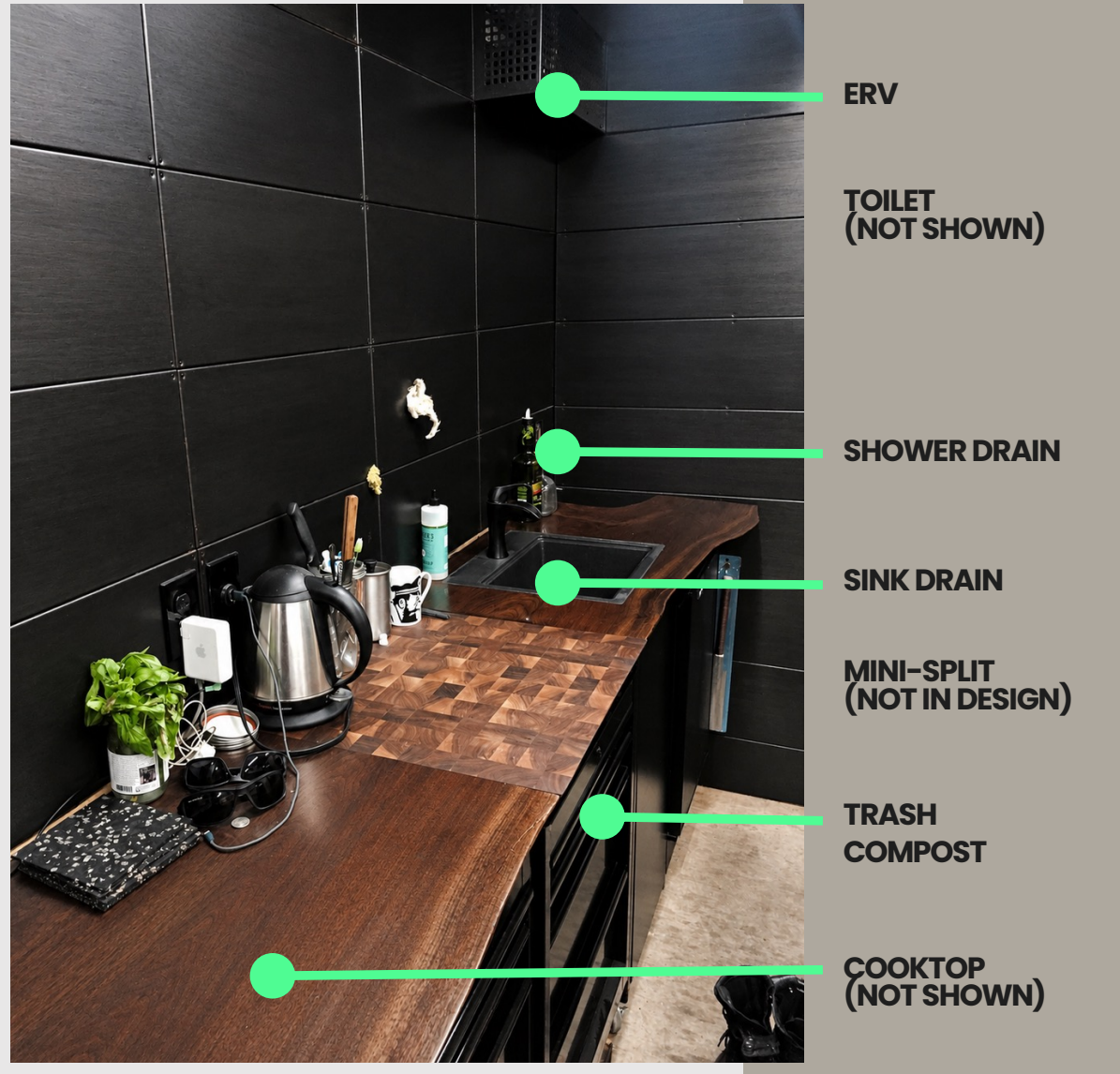


Tiny House Through This Lens

Overlooked Indoor Sources

**Source generation is
more concentrated**

Just as indoor latent loads / SF are



Avoiding penetrations – too far

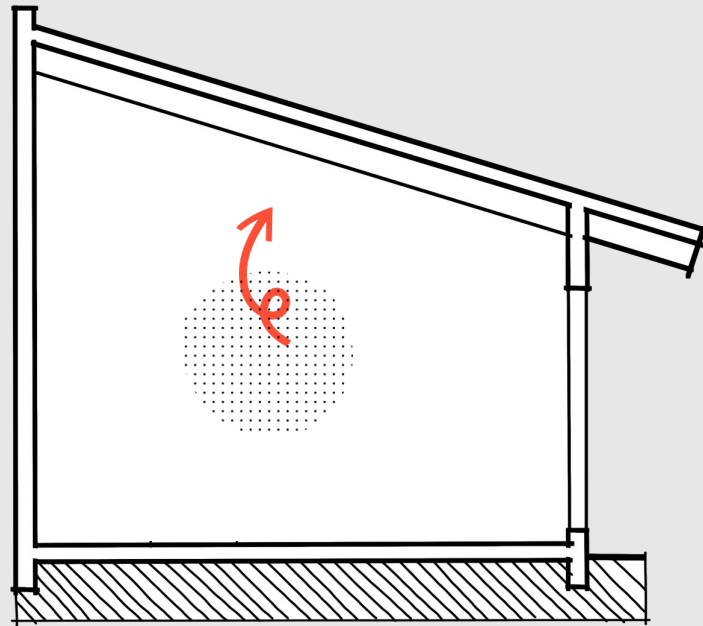
“Shift cost from Mech to Enclosure”

Mech/Plbg design :

- 0 – 0.1% construction budget

No dedicated space

- Wall hung mini-splits
- Through-wall ERVs



Market Observations

Unpredictable Indoor Sources

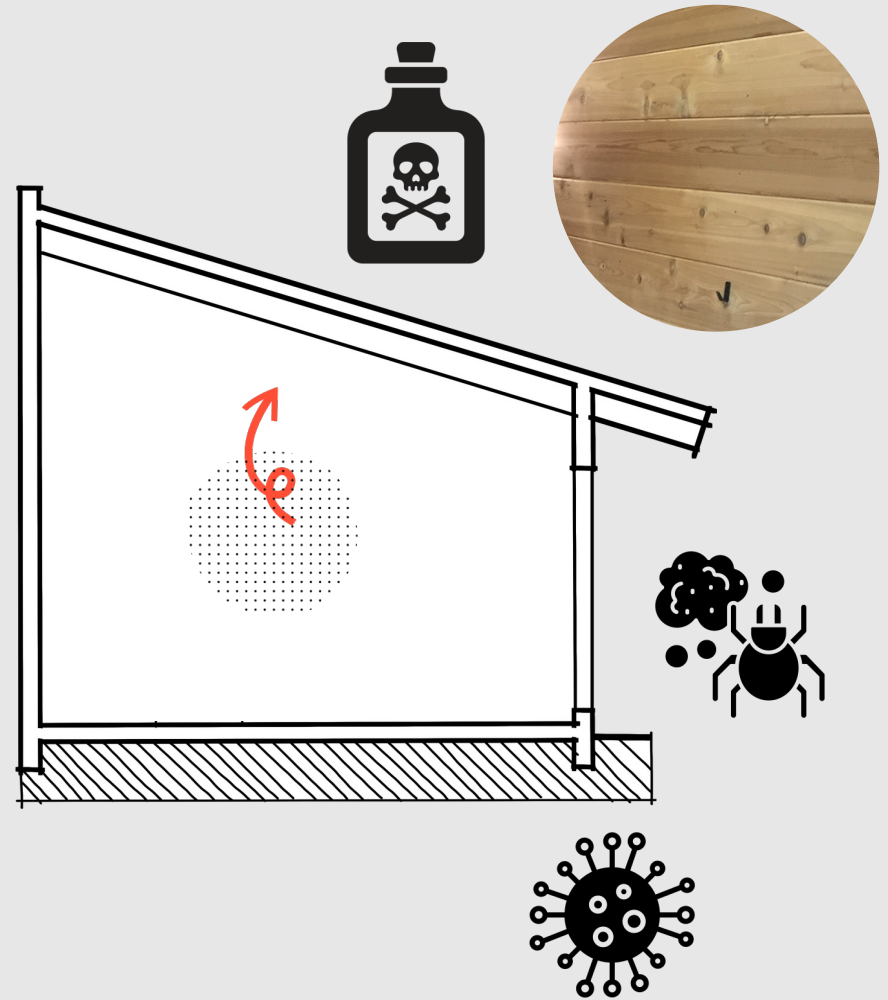
Indoor material off-gas
Occupant behaviour
Lack of maintenance
Unpredictable sensitization



**MECHANICAL
REMOVAL FOR
HOMEOSTASIS**

ASHRAE 241

**Big filters are
easy filters**



Leakage Magnitudes for 1000 SF House:

Leaky : ~ 70+++ CFM

Avg. N.C. : ~ 20 CFM

Tight ACH<1 : ~10 CFM

Dryer : 125+ CFM

Hood : 100 - 300 CFM, intentionally limited by designer

TOOLS:

PHIUS Intermittent Exhaust & MUA Calc.

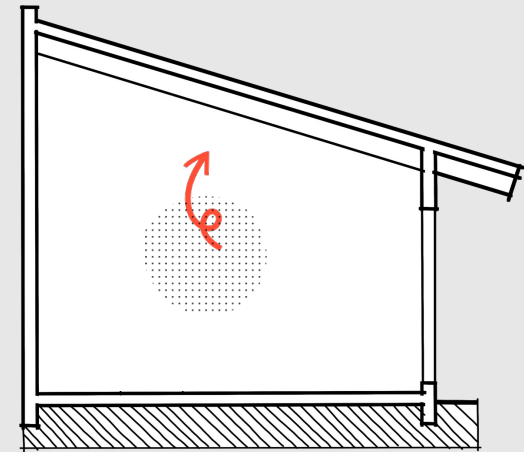
<https://www.phius.org/phius-intermittent-exhaust-make-air-estimator>

Building America Solutions Center Red Calc™

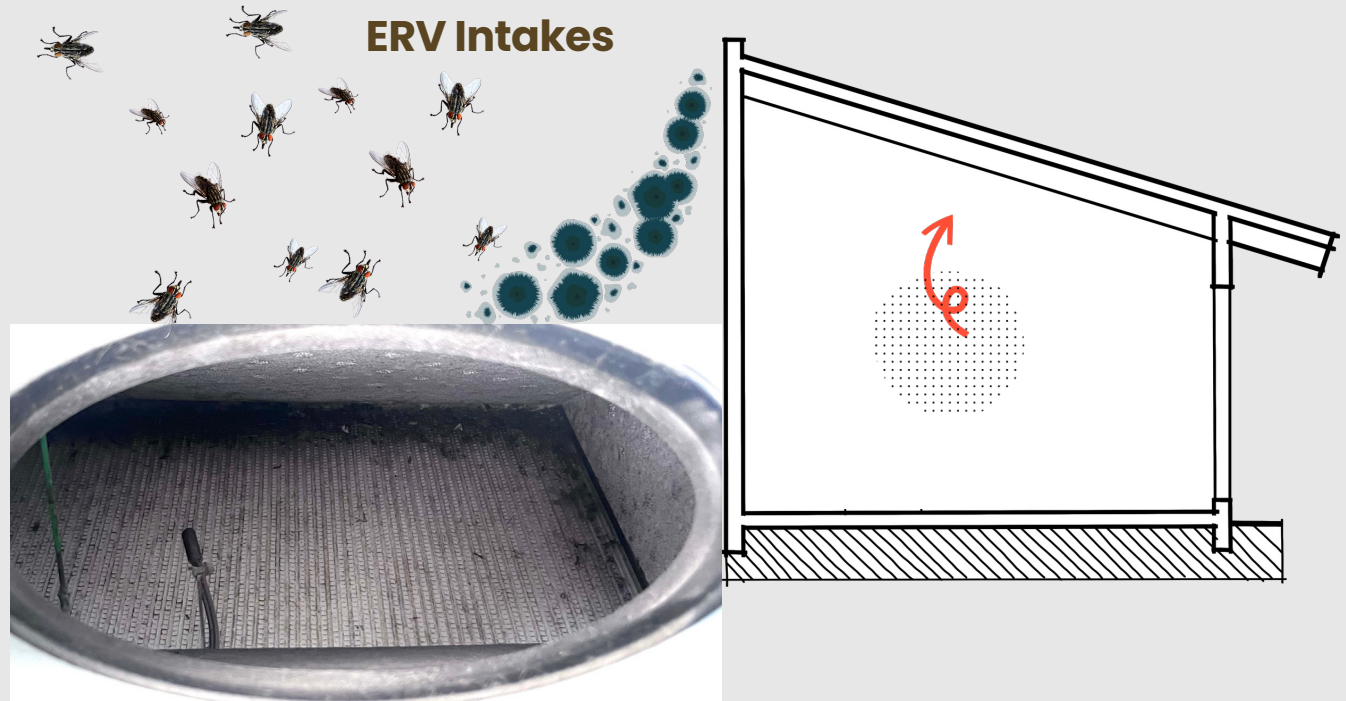
<https://basc.pnnl.gov/redcalc/tool/depressurization-analysis>

**Always a yes for compact homes but high unwillingness
& equipment for this lacks elegance**

**SENSITIZED
OCCUPANTS OFTEN
DO SEVERAL LOADS
OF LAUNDRY PER DAY!**

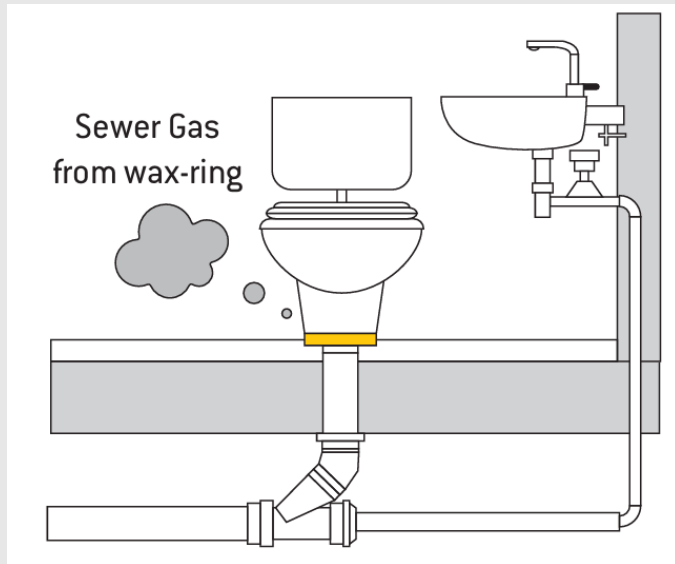


Hoods, Laundry, Makeup Air

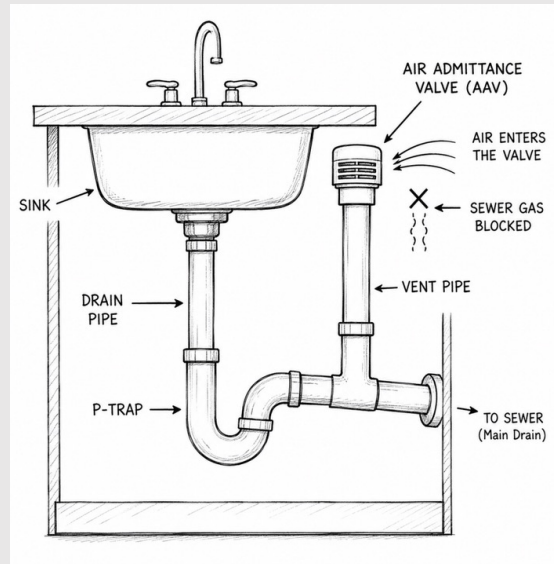


Coils Must Stay Clean

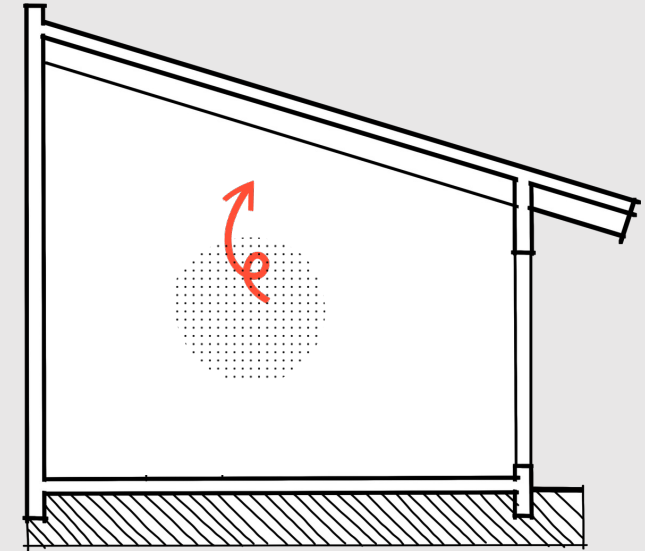
Water + Dust!



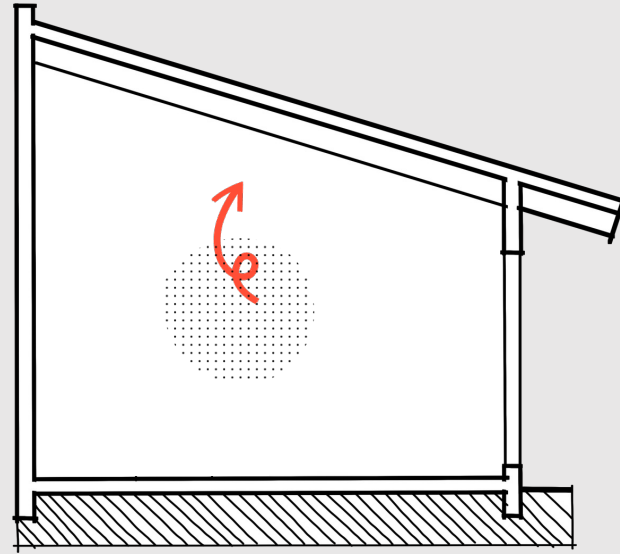
Source: ipsplumbingproducts.com sewer gas issues



Source: <https://atozstatewideplumbing.com/plumbing-vent/>



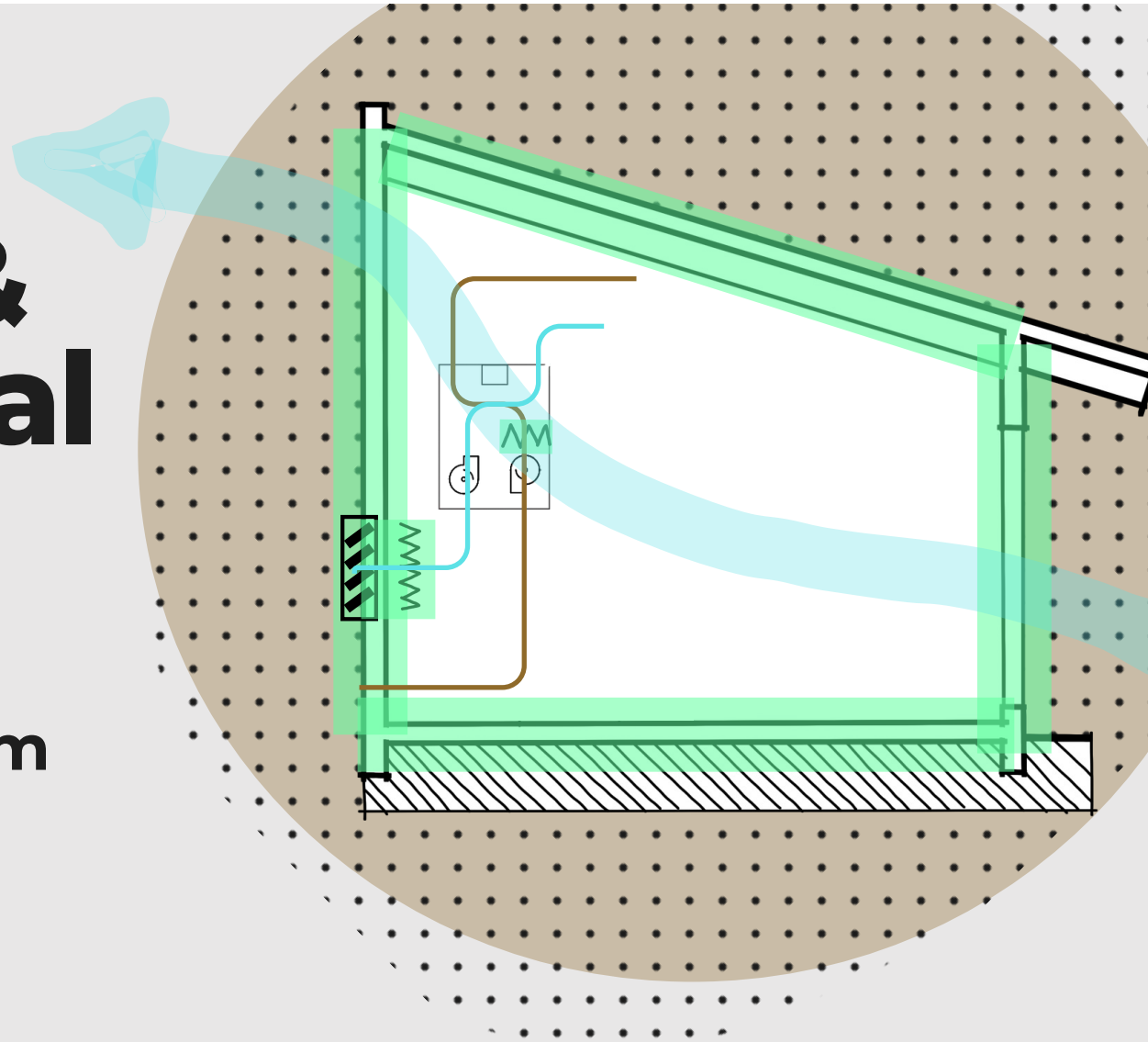
Bacteria, Toxic sewer gas



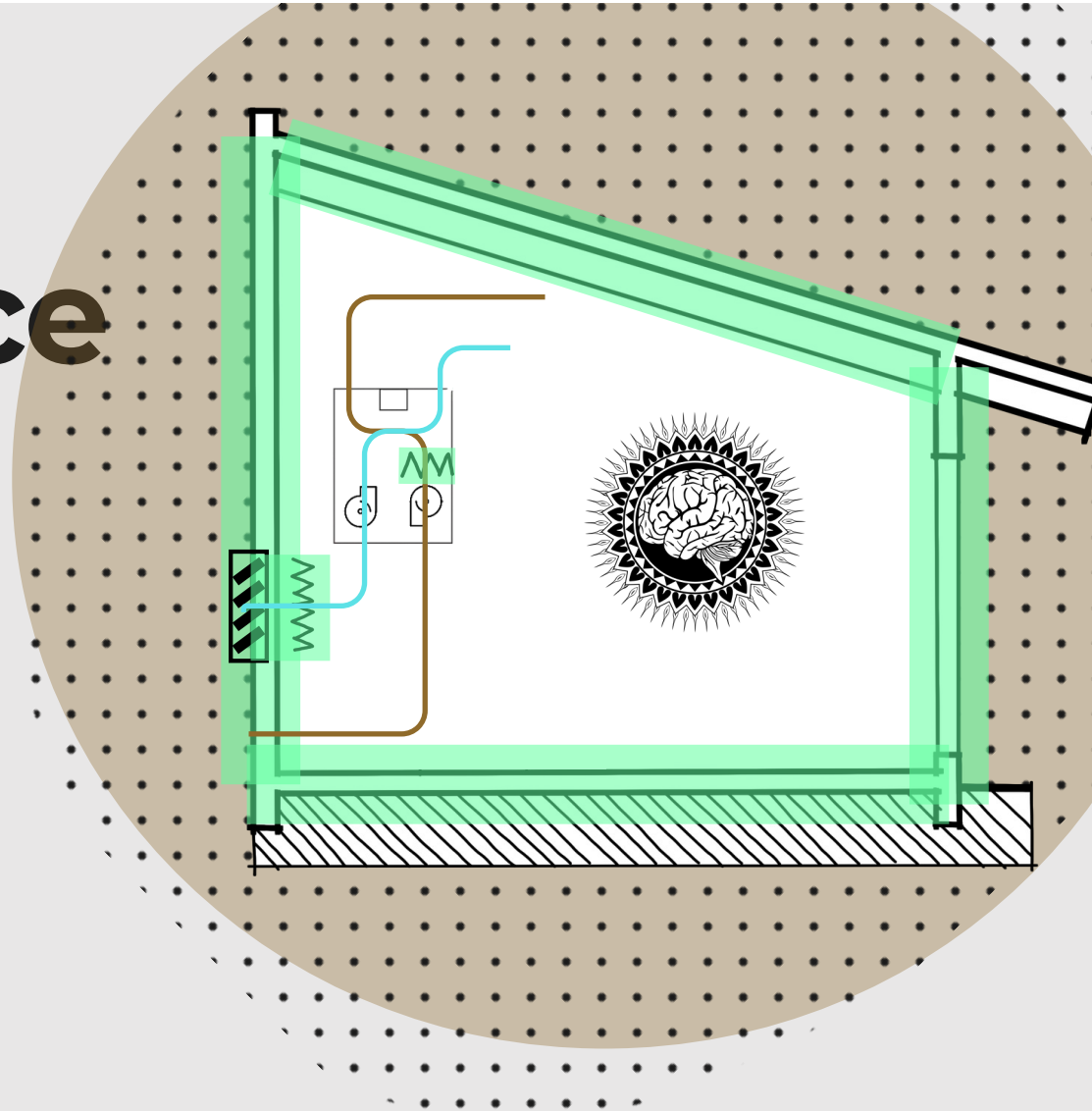
**Lumber Mold
Is Mold**

Indoor Ecology & Occasional House Burping?

Avoid paper gypsum



**High
Performance
Building
Science =
Nervous
System
Safety**





**How does this information inform
our design?**

BUILDINGS RECAP

It's not rocket science, it's building science.

- **Tight homes are safe with managed indoor ecology.**
- **Recirculating air cleaning – install as standard.**
- **This CDR framework → new research**
 - **How do buildings contribute to “health cycles”**

RESOURCES

- **Dr. Robert Naviaux** Metabolic features of the cell danger response – Mitochondrion 16(2014)7–17
- **Dr. Robert Naviaux** Mitochondrial and metabolic features of salugenesis and the healing cycle – Mitochondrion 70 (2023) 131–163
- **Dr. Robert Naviaux** Youtube : https://www.youtube.com/watch?v=OcrxK-PAe_l&list=PLc-qCBbybbupvzM8xHgAHRKcx99oljnse&index=9
- **Dr. Robert Naviaux** Metabolic features and regulation of the healing cycle—A new model for chronic disease pathogenesis and treatment
- **Dr. Robert Naviaux** Cell Danger Response Biology—The new science that connects environmental health with mitochondria and the rising tide of chronic illness. Mitochondrion 2020;51:40–45
- **Dr. Derrick Lonsdale & Dr. Chandler Marrs** Thiamine Deficiency Disease, Dysautonomia, and High Calorie Malnutrition (Book)
- **Dr. Claudia Miller** <https://tiltresearch.org/>
 - <https://www.youtube.com/watch?v=NcdMhWvMI34>
- **Change The Air Foundation & Carl Grimes** The Out of Site Dust Mite: Interview with Carl Grimes
 - https://www.youtube.com/watch?v=_cKIXPlv_lg
- **CDC** Trends in Multiple Chronic Conditions Among US Adults, By Life Stage, Behavioral Risk Factor Surveillance System, 2013–2023
 - https://www.cdc.gov/pcd/issues/2025/24_0539.htm
- **Tan et. al.** Hans Selye (1907–1982): Founder of the stress theory
- <https://www.epithelialbarriertheory.com/reviews/recent-advances-in-the-epithelial-barrier-theory>
- **Environmental assessment and exposure control of dust mites: a practice parameter**
 - Portnoy et al. ; <https://pmc.ncbi.nlm.nih.gov/articles/PMC5156485/>
- **Dr. Bruce Hoffman** <https://www.drbrucehoffman.com/courses/7-stages>
- **Mucus barrier, mucins and gut microbiota: the expected slimy partners?**
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7677487/#s6>

THANK YOU

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