

FLORA FUNGA PODCAST

Fungi and the electromagnetic spectrum

From counting x-ray photons to reading mushrooms

KK with Matthew Getzin · 09/30/2026

INTRODUCTION

Who is Mushroom Matthew?



TRAINING

PhD in Biomedical Engineering from Rensselaer Polytechnic Institute '19
Thesis: Photon-Counting X-ray Computed Tomography

POST GRADUATE WORK

X-ray physics for GE HealthCare's deep-silicon photon-counting CT

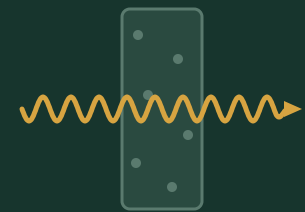
OPEN TO WORK

Available now for data science, AI and imaging-physics roles, while building myco.ai and AI tools

FUNGI

Self-started foraging over 10 years ago after "chance" encounters with fungi in the wild · founder of myco.ai

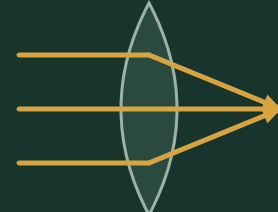
Six things a photon can do when it hits matter



Pass through

TRANSMISSION

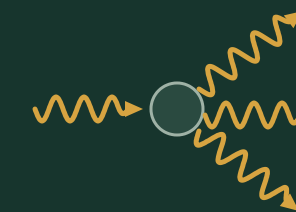
An x-ray image is a shadow of what got through.



Bend

REFRACTION

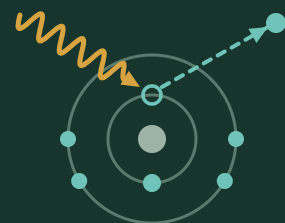
A lens slows light and bends it to a focus; no energy lost.



Bounce

ELASTIC SCATTER

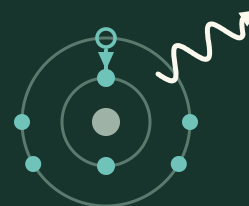
Same wavelength out: why a white mushroom looks white.



Get absorbed

PHOTOELECTRIC

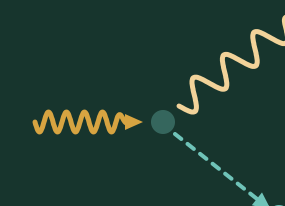
The photon vanishes; its energy frees an electron (lead K shell, 88 keV).



Re-emerge

FLUORESCENCE

The gap refills and a new, lower-energy photon leaves.



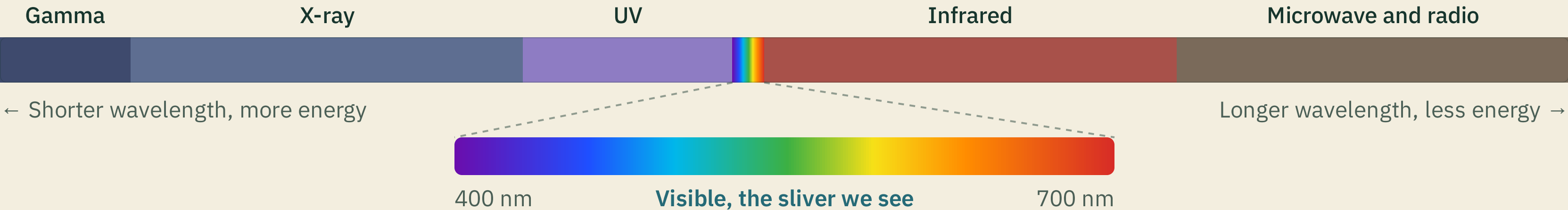
Share its energy

COMPTON SCATTER

It kicks an electron and leaves with a longer wavelength.

What wins depends on photon energy and the electron's orbital: a tight K shell needs keV, a spread-out pigment orbital a few eV, and melanin's overlapping bands absorb every color.

Light arrives in packets called photons



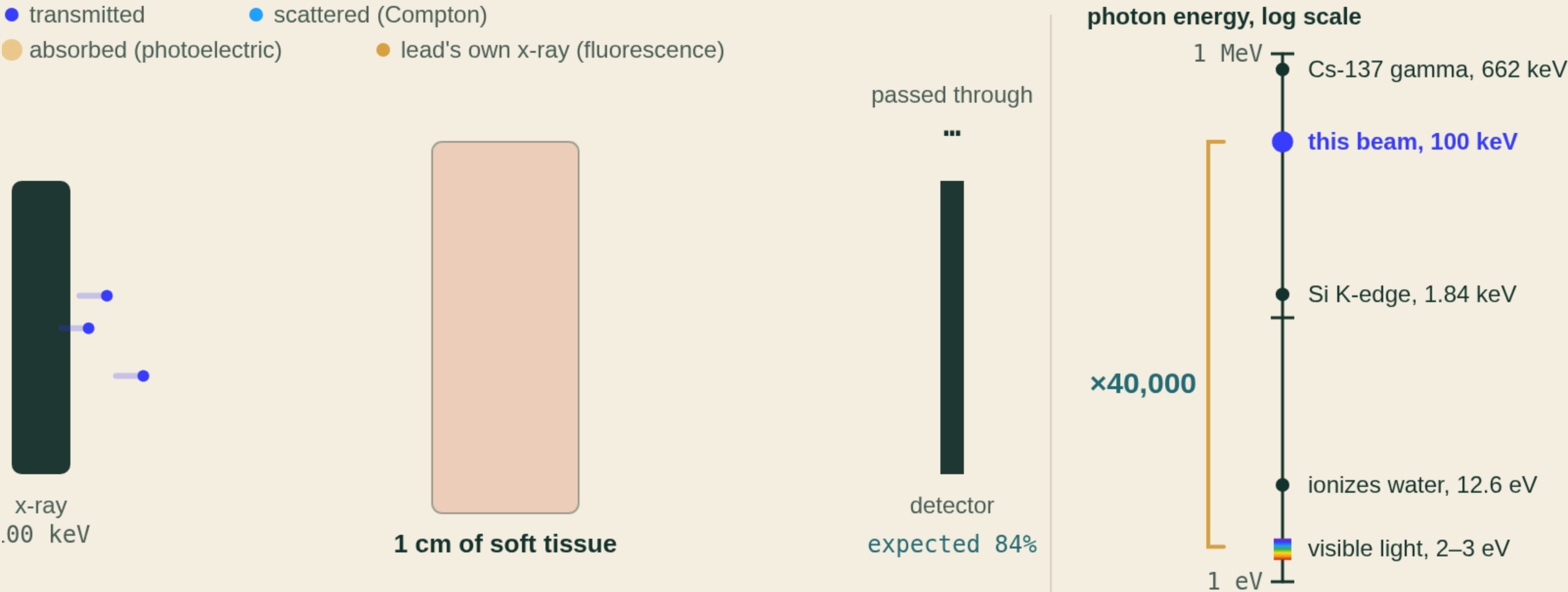
$$E = hf = hc/\lambda$$

$E \text{ (eV)} \approx 1240 \div \lambda \text{ (nm)}$

Brightness is how many photons arrive; color is the energy of each one.

Band	Wavelength	Frequency	Photon energy
Gamma	< 0.01 nm	> 3×10 ¹⁹ Hz	≥ 100 keV
X-ray	0.01–10 nm	3×10 ¹⁶ –3×10 ¹⁹ Hz	0.1–100 keV
Ultraviolet	10–400 nm	7.5×10 ¹⁴ –3×10 ¹⁶ Hz	3.1–124 eV
Visible	400–700 nm	4.3–7.5×10 ¹⁴ Hz	1.8–3.1 eV
Infrared	700 nm–1 mm	3×10 ¹¹ –4.3×10 ¹⁴ Hz	0.001–1.8 eV

Same photons, 40,000× the energy



THE BRIDGE

Same question, new subject: what happens when a photon meets matter?

In a detector, we measure it. In a mushroom, evolution uses it.

Energy decides what a photon does



VISIBLE · 1.8–3.1 EV

Lifts an electron

β-carotene's 2.8 eV gap absorbs blue; the electron stays bound

Pigment colors, glowing mushrooms, fungal light sensing

ULTRAVIOLET · 3.1–124 EV

Breaks bonds

From about 10 eV, photons can tear electrons off molecules

Vitamin D in mushrooms; light-powered DNA repair

X-RAY AND GAMMA · KEV–MEV

Knocks one out

Lead's 88 keV K edge; refilling the hole emits a 75 keV x-ray

Melanized molds at Chernobyl; fungi that mineralize lead

THE EPISODE

Six stops, from settled chemistry to open questions

01

Color

Which molecules
paint mushrooms

02

Glow

How fungi make
light

03

UV

Vitamin D,
sunscreen, repair

04

Seeing

Fungal eyes and
ours

05

Melanin

Fungi, skin and
brain

06

Radiation

Chernobyl to the
ISS

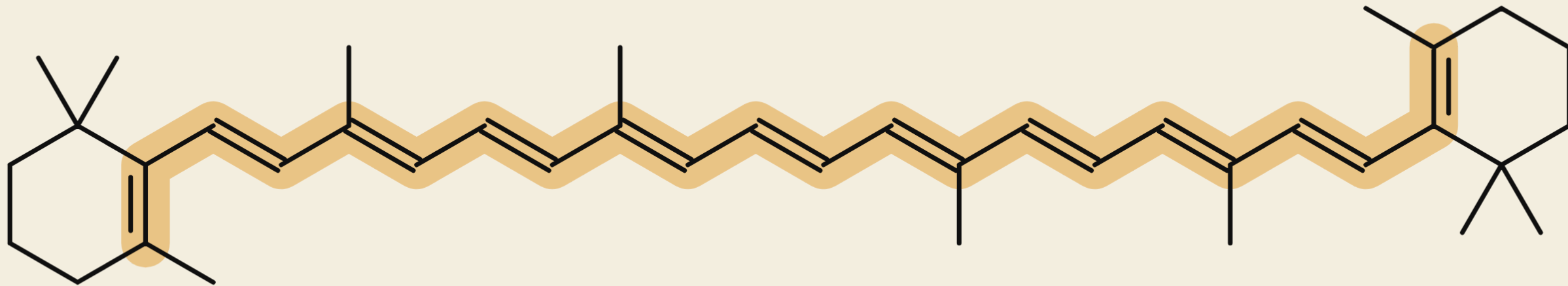
Settled chemistry

Hypothesis and open questions

Color is the light a pigment leaves over



Spread-out electrons set a mushroom's color



Alternating single and double bonds
share one electron cloud

Longer cloud, smaller energy step,
longer wavelength absorbed

Beta-carotene: 11 double bonds,
absorbs blue, looks orange

Knob one: runway length. But each extra double bond helps less and less; next, a shortcut.

Push-pull beats length

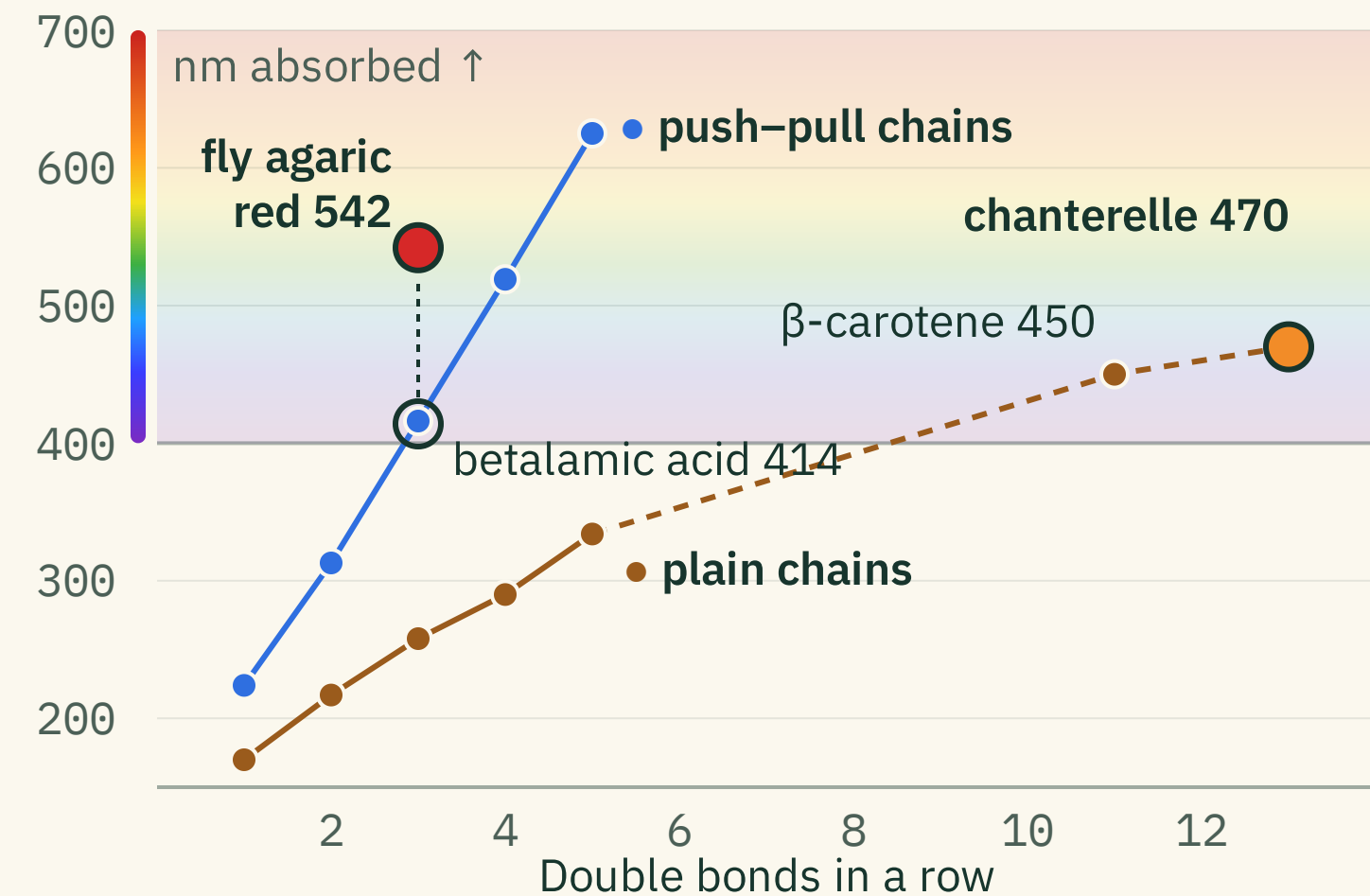
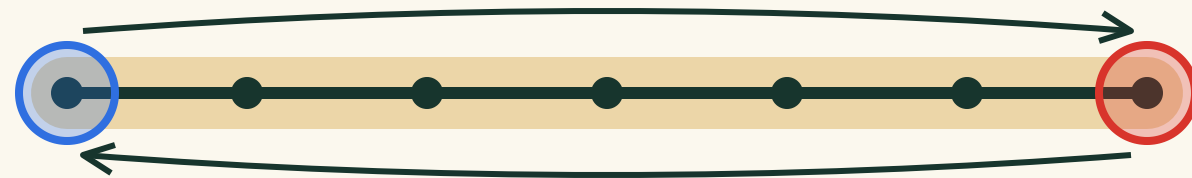
Plain chain: longer, slowly redder

β -carotene needs 11 double bonds just to reach blue (450 nm).



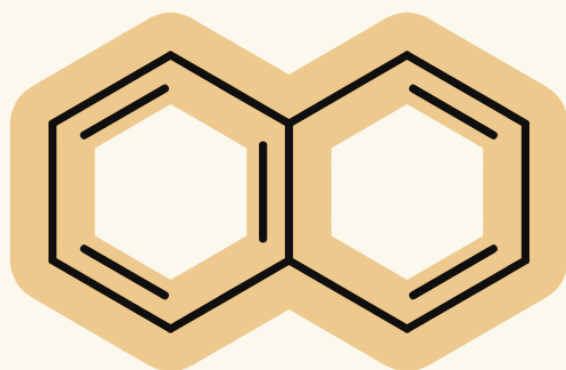
Push-pull chain: the shortcut

N pushes, N⁺ pulls, bonds even out: 3 double bonds reach green.



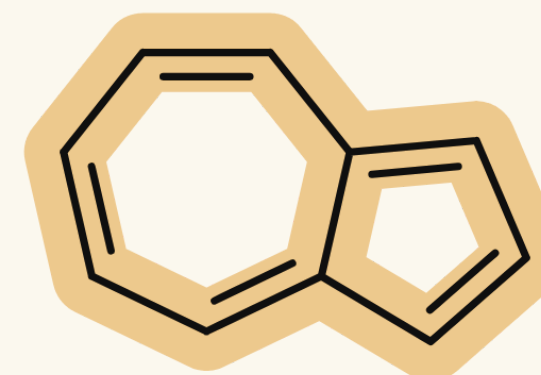
On the rainbow: the chanterelle is a long plain chain; the fly agaric is a short push-pull chain, and it wins.

Same atoms, different color



Naphthalene

C₁₀H₈ · colorless · mothballs

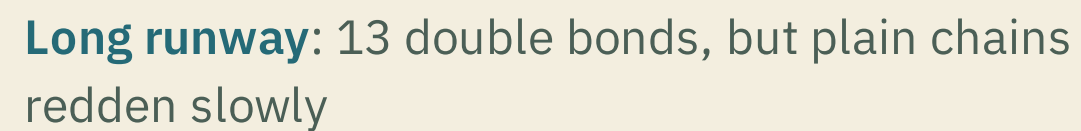
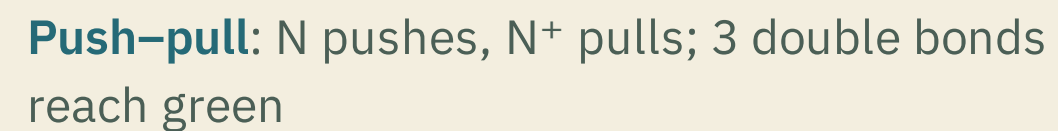
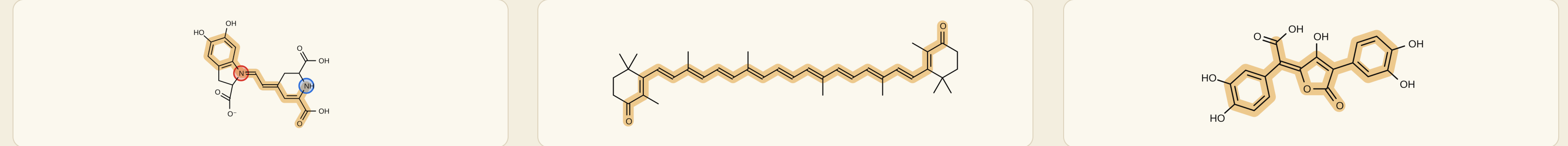


Azulene

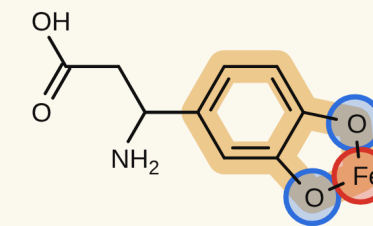
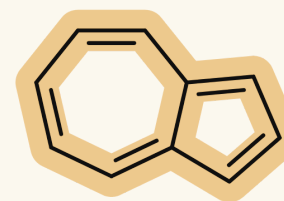
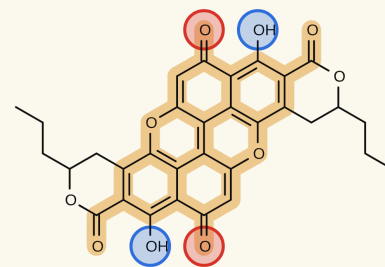
C₁₀H₈ · deep blue · core of Lactarius indigo's pigment

Naphthalene's electrons spread evenly. Azulene's odd rings pull them lopsided: the 5-ring gains charge, the 7-ring loses it, and the jump to the first empty orbital shrinks enough for yellow light (≈ 580 nm).

Warm colors: red, orange and yellow

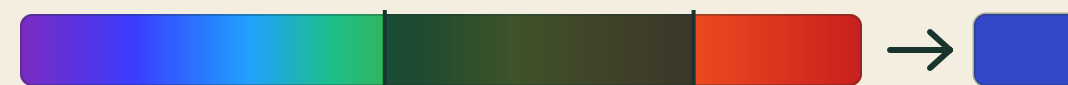


Cool colors: green, blue and violet



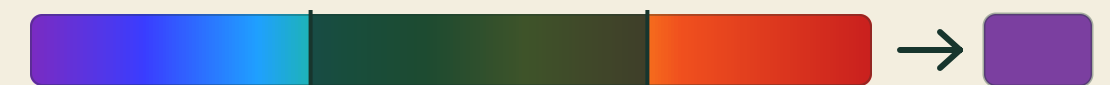
Green · Green elfcup

Sheet + push-pull: eight fused rings; OH pushes, C=O pulls



Blue · Indigo milk cap

Shape: lopsided 7+5 rings, same atoms as colorless naphthalene



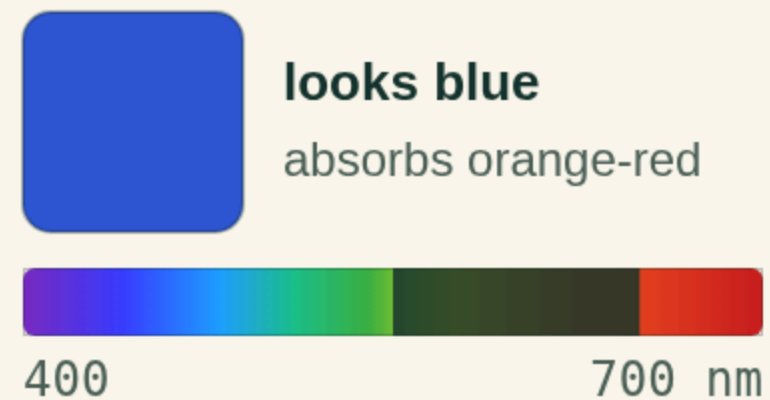
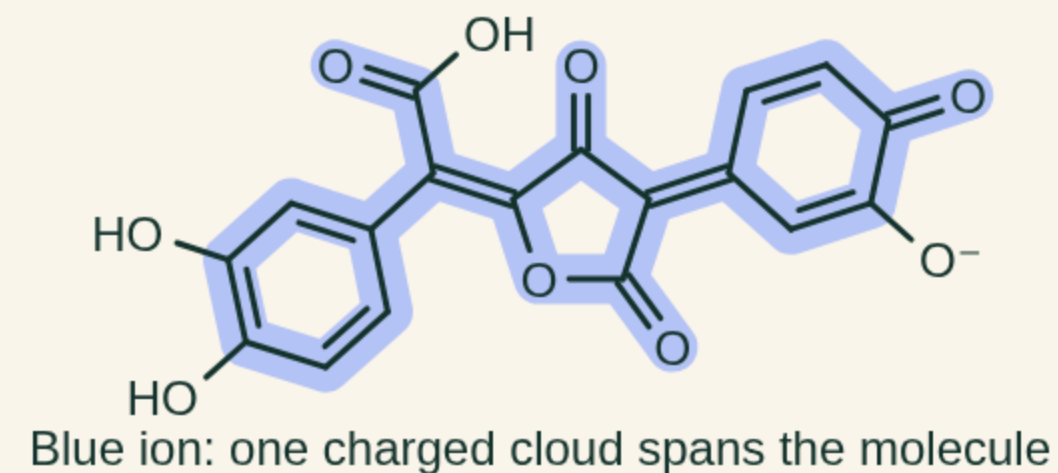
Violet · Violet webcap

Charge transfer: the catechol hands an electron to iron

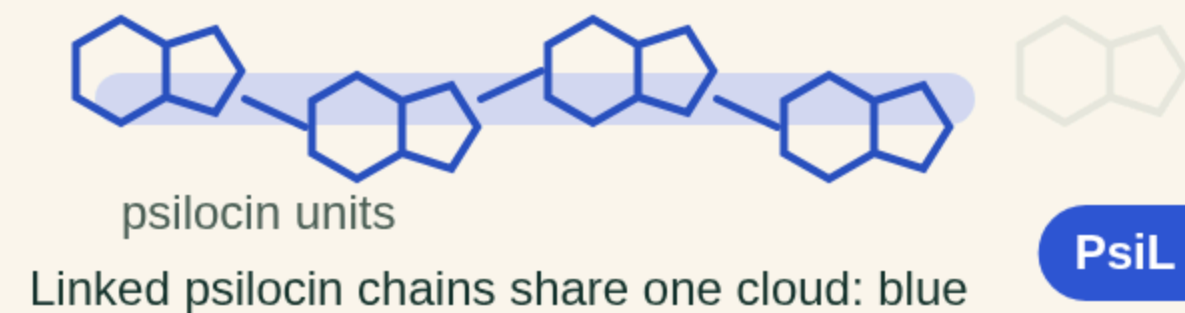
Sources: [13–16] · full list at the end

Why mushrooms bruise blue

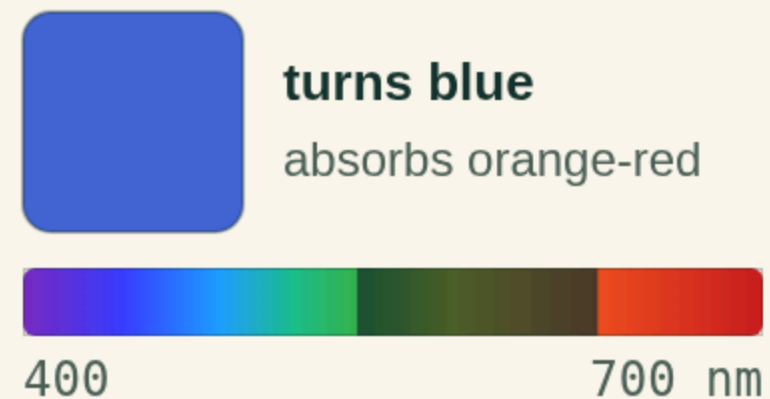
Bolete variegatic acid



Psilocybe psilocybin



PsiL + O₂



WHY BLUE?

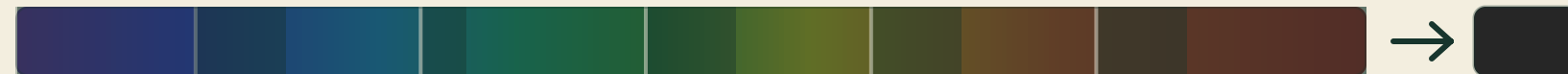
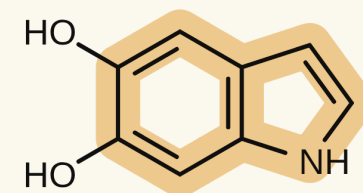
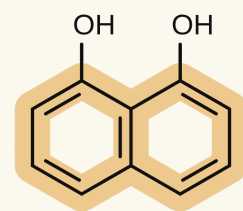
Probably a side effect, not a signal.

Injury lets enzymes reach pigments kept apart in intact cells.

Variegatic acid may feed iron to wood-rot chemistry [24]; disputed [67].

INTO THE VISIBLE • THE EXTREMES

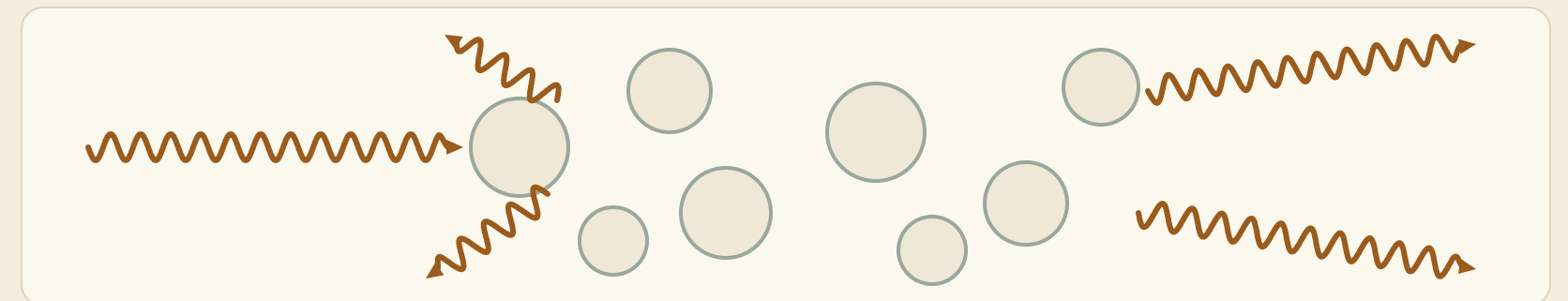
Black and white: absorb everything, or nothing



Many overlapping bands → black

Black • Melanized fungi

Every gap at once: a jumble of units, chain lengths and stacks, each absorbing its own color; together, all of them



Absorbs nothing → white

White • Button mushroom

No chromophore: hyphae and air pockets scatter every color back

AFTER ABSORPTION

An excited electron has five ways out

Next stops: Glow runs 02 on chemistry · UV uses 03 and 04 · Seeing uses 03 · Melanin is 01.

01 Heat

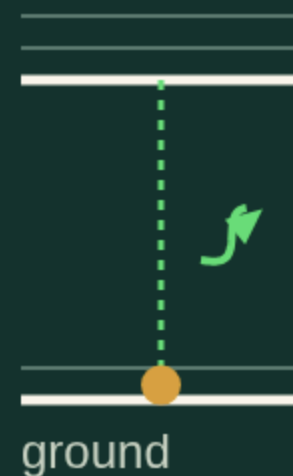


Slides down the rungs,
shaking the molecule

picoseconds

Most pigments and
melanin: >99%

02 Fluorescence

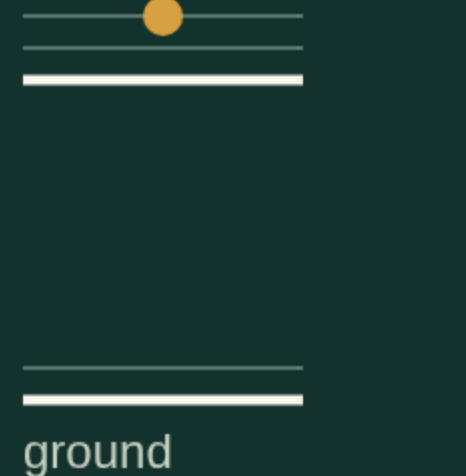


Drops back and re-emits
a redder photon

nanoseconds

Flavins, some Cortinarius

03 Bond change



Twists or breaks a bond
while excited

femtoseconds

Retinal in your eye,
vitamin D

04 Hand-off

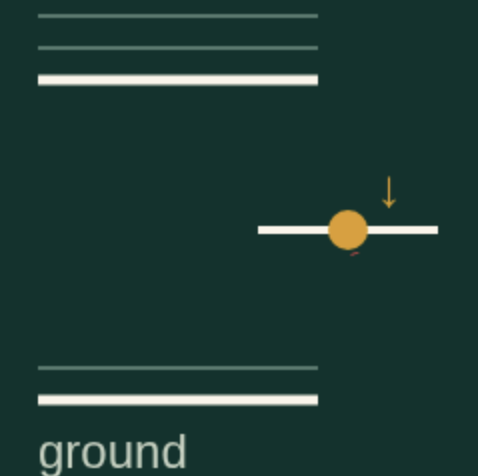


Jumps to a neighboring
molecule

picoseconds

DNA repair,
photosynthesis

05 Singlet O₂

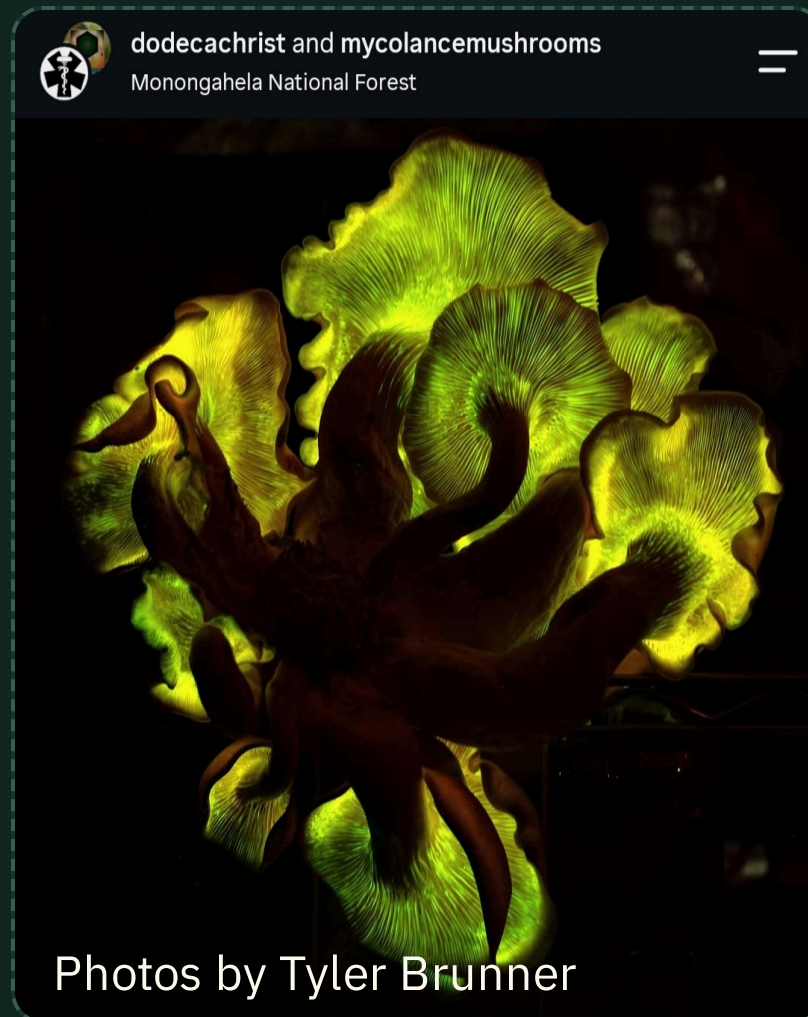


Spin flips; hands energy
to O₂, making it reactive

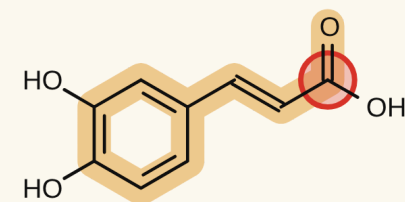
microseconds

Cercosporin; carotenoids
block it

Glow: chemistry does the exciting

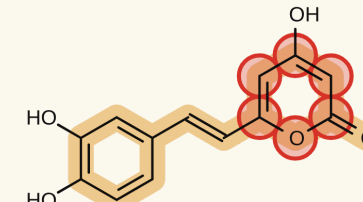


1 • BUILD THE FUEL



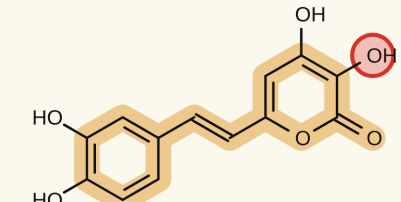
Caffeic acid

→
+ ring



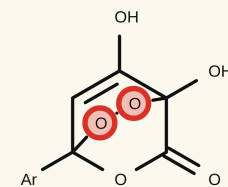
Hispidin

→
+ OH



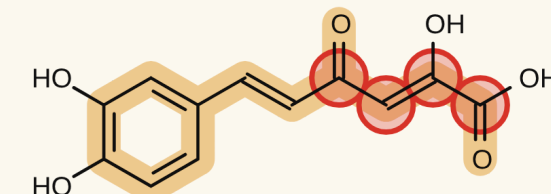
3-OH-hispidin (fuel)

2 • BURN IT FOR LIGHT



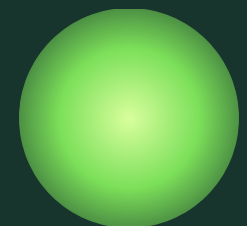
O–O ring (unstable)

→
– CO₂



Caffeylpyruvic acid*

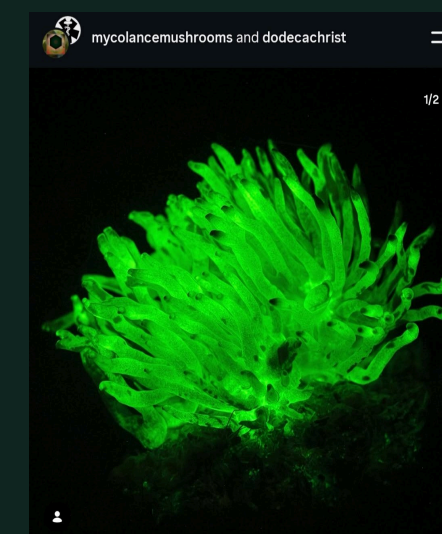
→
light



green light
≈520 nm

Red circles: what changes at each step. Losing CO₂ pays for the photon (≈2.4 eV).

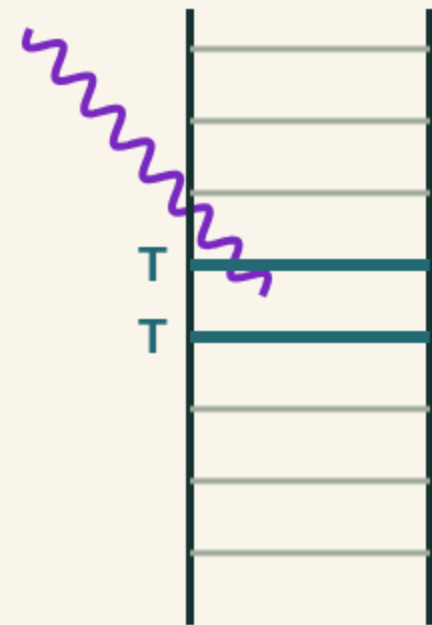
Sources: [31–34] • full list at the end



UV: damage, defense and vitamin D

UV photons carry 3–4+ eV: enough to break and rearrange bonds, not just lift electrons.

Damage, then repair

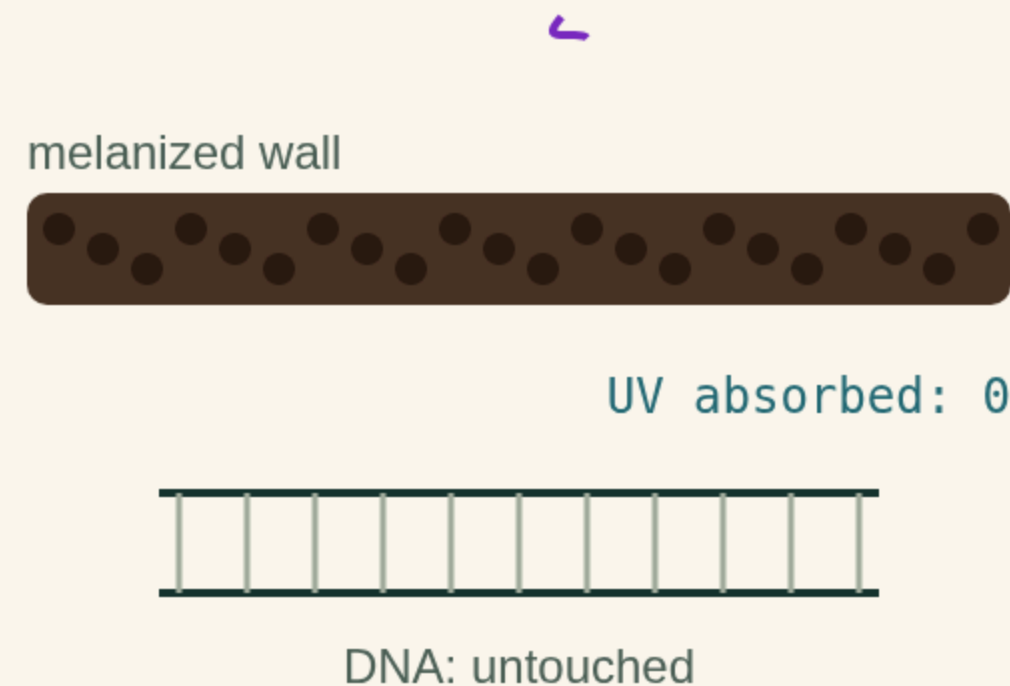


UV-B fuses two DNA letters; photolyase uses blue light to hand them an electron and split them

UV-B damages • blue repairs

Photolyase with a flavin (FAD)

Defense: block it

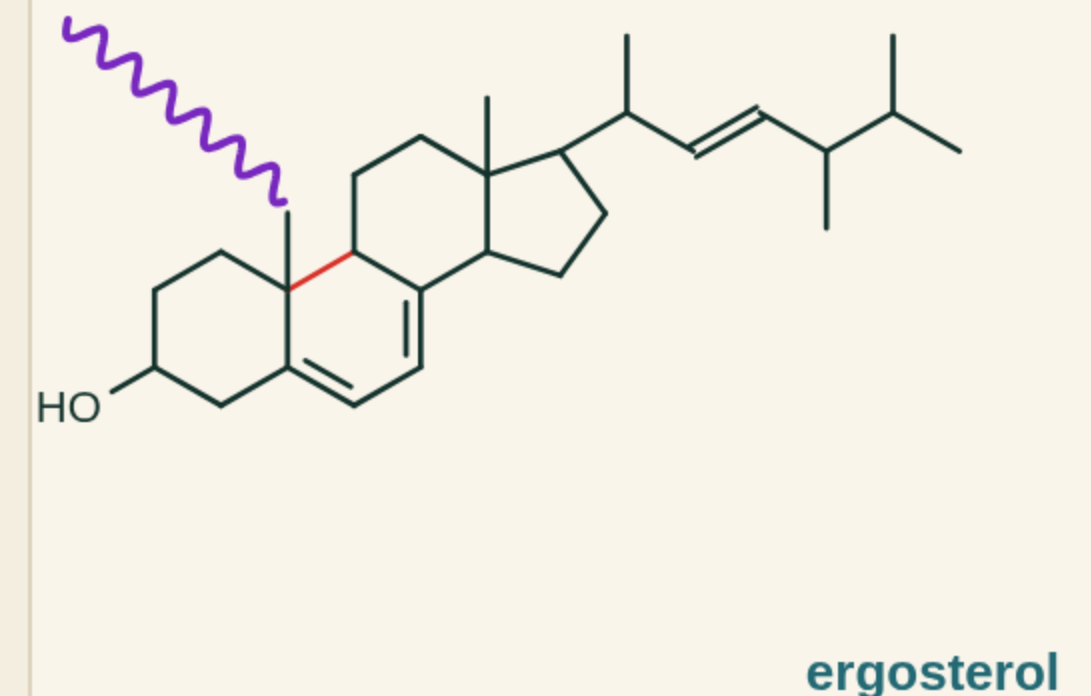


Pigments in the wall soak up UV before it reaches DNA, and shed it as heat

absorb → heat (route 01)

Melanin, carotenoids, mycosporines

Vitamin D: put UV to work



UV-B snaps ring B open; ring A swings free, giving vitamin D₂

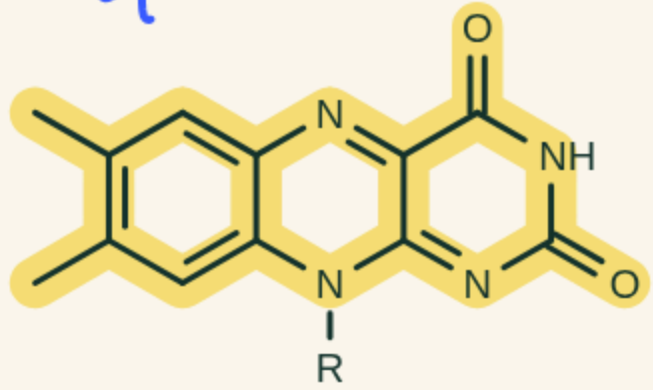
UV-B, 280–315 nm

Your skin: 7-dehydrocholesterol → D₃

Seeing: fungi sense light with our toolkit

Three chromophores we share with fungi, flavin, retinal and a bilin, plus one lens.

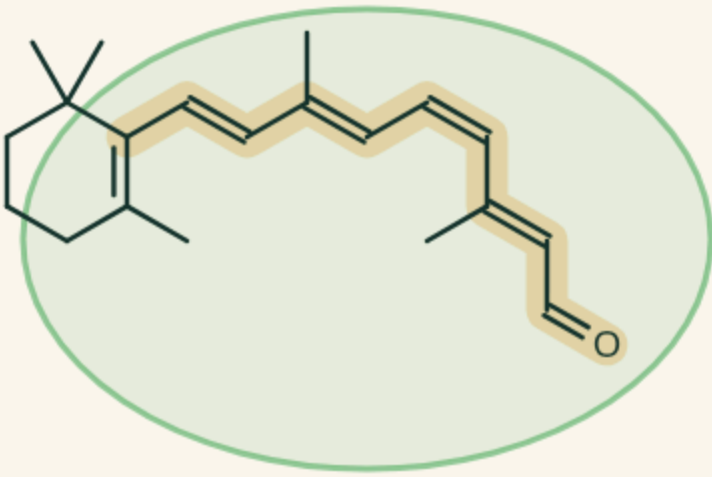
Blue: flavins
Cys S flavin: yellow



protein helix

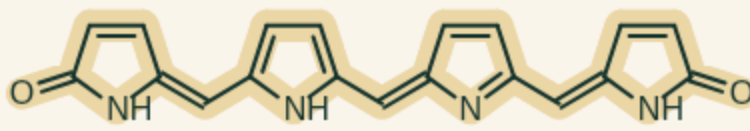
Blue light makes the flavin grab a sulfur from its protein; a helix unwinds and signals
≈450 nm • resets in the dark
White Collar-1 runs Neurospora's clock

Green: opsins
11-cis: bent



Light flips retinal from bent to straight; the opsin changes shape
≈200 femtoseconds
Same retinal in fungi and your eye

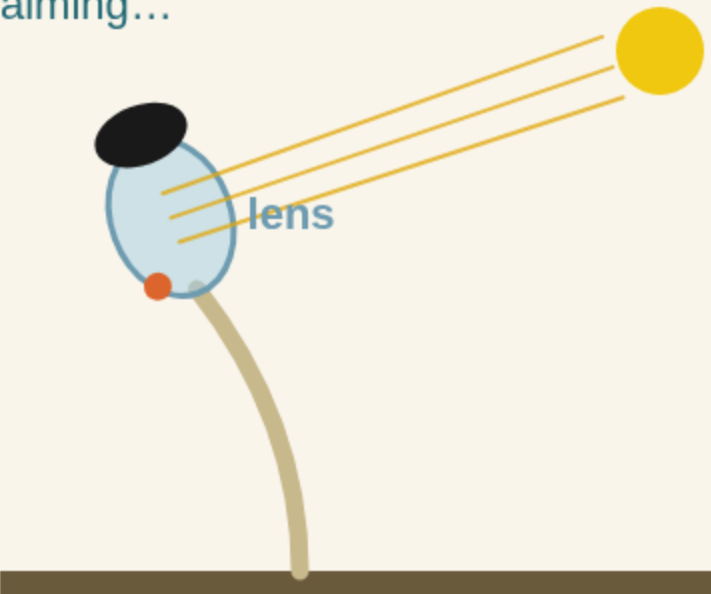
Red: phytochromes
Pr: resting



side groups omitted

Red light flips the end ring of biliverdin; far-red flips it back
red ≈660 ≠ far-red ≈730 nm
Aspergillus: make spores, or mate?

A fungal eye
aiming...

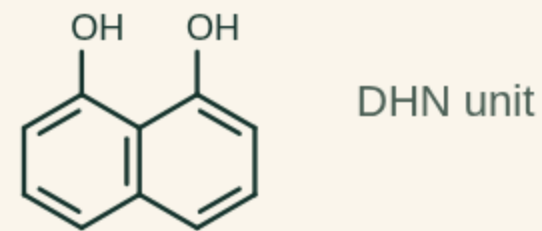


A clear swollen cell focuses sunlight on its base; the stalk bends until the spot is centered, then fires
aim → fire
Pilobolus, on dung

One pigment, three places

Same chemistry everywhere: soak up light, return it as heat, mop up radicals.

Fungal cell walls

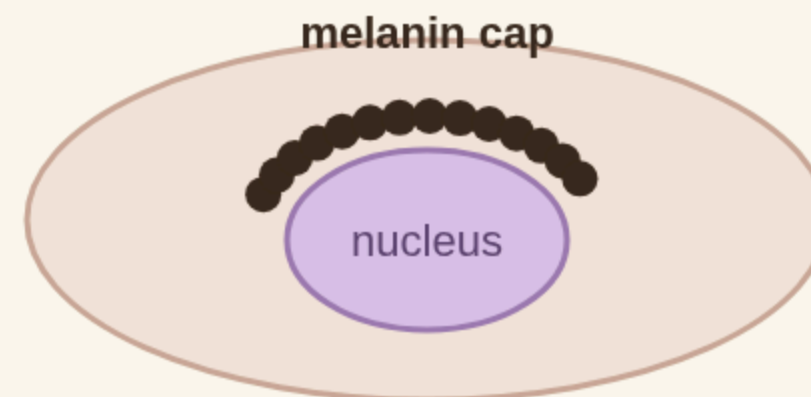
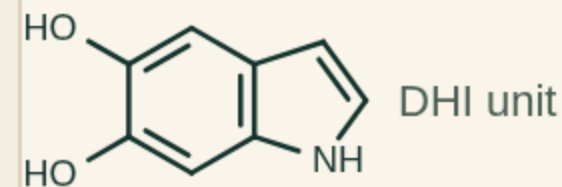


DHN units link into a dark, disordered polymer inside the wall

armor: UV, radicals, metals

Most molds, dark caps, Chernobyl fungi

Your skin and eyes



UV stopped above the DNA

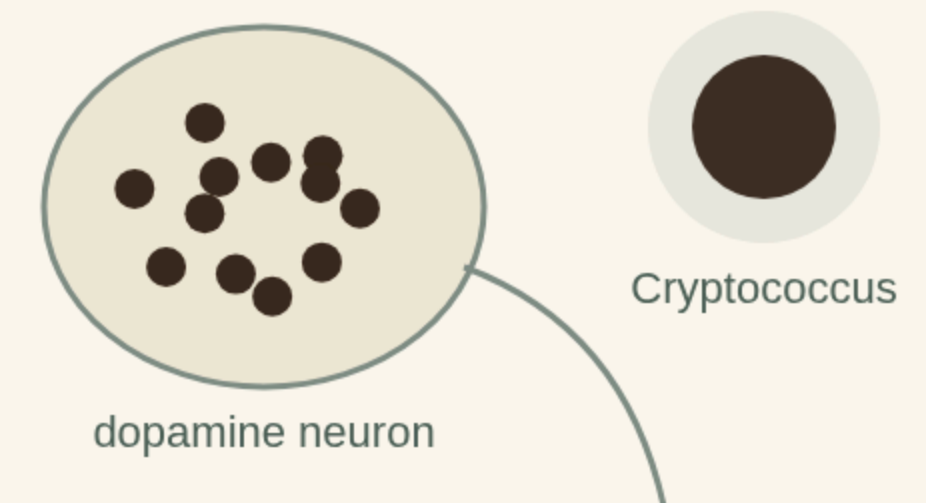
Melanin granules gather into a cap over each nucleus, a parasol against UV

tyrosine → DOPA → DHI

Skin, hair, the back of the eye

Your brain

age 80

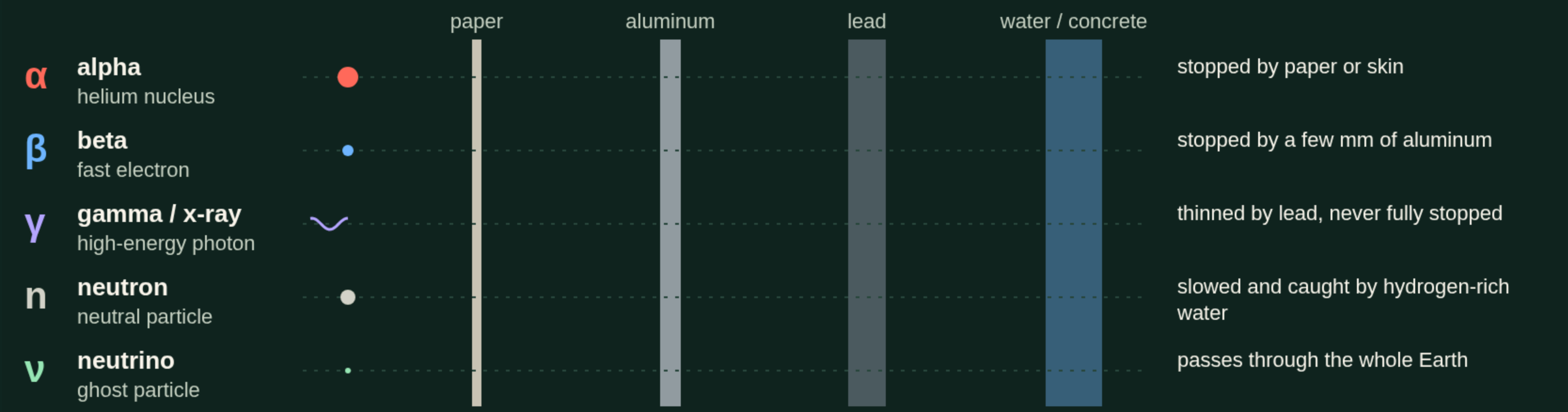


Leftover dopamine slowly darkens into neuromelanin; Cryptococcus steals the same molecules for its own armor

dopamine → neuromelanin

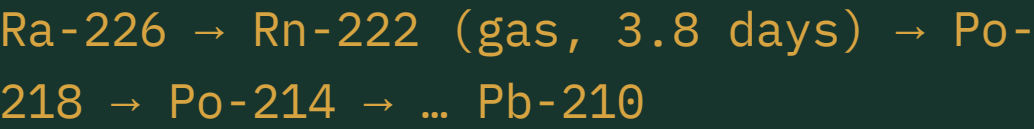
Substantia nigra; Cryptococcus infections

Five kinds of radiation, five kinds of armor



Radon: the alpha you breathe

Radium in soil decays into radon gas that seeps into basements. Skin blocks its alphas, but breathed in, radon and its decay products fire them straight into lung tissue.



From solid ground to open question

straight through: 0%
Compton hits: 0%



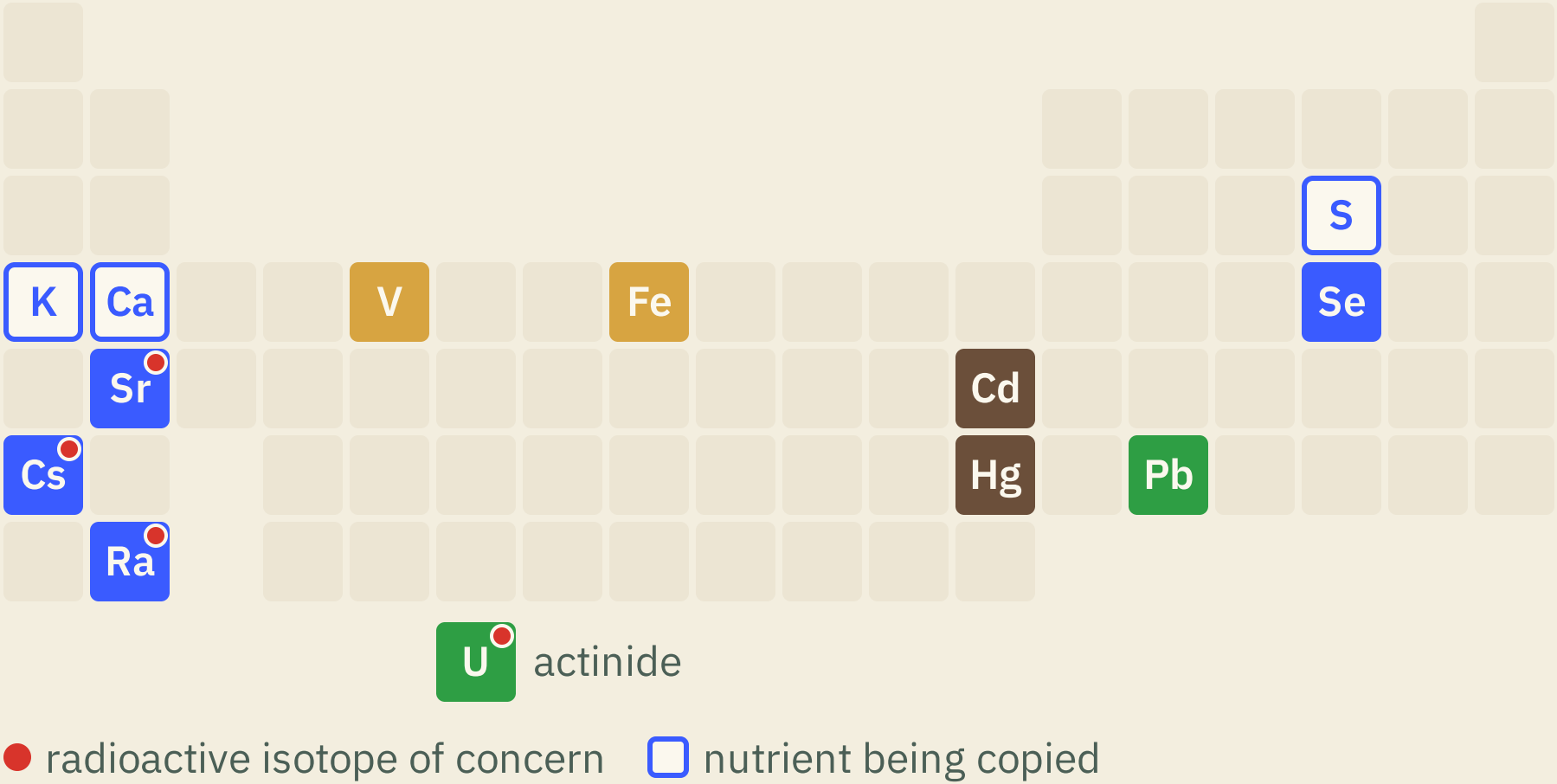
Cs-137
662 keV γ
most γ rays pass straight through; the rare hit frees an electron that rattles through melanin, leaving a trail of ionizations

Open question: is any of that energy captured for growth?

Hypothesis	“Radiosynthesis”: fungi harvest usable energy from radiation [56]
Suggestive	On the ISS: growth 1.21× (±0.37) ground; ≈2% fewer counts under the mat [57, 64]
Well supported	Radiation alters melanin's electrons; melanized fungi grow faster at ≈500× background [55]
Established	In 18 of 27 tests, soil fungi grew toward beta and gamma sources [54]
Established	Melanized fungi dominate Chernobyl's damaged reactor rooms [53]

“Radiation-stimulated” is accurate; “eats radiation” is not.

Fungi soak up the soil, radioactive or not



Poses as a nutrient
Cs-137 sneaks in as potassium [68]; radium and Sr-90 as calcium

Grabbed on purpose
The fly agaric builds amavadin to hoard vanadium; siderophores fetch iron [59]

Sticks to wall and melanin
Lead, cadmium and mercury cling to chitin and melanin; cesium to a cap pigment [58, 60]

Turned into a mineral
Lead becomes pyromorphite; uranium becomes uranyl phosphate [61–63]

Swallow a radioactive element and the fungus becomes its own radiation source.

Sources: [58–63, 68] · full list at the end

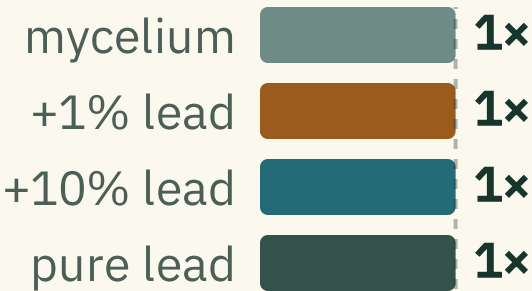
Lead stops x-rays. Could metal-loaded fungi?

Stopping power per gram

100 keV x-rays



1 MeV gamma



Photoelectric absorption climbs with atomic number; at gamma energies Compton wins and every material is $\approx$ equal per gram. A 1.7 mm fungal lawn blocks $\sim$ 1–2% at 662 keV.

X-rays: Metals help

Photoelectric absorption climbs steeply with atomic number; a few % lead, bismuth or barium multiplies stopping

Neutrons: Hydrogen plus a capturer

Wet mycelium is hydrogen-rich and slows neutrons; boron or gadolinium would swallow them

Space radiation: Mass beats metal

For fast protons and heavy ions, hydrogen-rich bulk works best; heavy metals shatter them into secondaries

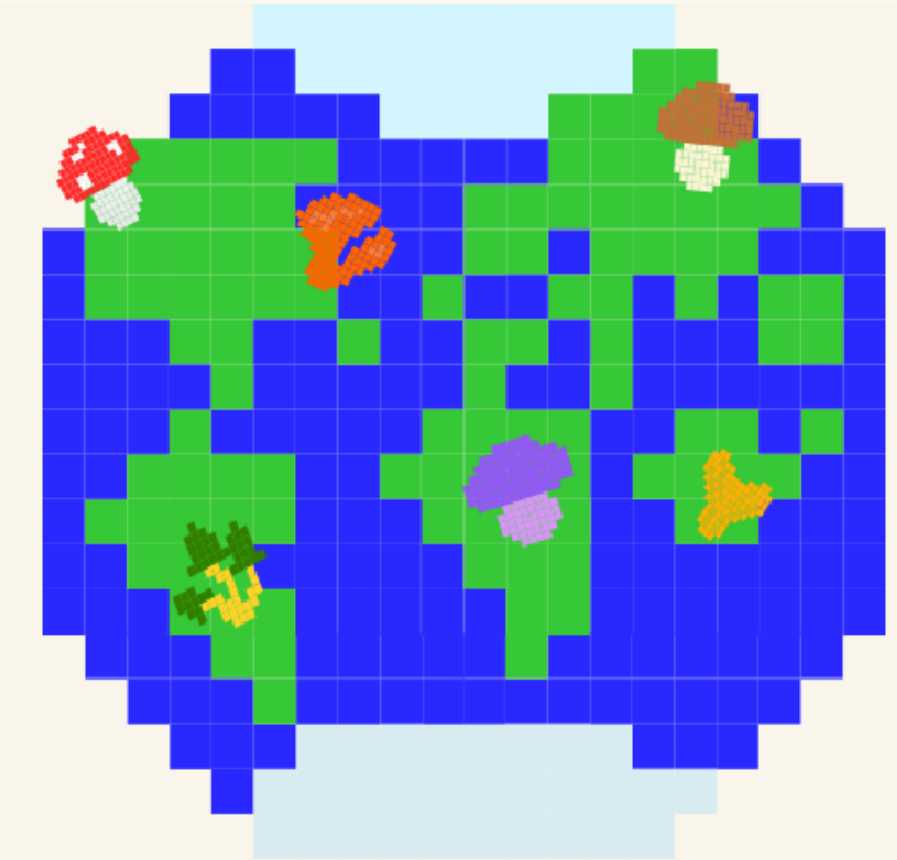
The pitch: grow hydrogen-rich bulk on site; dope thin layers with metals only where photons or neutrons matter.

MYCO.AI · ADAPTIVE BY NATURE, COOPERATIVE BY DESIGN

A field companion for mushroom hunters

A mushroom scouting aid and private field record.

A scouting signal, not a promise.



Field-guide illustration · not real finds

1

See where conditions
look right

2

Save a place

3

Create a private foray
record

4

Look back on your
finds

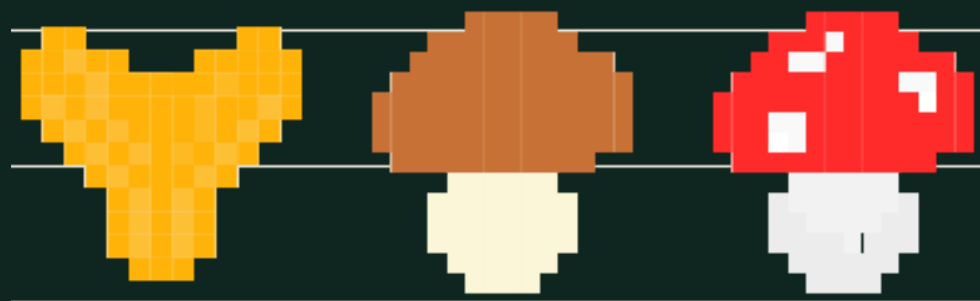
MYCO.AI • THE NEXT SIGNAL COMES FROM YOU

Help shape the field companion.

Join the early-interest list and tell us what would make myco.ai useful in the field.

WHAT YOU GET: EMAIL UPDATES • OPTIONAL FEEDBACK

| Be first to hear when it opens.



SCAN TO SHARE YOUR INTEREST

myco.ai

Occasional updates, no spam.

Sources

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