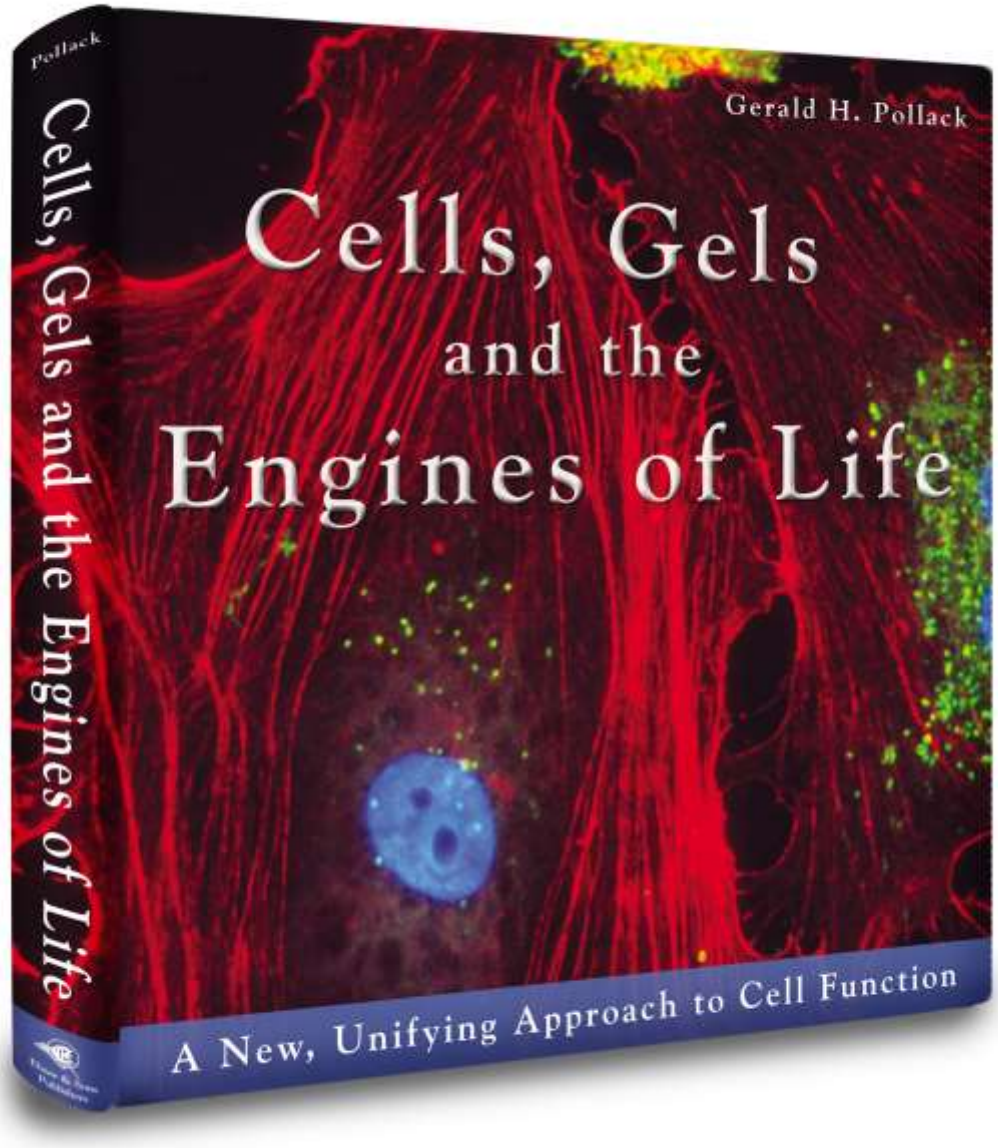
The Fourth Phase of Water
A Central Role in Health

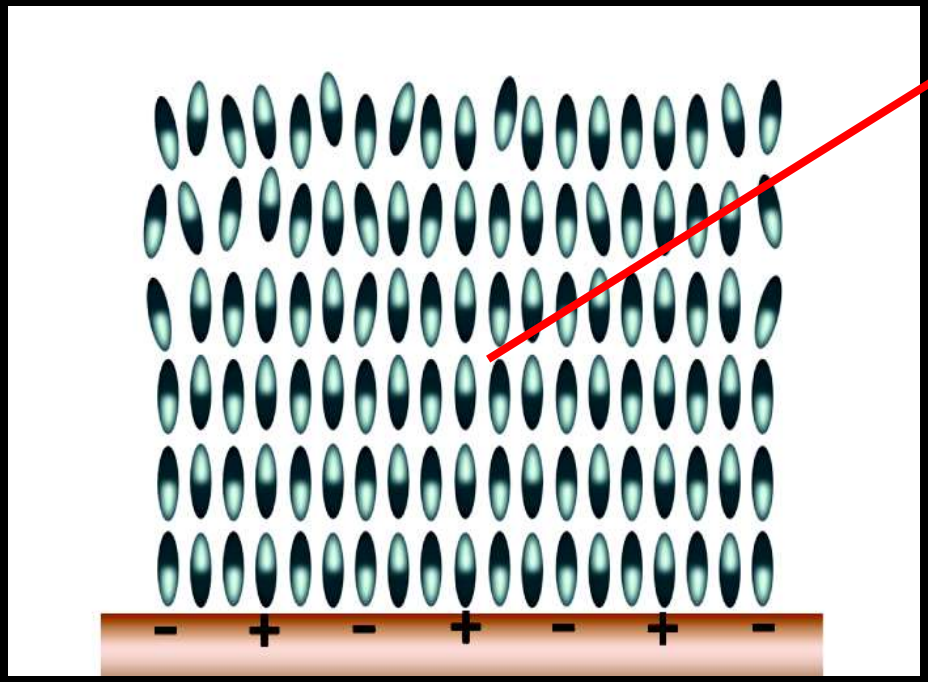
Gerald H. Pollack, PhD
University of Washington
Seattle

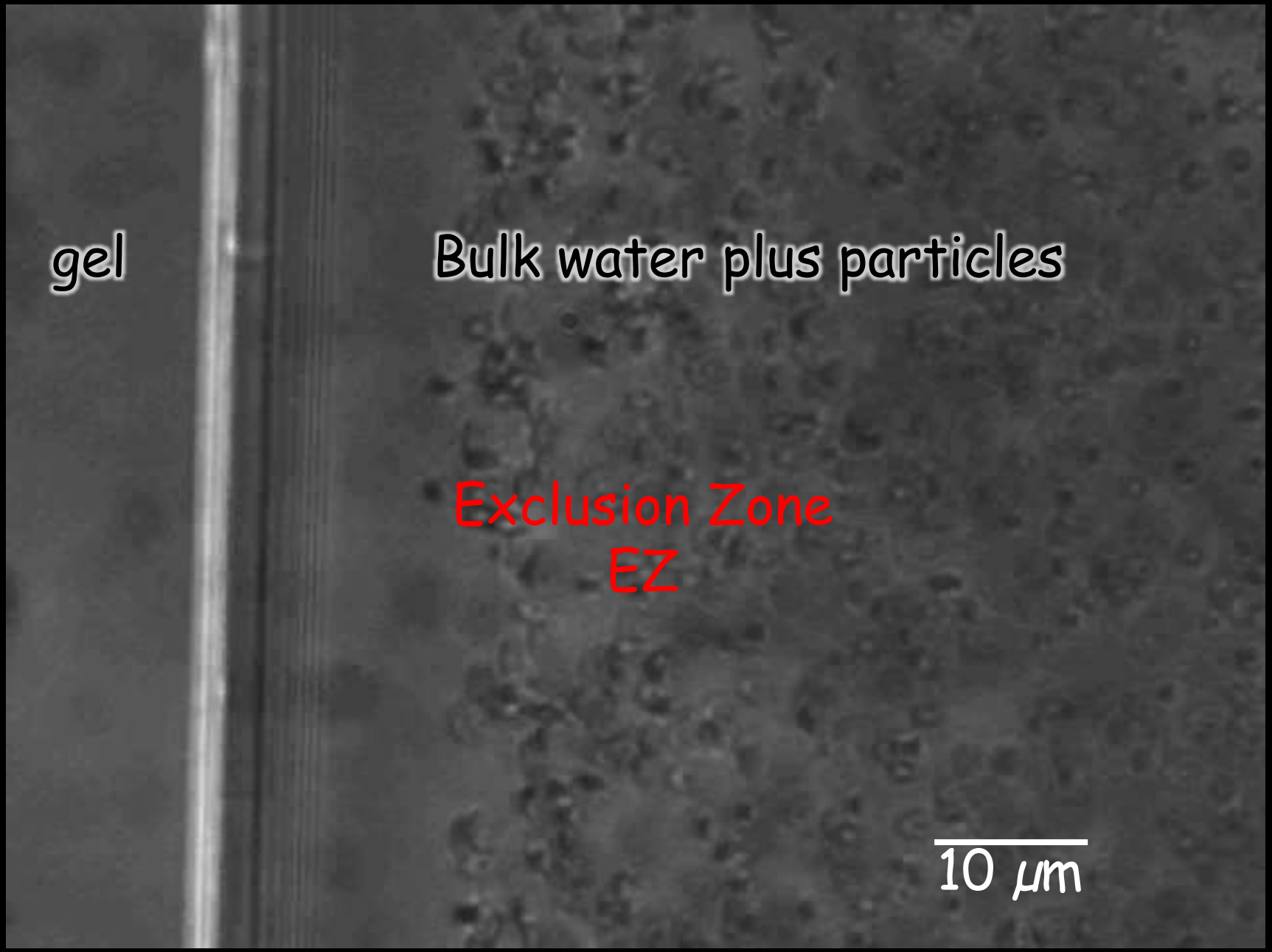
Kobe
November 2016

Gilbert Ling, 1919-

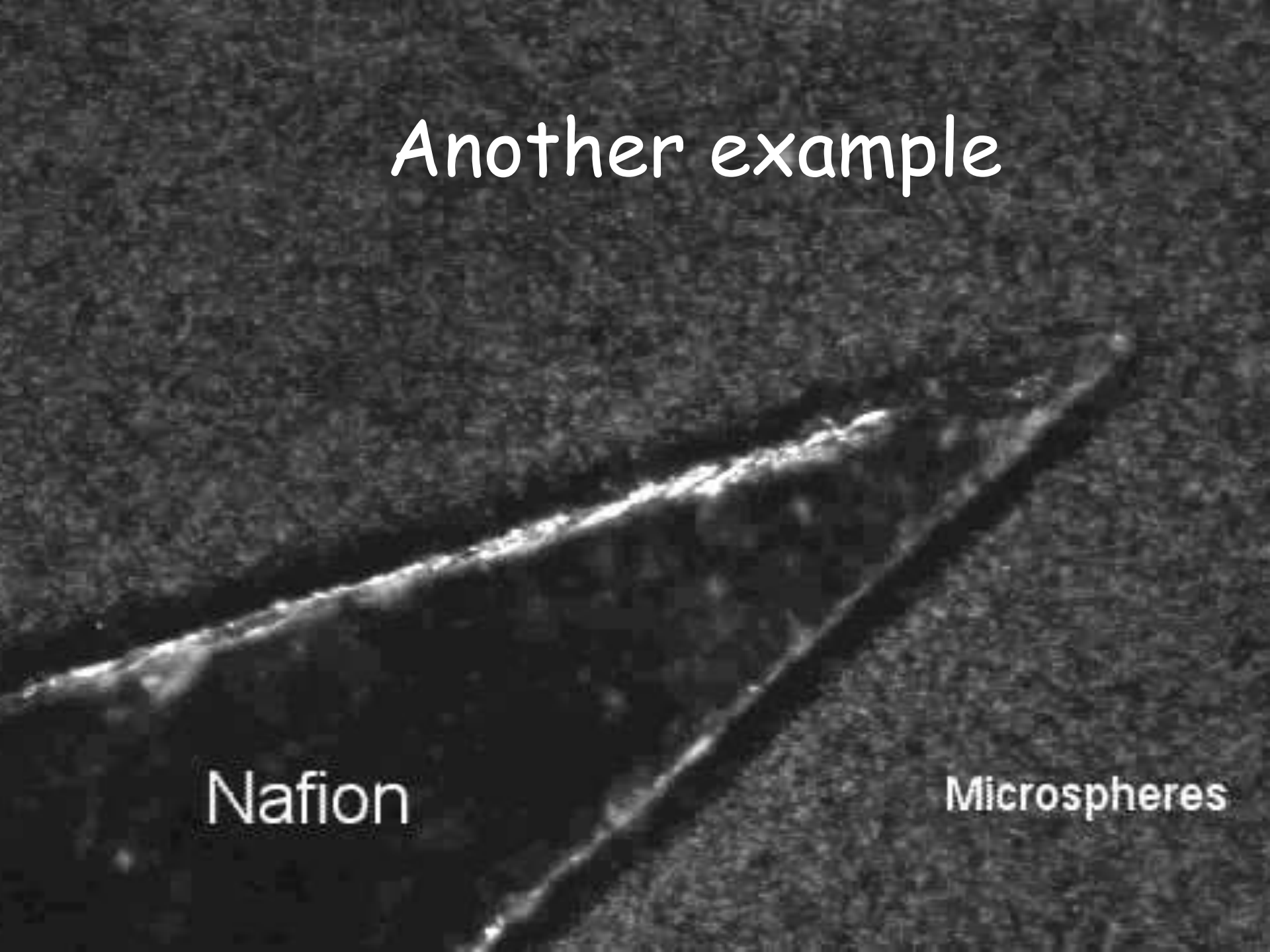
Central role of water in biology…




Excludes solutes, particles
protein


gel
Bulk water plus particles
Exclusion Zone
EZ
10 μm

Another example



Basic finding confirmed

- Felix Blyakhman (Ural State Univ)
- Wei-Chun Chin (U. Cal. Merced)
- Toshio Hirai (Shinshu University)
- Mark Banaszak Holl (Univ. of Michigan)
- Tom Lowell (Vermont Photonics)
- Diedrich Schmidt (Tsukuba)
- Gerhard Artmann (Aachen)
- David Maughan (U. Vermont)
- Miklos Kellermayer (Budapest)
- Fettah Kosar (Harvard)
- Jacques Huyghe (Eindhoven)
- Nikolay Bunkin (Moscow)
- Federico Carpi (London)
- etc.

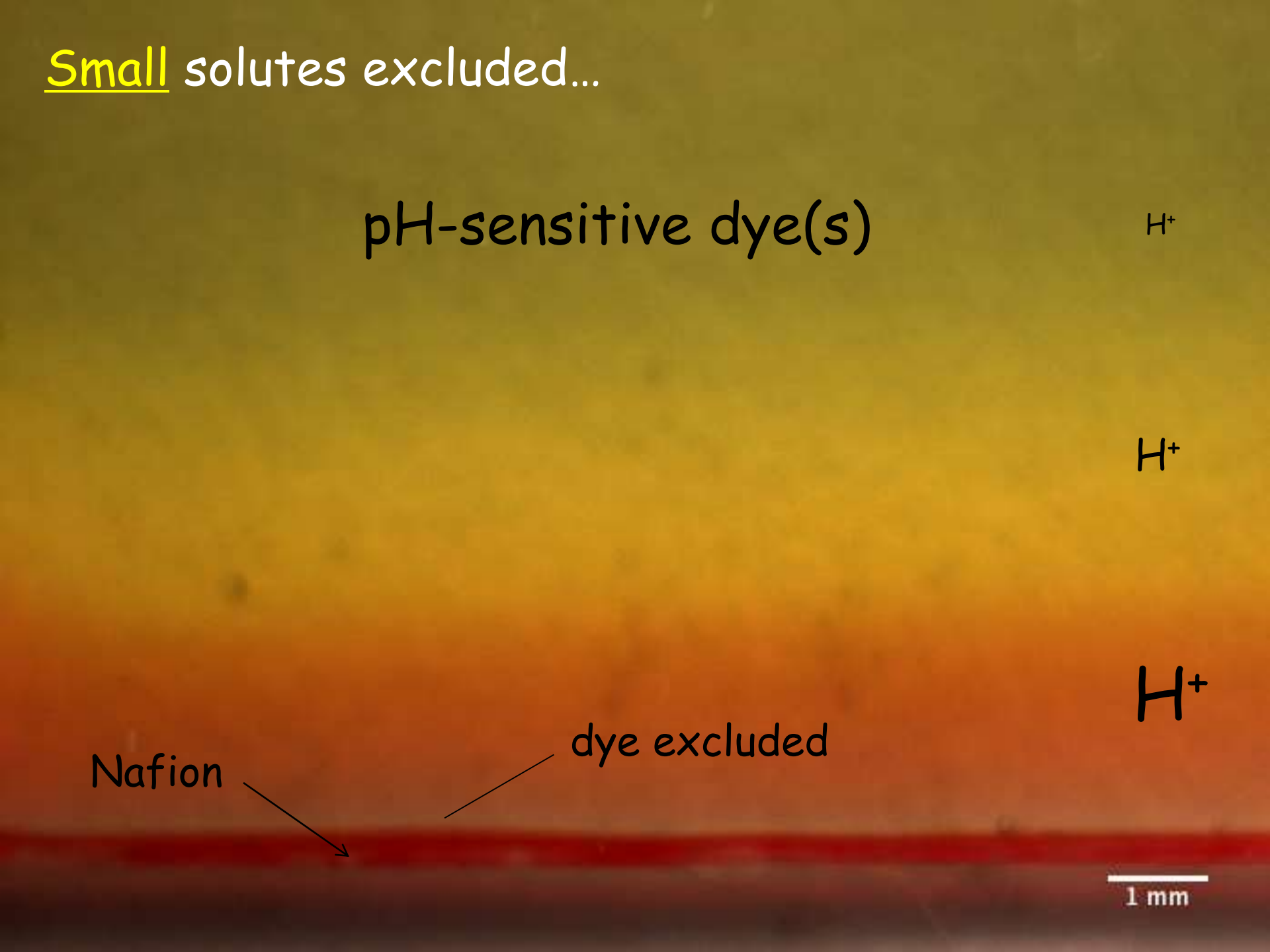
Getting to the basis…

Questions to Answer

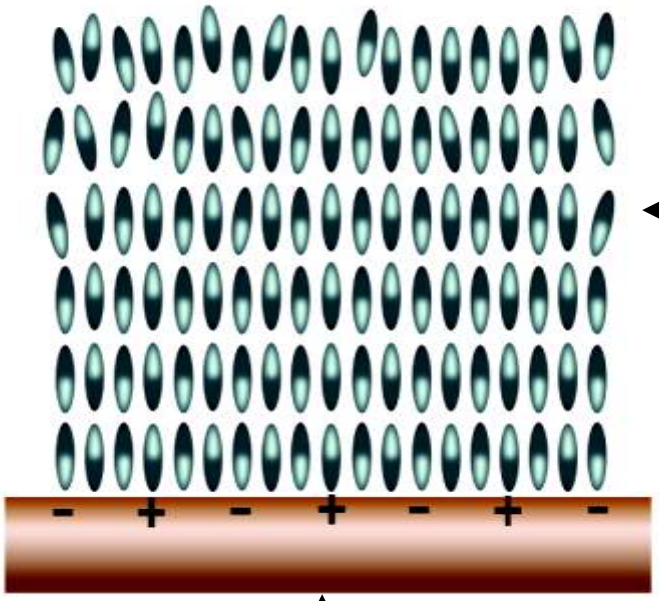
- Is the exclusion phenomenon general?
- Does it really arise from water ordering?
- Can water ordering explain anomalies?
- What energy creates this order?
- Might these findings apply to health?

Question #1: Generality

- Surfaces: gels, polymers, biological surfaces, monolayers
- Solutes excluded: down to mw 100 and lower


Small solutes excluded…
pH-sensitive dye(s)
H+
H+
H+
dye excluded
Nafion
1 mm

Generality

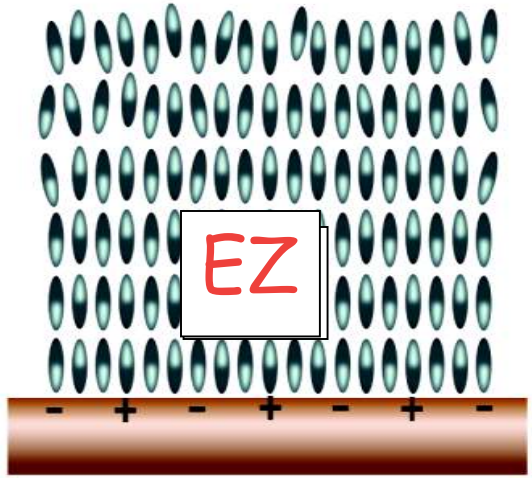


← many solutes excluded

many hydrophilic surfaces
generate exclusion zones

Question #2

Is this zone physically different from bulk water?



Evidence that exclusion-zone (EZ) water is physically different from bulk water

- EZ water molecules more constrained (NMR)
- EZ molecules more stable (infrared radiation)
- EZ has negative charge (electrical potential)
- EZ absorbs at 270 nm (light-absorption spectrum)
- EZ is more viscous (falling ball viscometry)
- EZ molecules aligned (polarizing microscopy)
- EZ molecular structure different (IR absorption)
- EZ optical properties different (refractive index)

Zheng et al., *Adv. Colloid and Interface Sci*, 127: 19-27, 2006
Chai et al., *J Phys Chem*, 112: 2242 – 2247, 2008
Zheng et al., *J. Coll. Interface Sci*, 332: 511–514, 2009
Yoo et al. *J. Phys. Chem. Letters* 2: 532- 536, 2011

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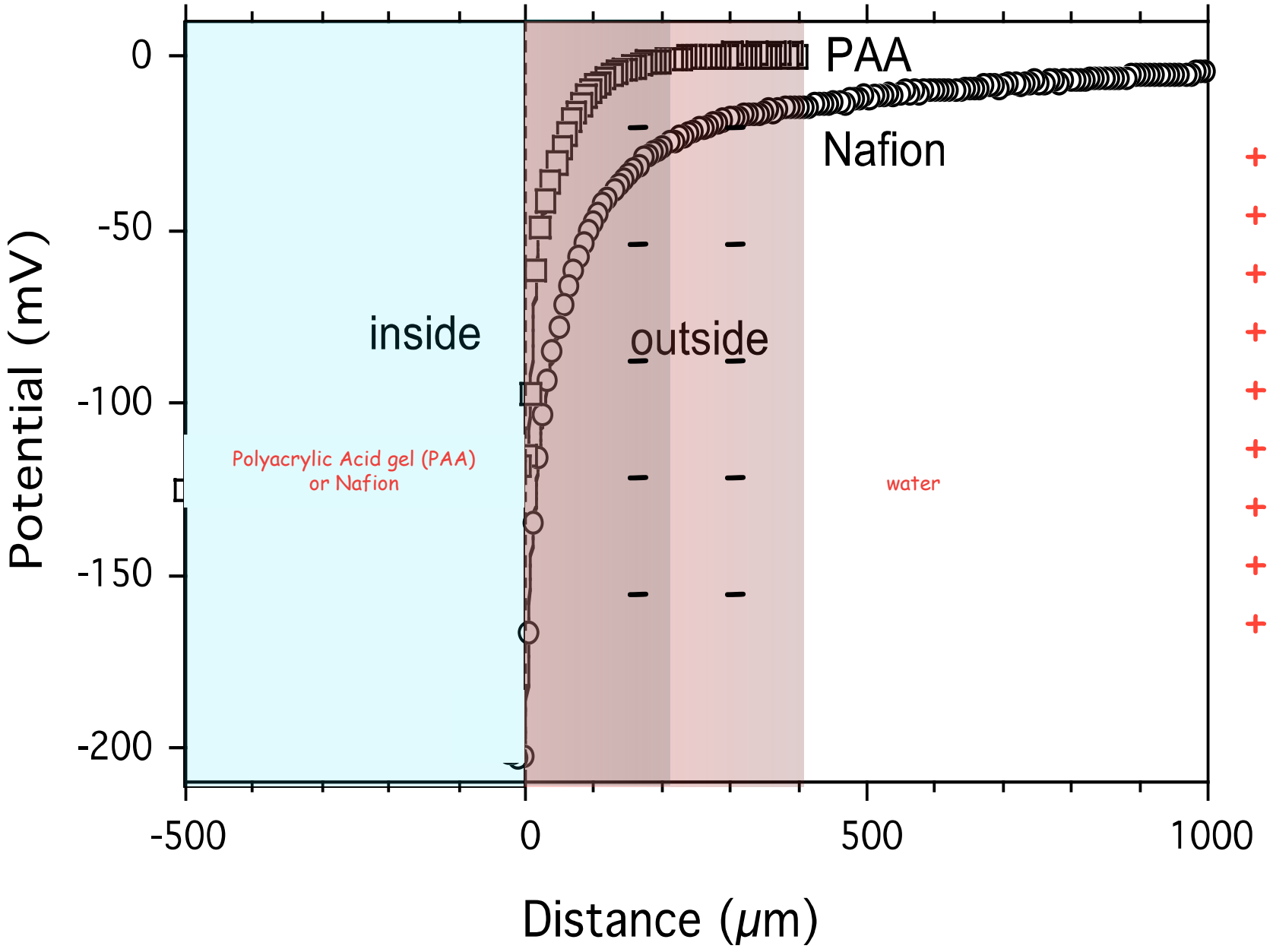
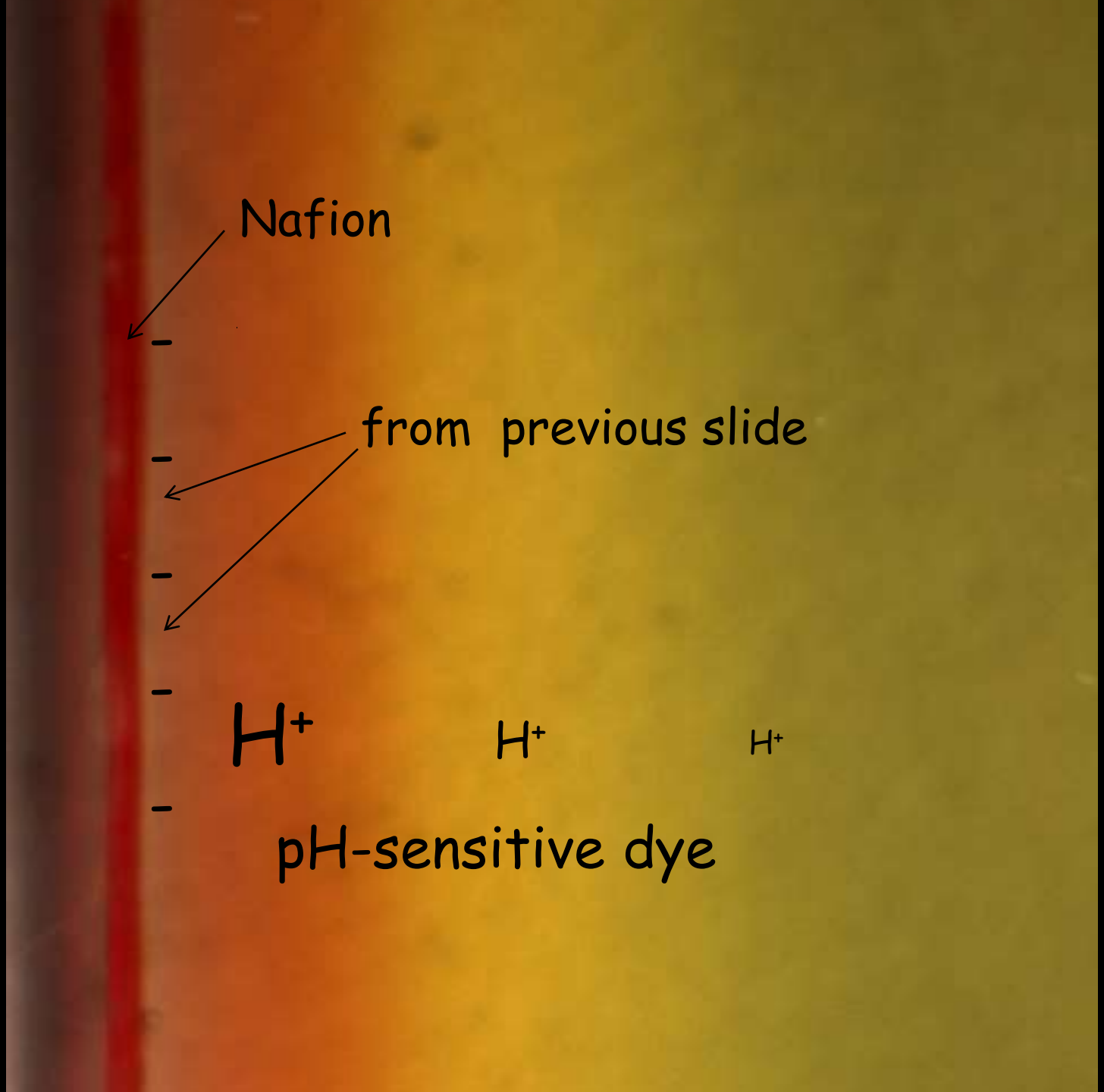
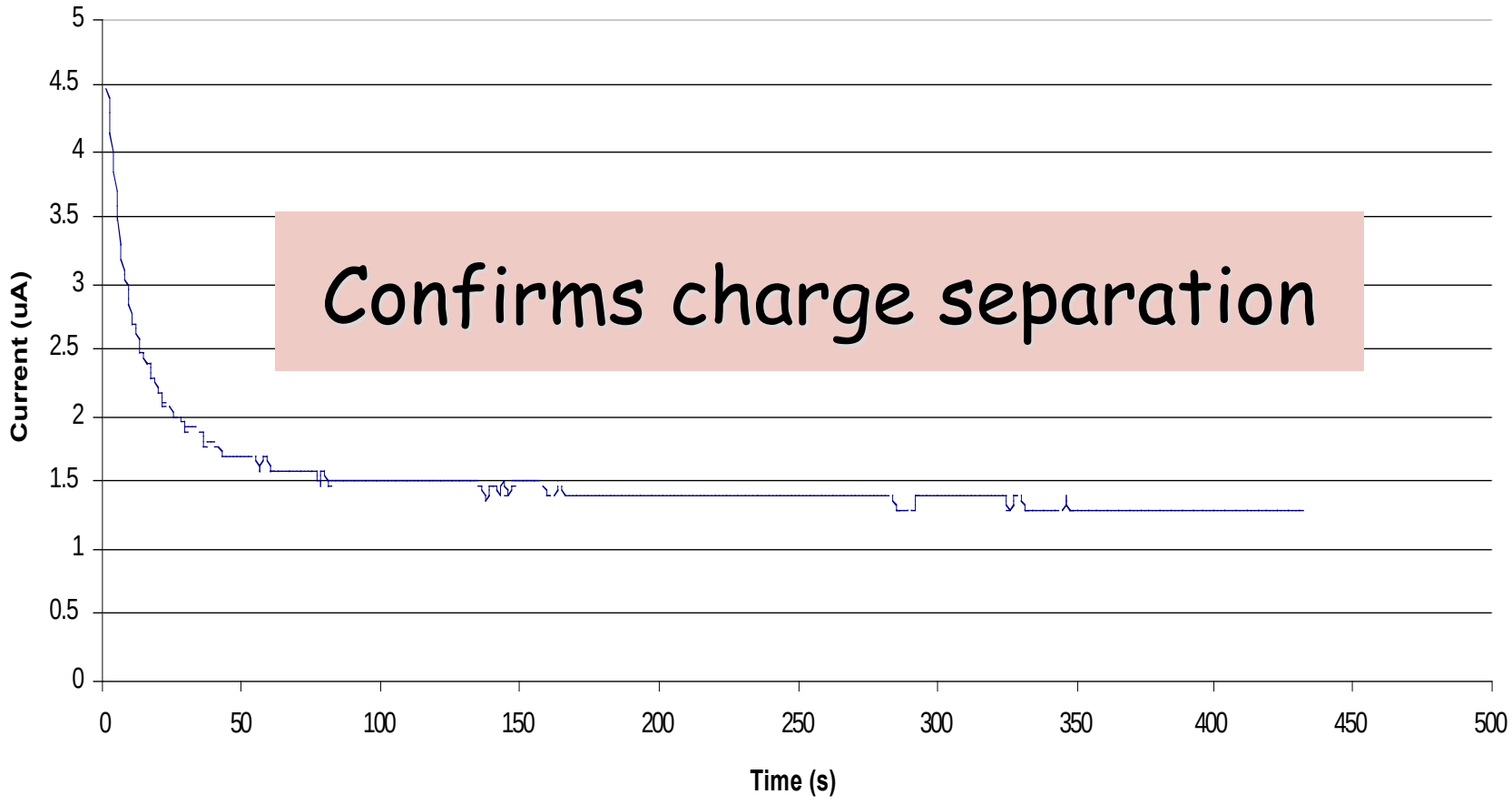

PAA
Nafion
inside
outside
Polyacrylic Acid gel (PAA)
or Nafion
water
Potential (mV)
0
-50
-100
-150
-200
-500
0
500
1000
Distance (μm)

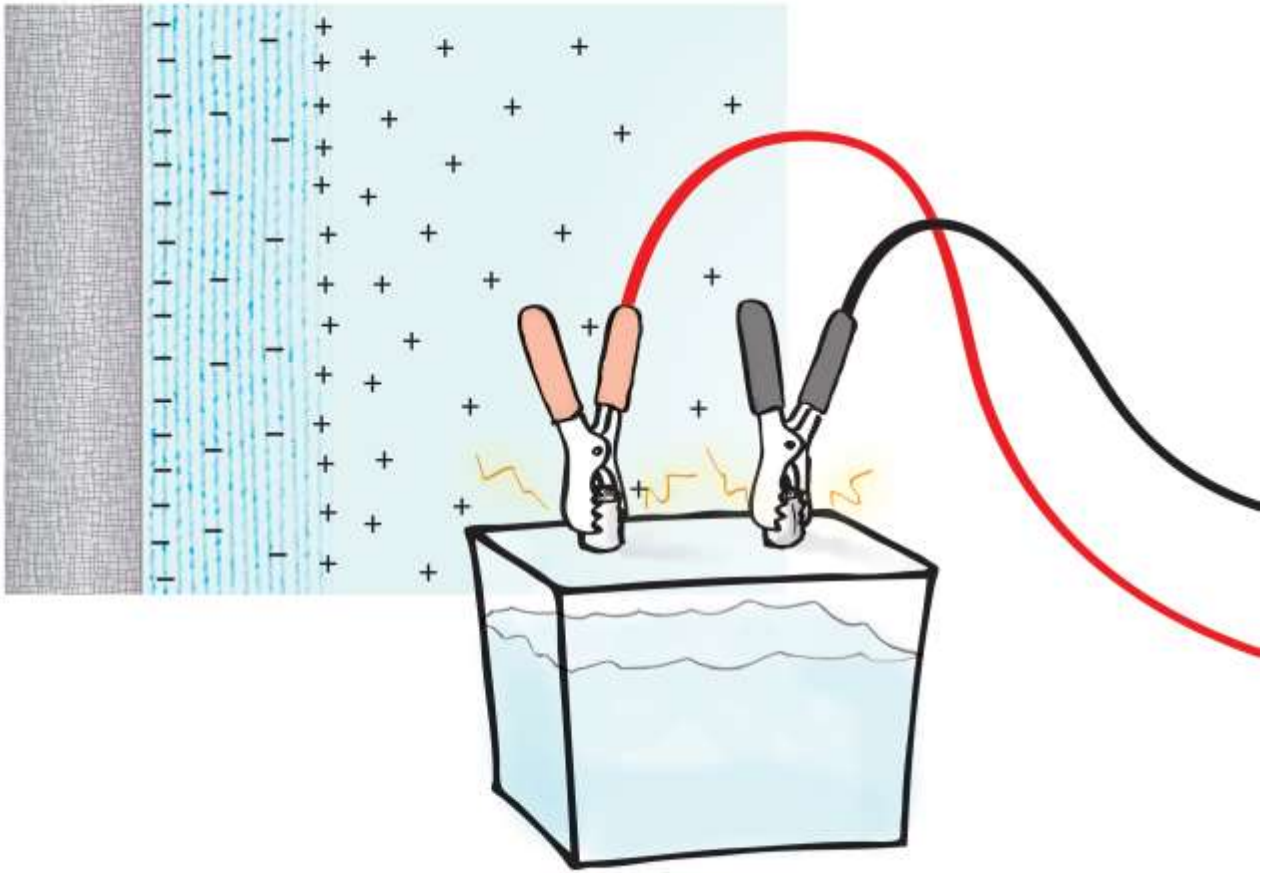

Nafion
from previous slide
H+
H+
H+
pH-sensitive dye

Current flow between exciusion zone and water beyond



Confirms charge separation

A charged battery in water



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Liquid Crystal?

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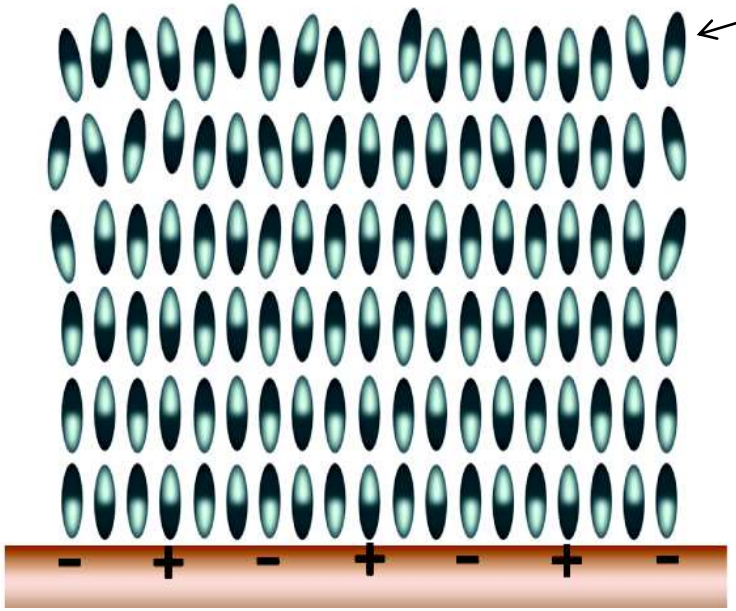
Summary, so far

Liquid crystalline

Negative charge

Excludes solutes

(Non-dipolar?)



Fourth phase of water?

(Sir Wm. Hardy, 1912)

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Liquid crystalline

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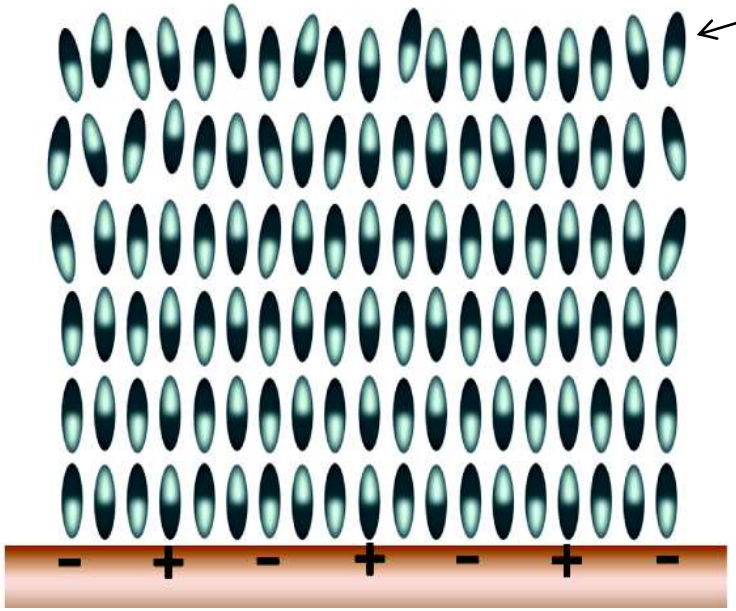


Fourth phase of water?

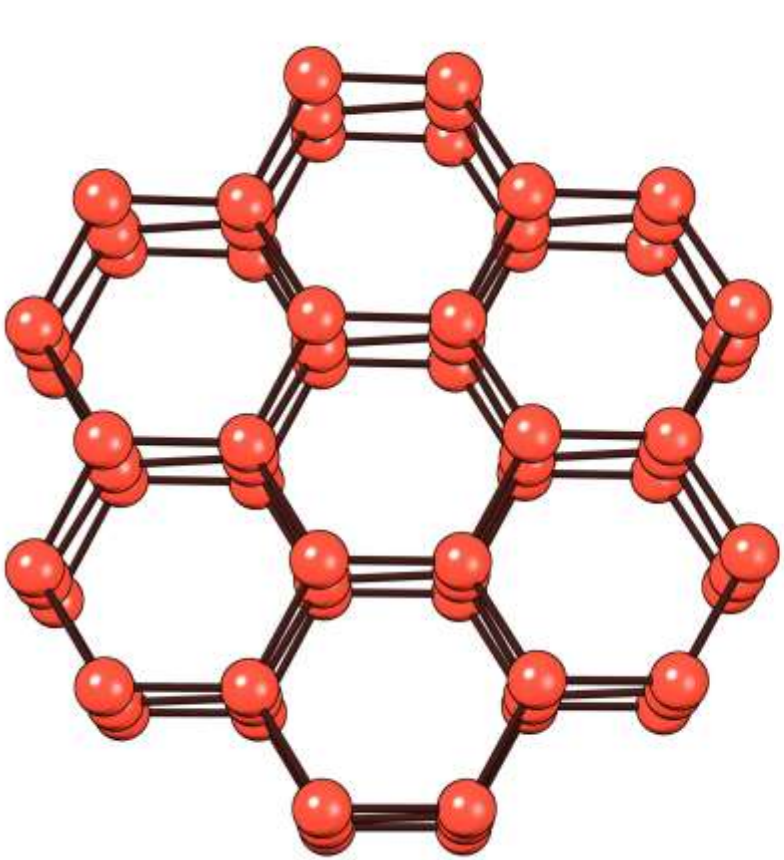
(Sir Wm. Hardy, 1912)

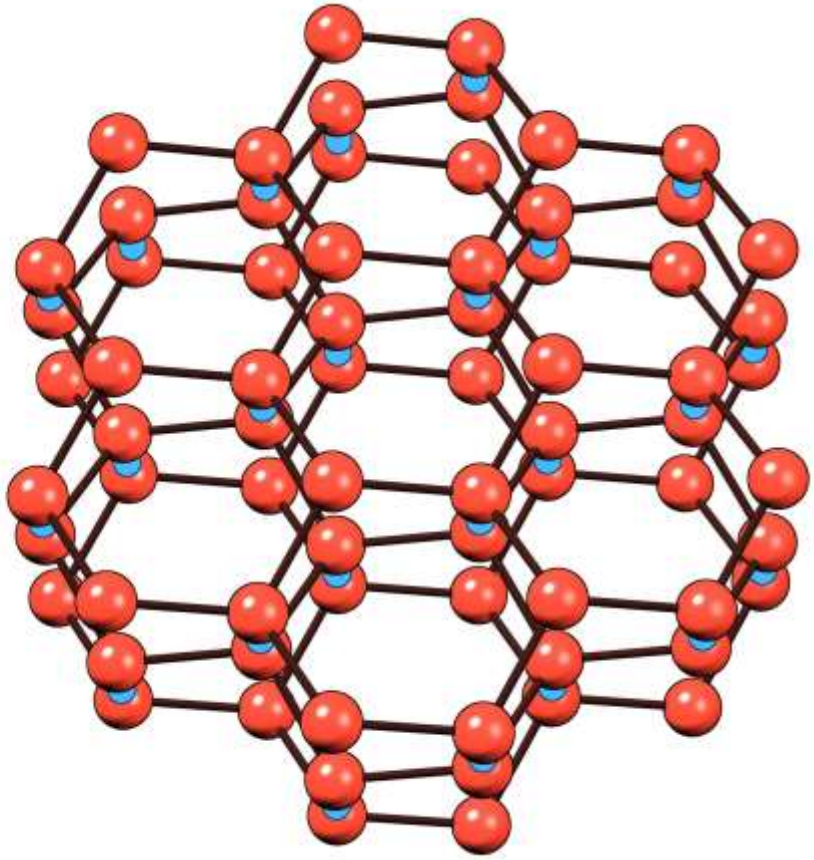
Non-dipolar EZ Structure?

- Negative charge (dipoles neutral)
- 270-nm absorption (ring-like structures)

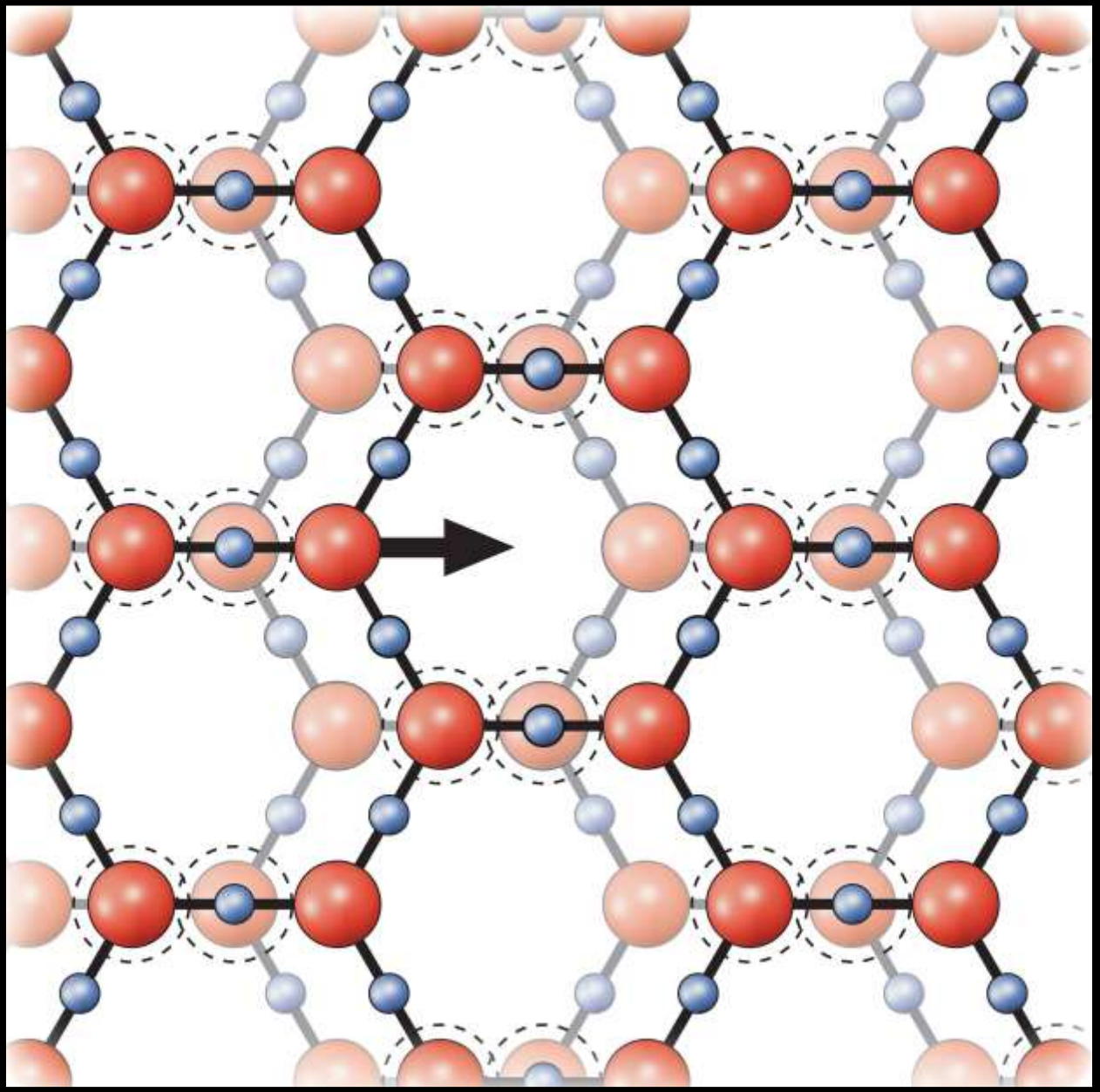
- Structure should have precedent

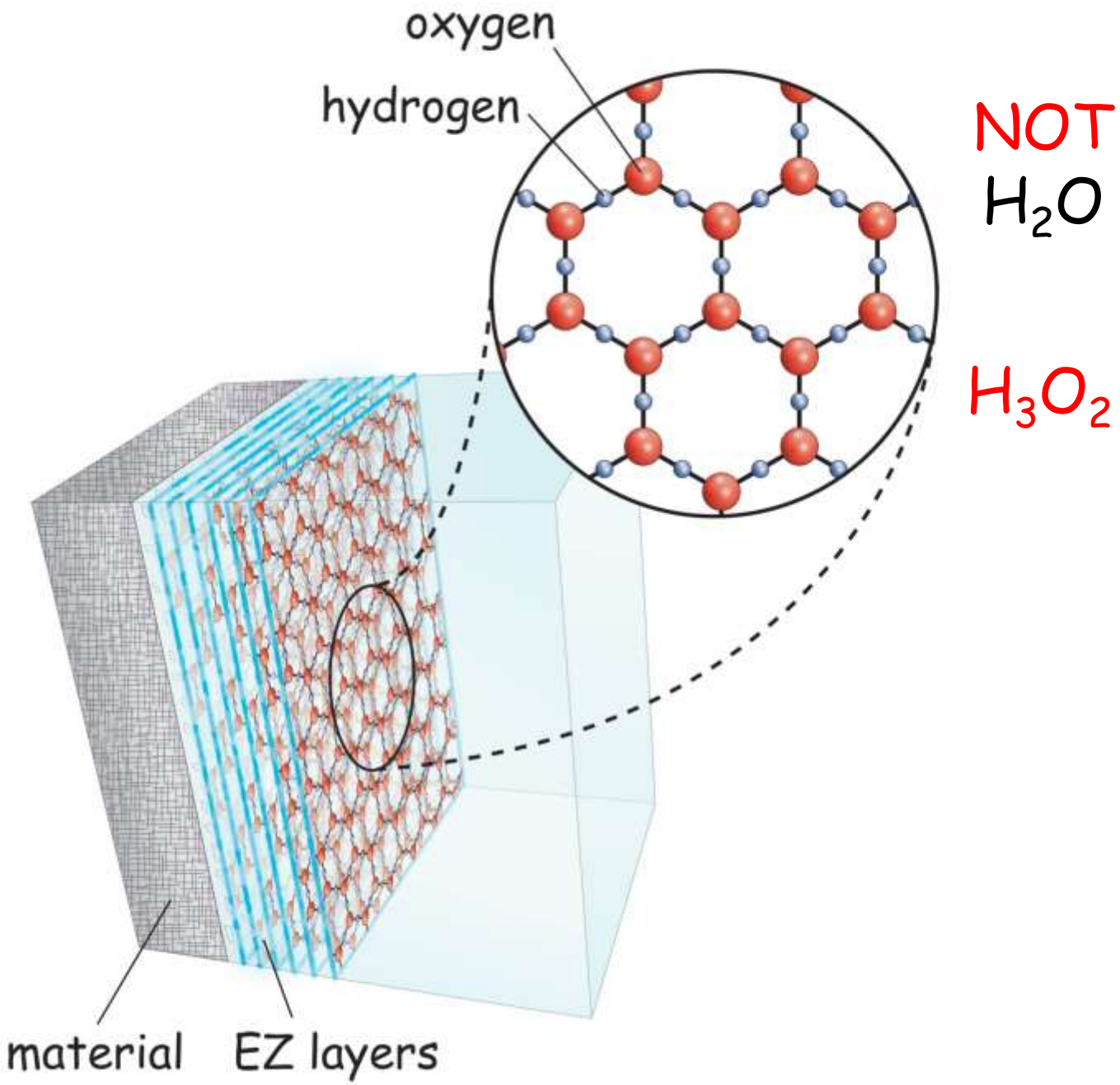
Precedent: ICE



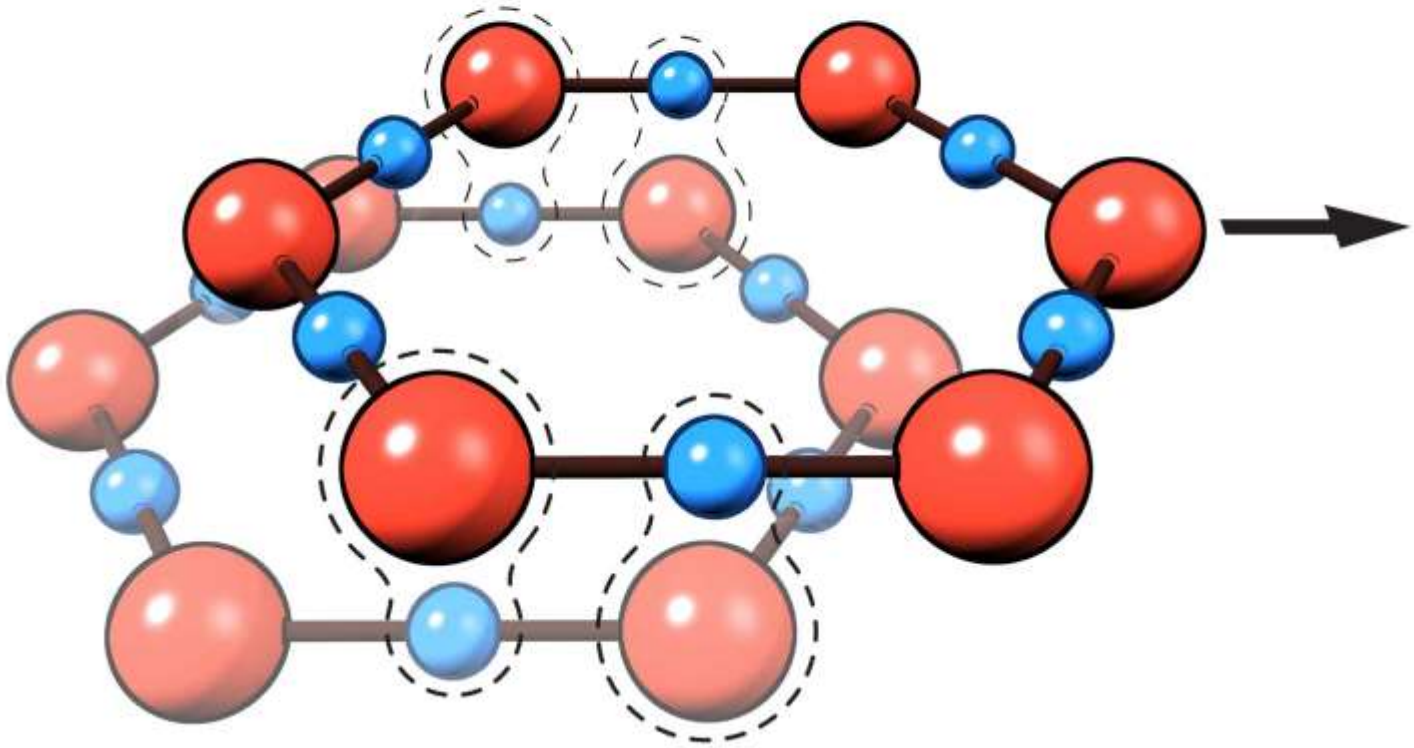


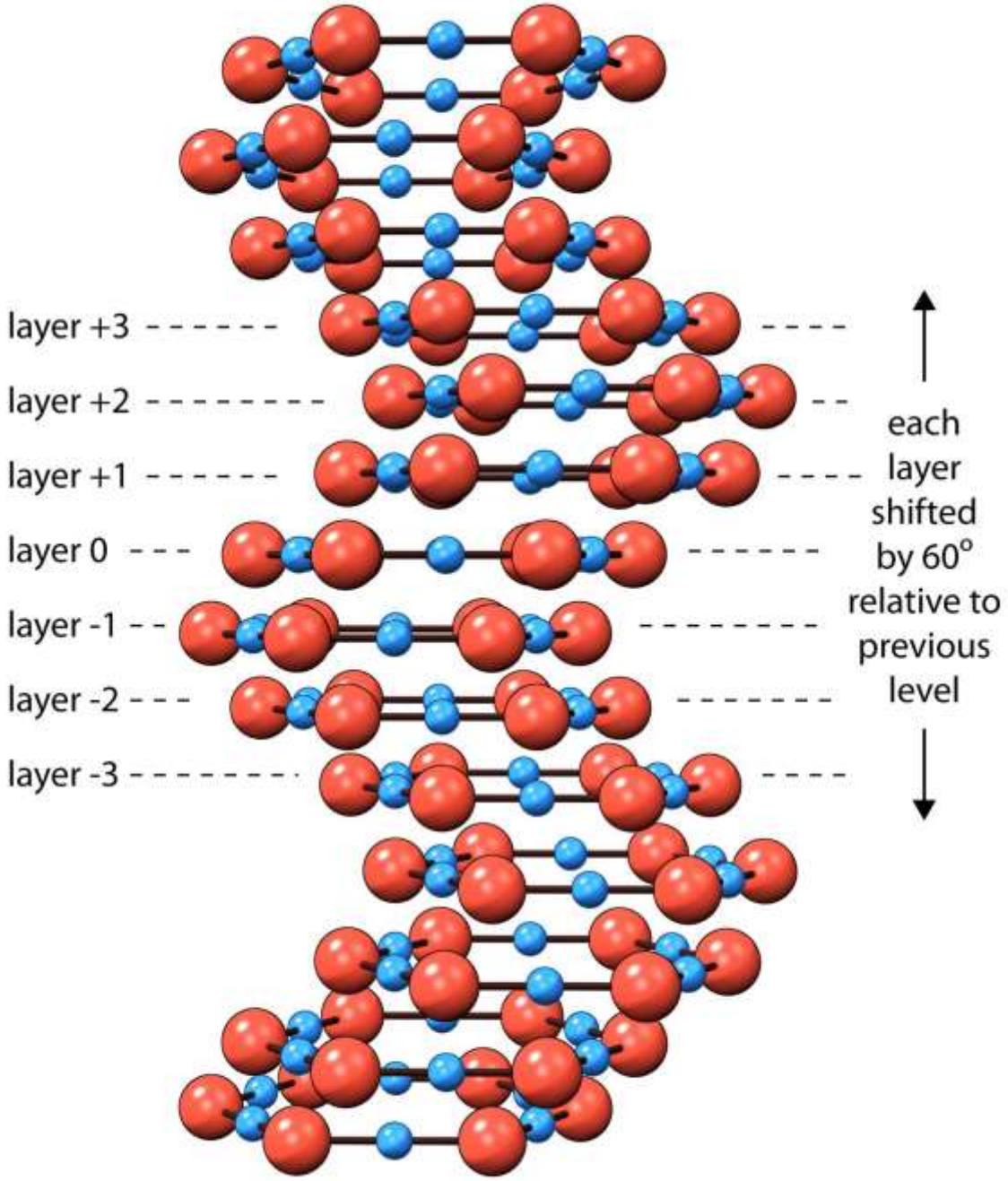
remove protons: negative charge; non solid




oxygen
hydrogen
NOT
H_2O
H_3O_2
material
EZ layers

right shift




layer +3
layer +2
layer +1
layer 0
layer -1
layer -2
layer -3
each layer shifted by 60° relative to previous level

"Advantages" of Non-dipolar EZ

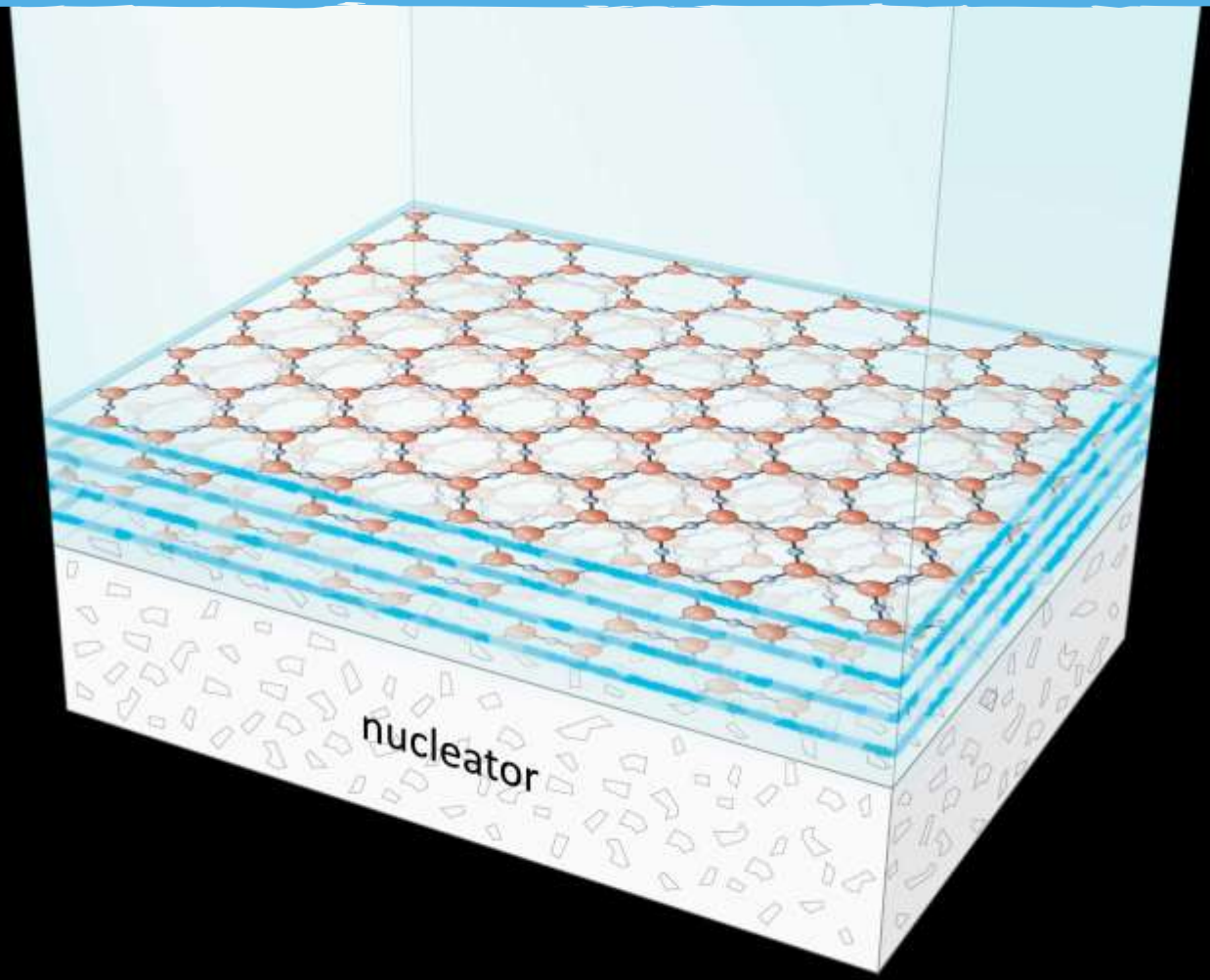
- Precedent ✔
- Negative charge ✔
- Ring-like structures (270-nm absorption) ✔
- Able to accommodate helical structures ✔
- Crystal-like structure – can be solidified ✔

Freeze-dry: Solid EZ water at room temperature

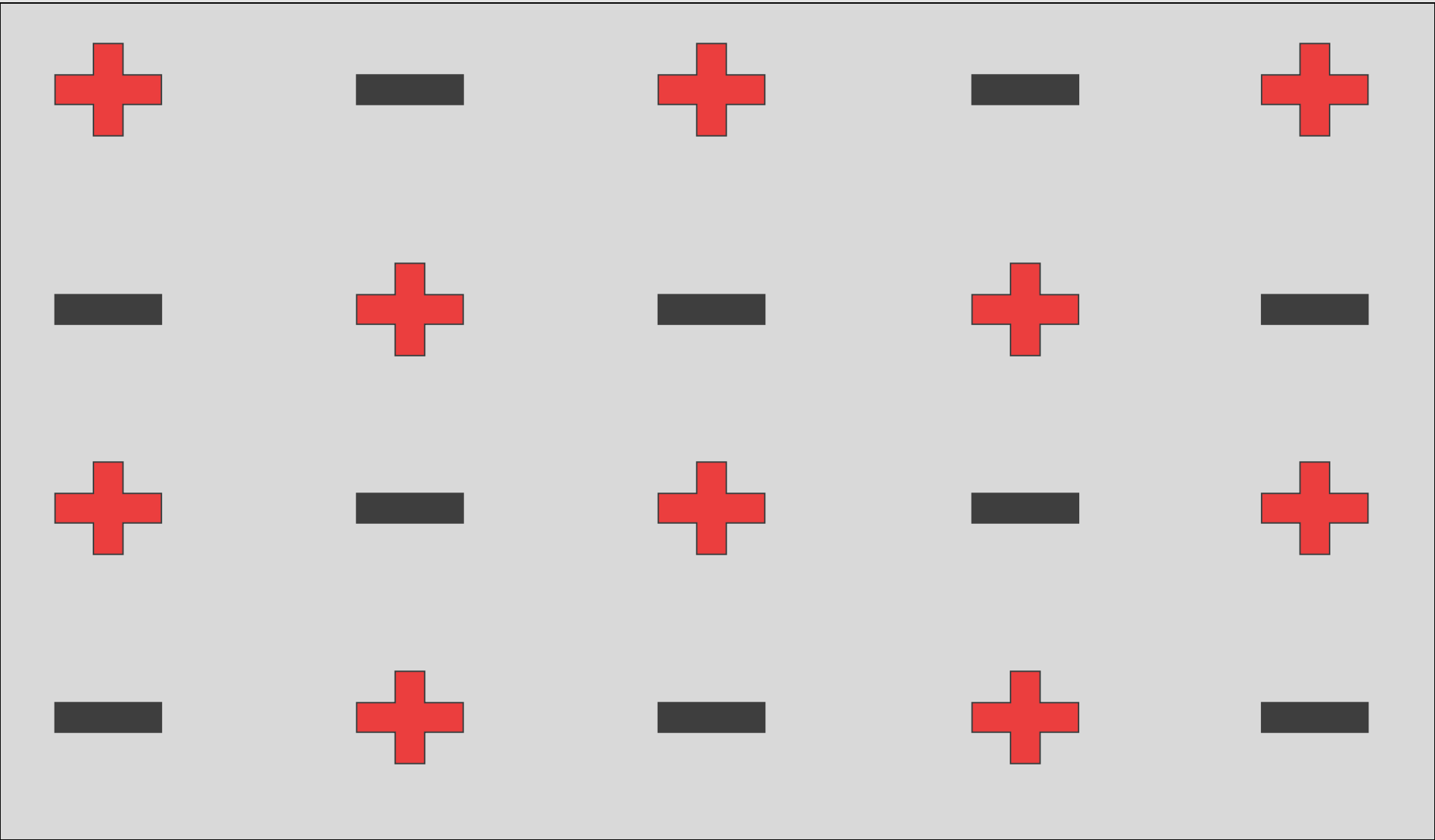
Elia et al. *WATER* 2013

Elia et al. (in press)

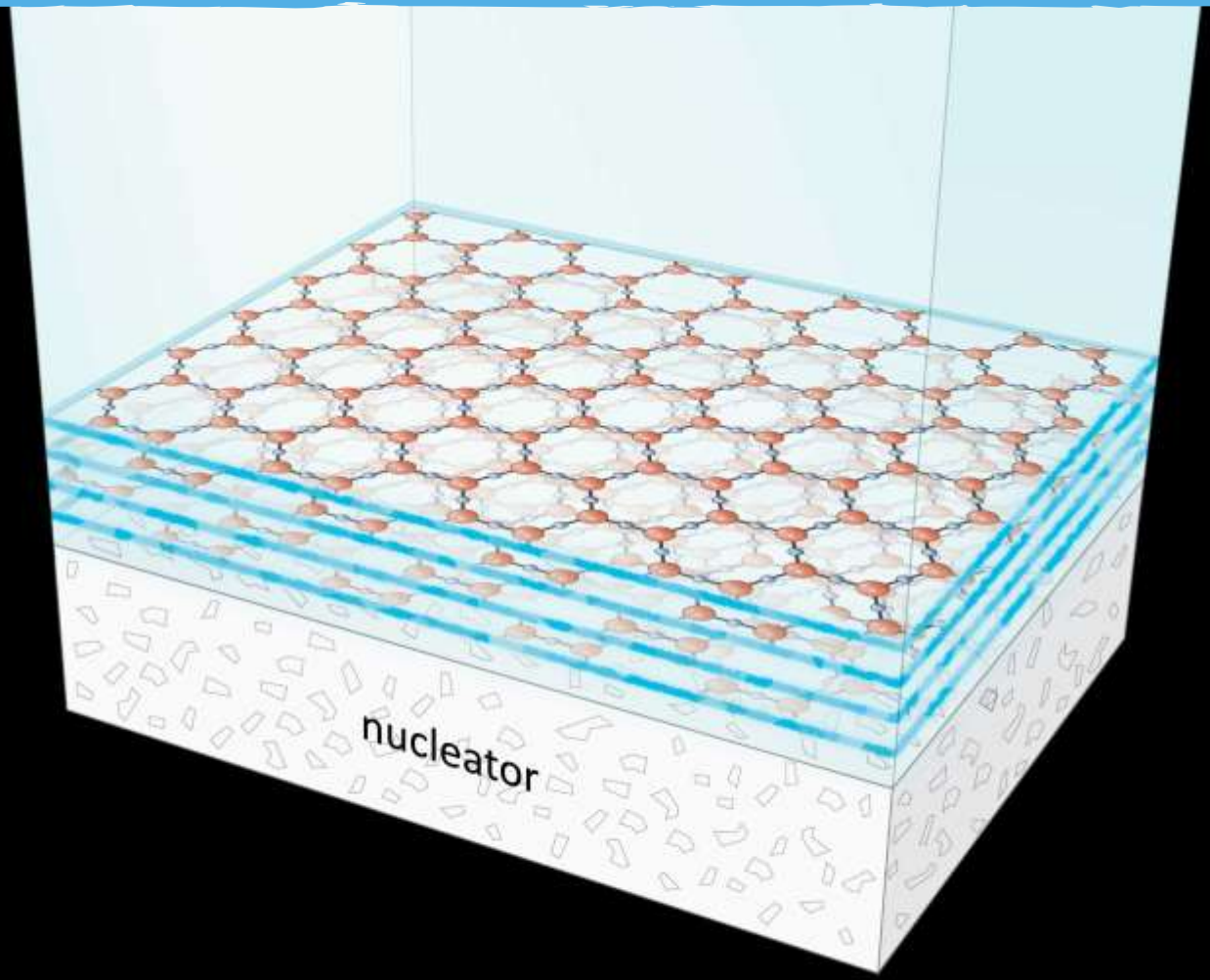
Hypothesis: Information stored in EZ Water



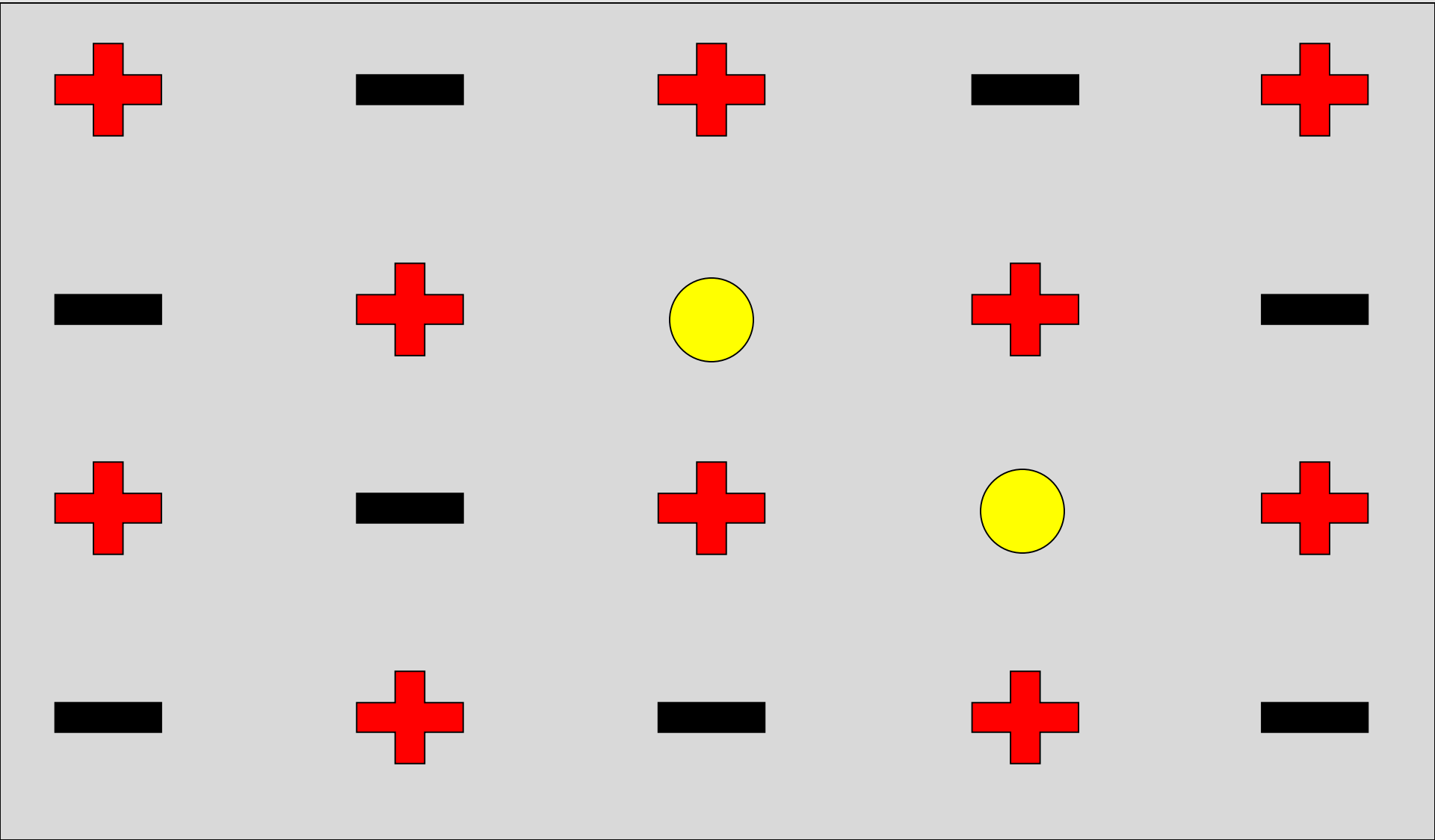
Generic nucleator surface has no info



No information



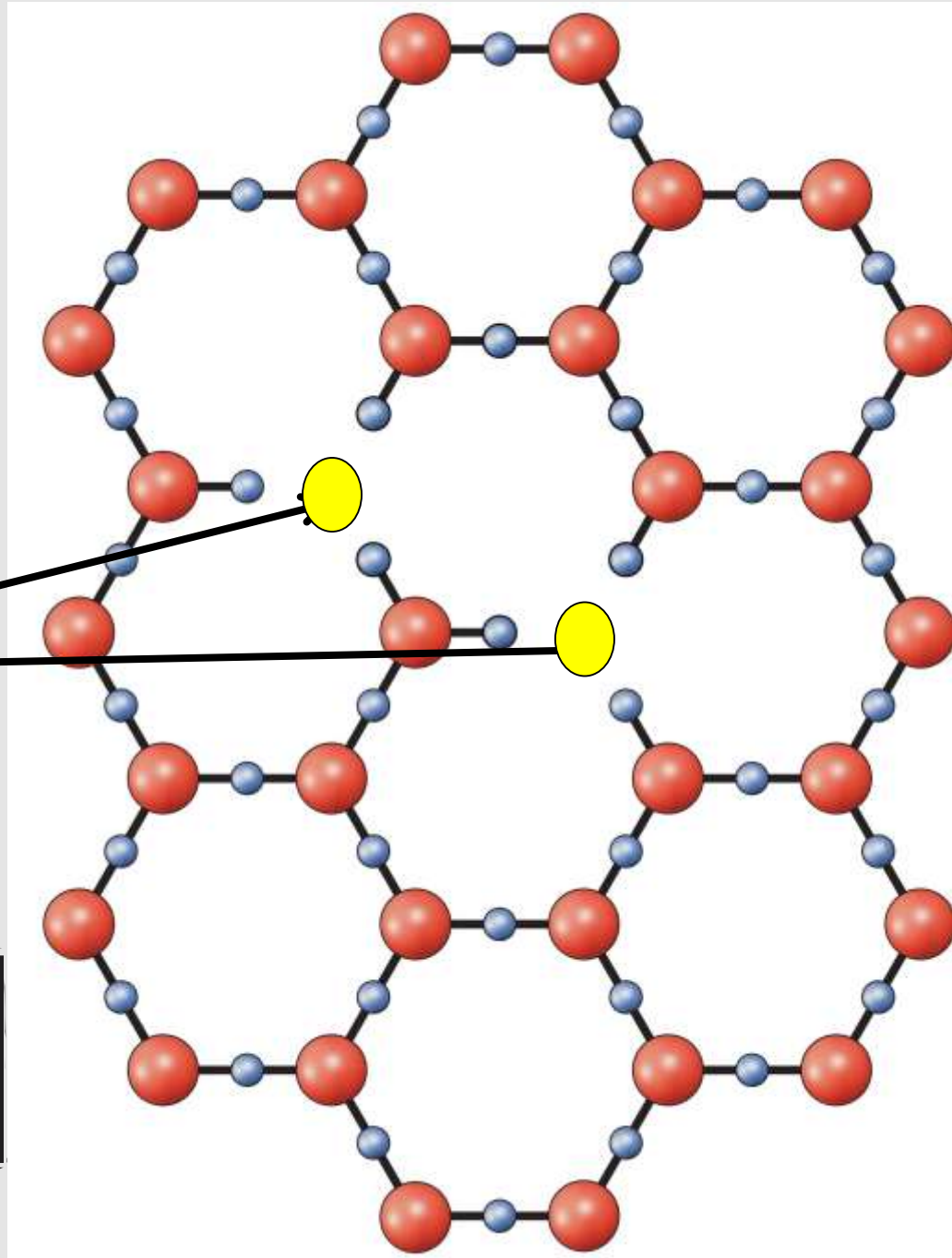
Real nucleator surface contains info



Information from nucleating surface

“Defects” project over many EZ layers

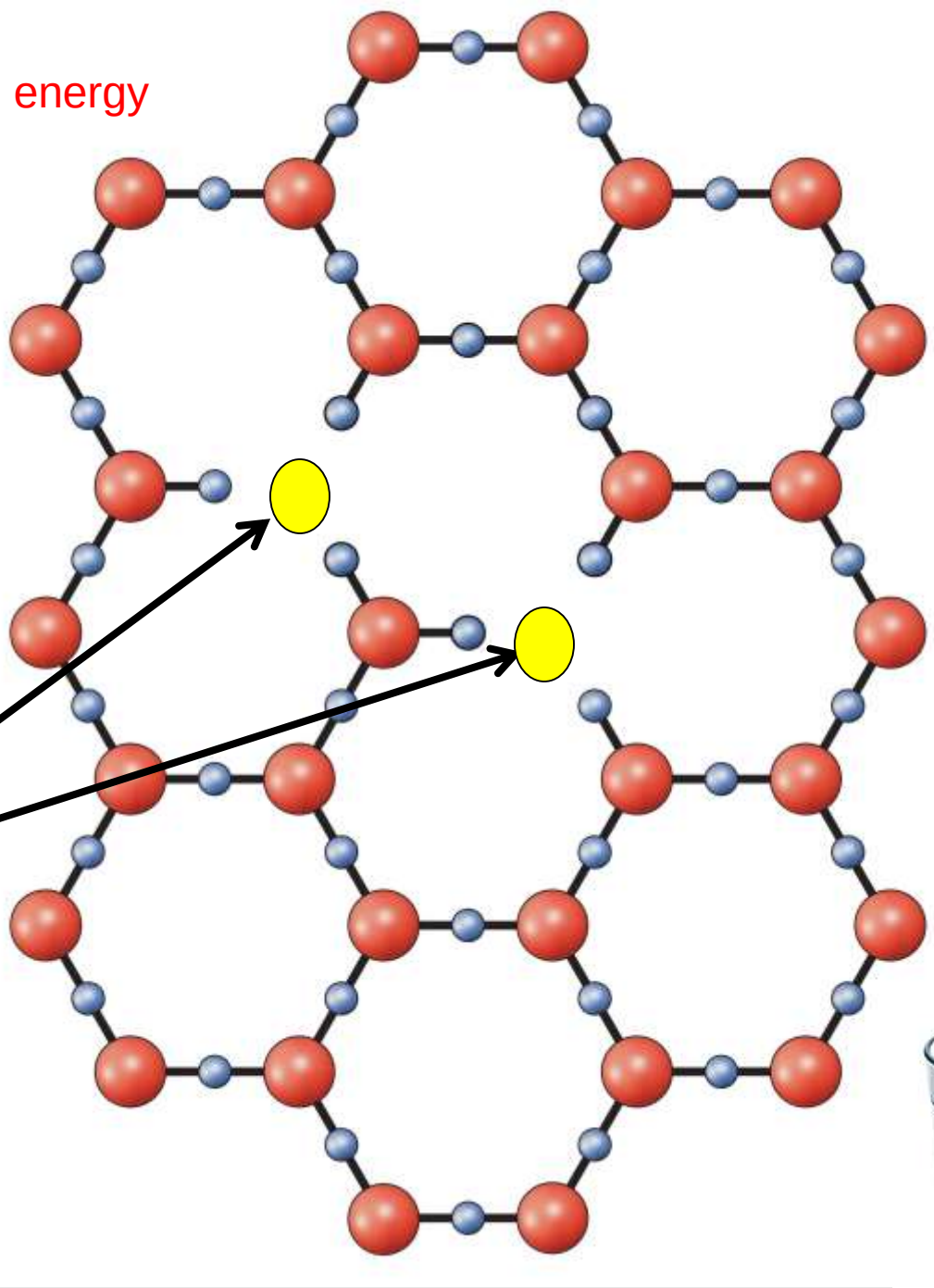
INFORMATION



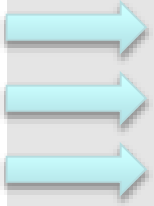
Another way of imparting information:

Electromagnetic energy

Resonant vibratory modes



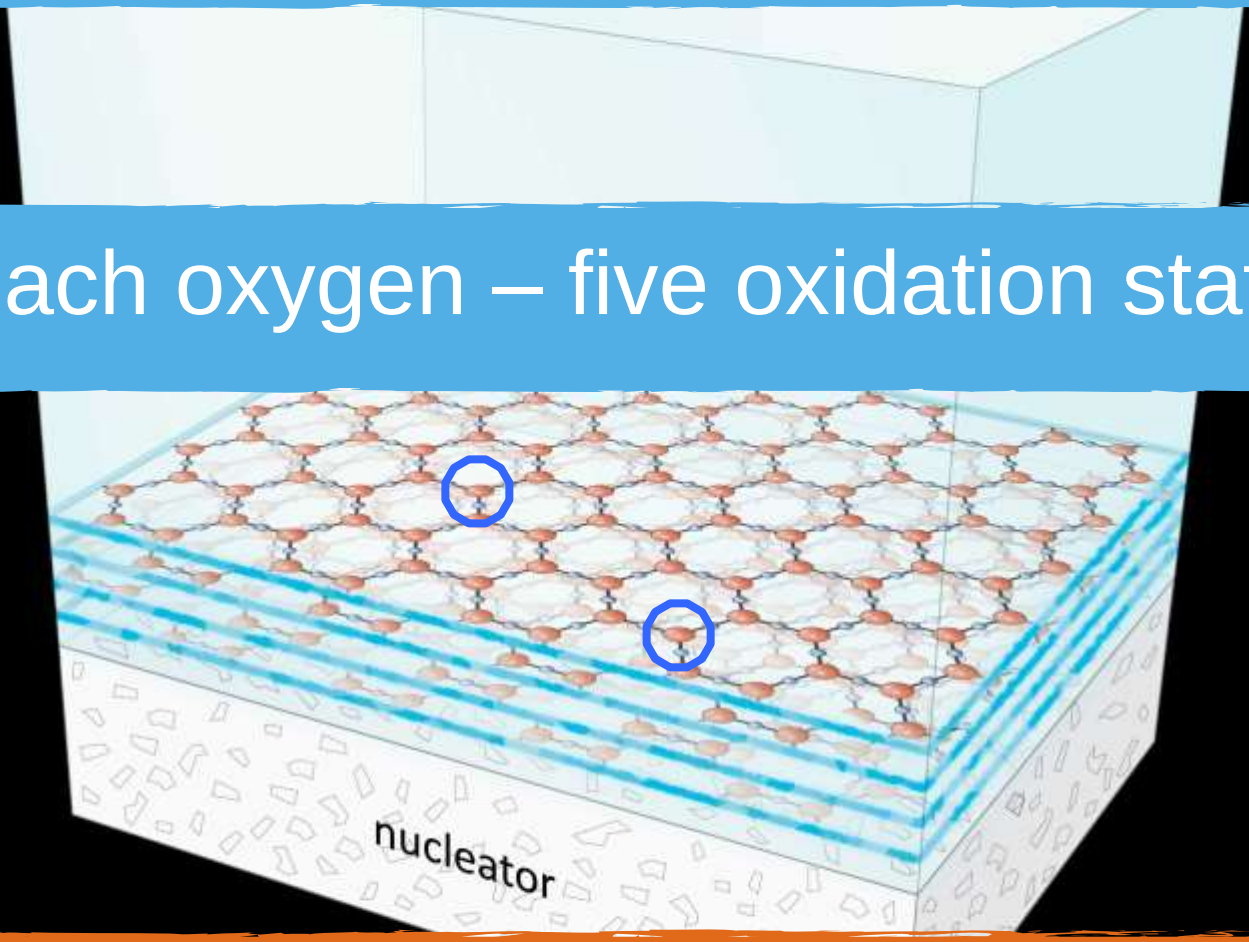
Information out



Input Electromagnetic Energy can CREATE Information

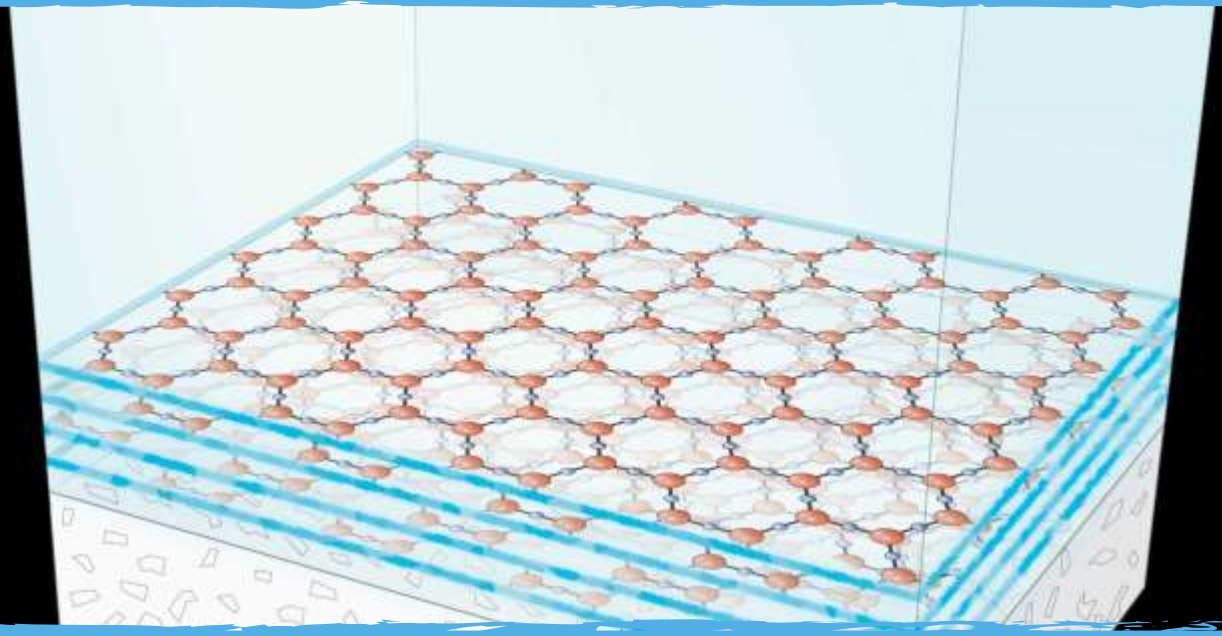
EM waves can impact particular oxygen atoms

Each oxygen – five oxidation states



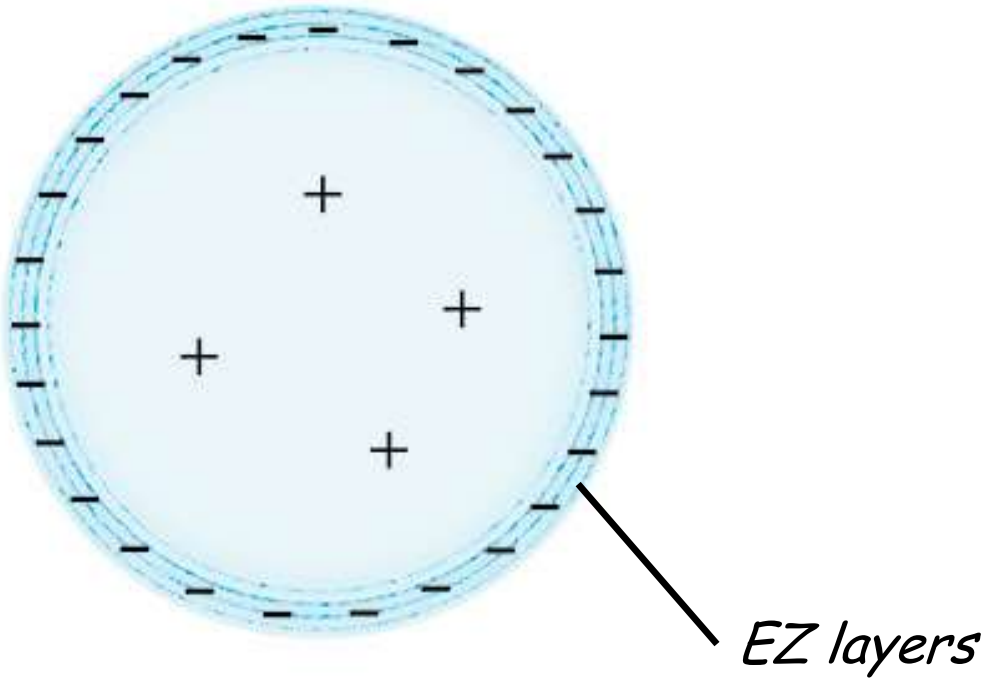
Huge information-storage capacity

Will information storage in EZ water replace conventional info storage?

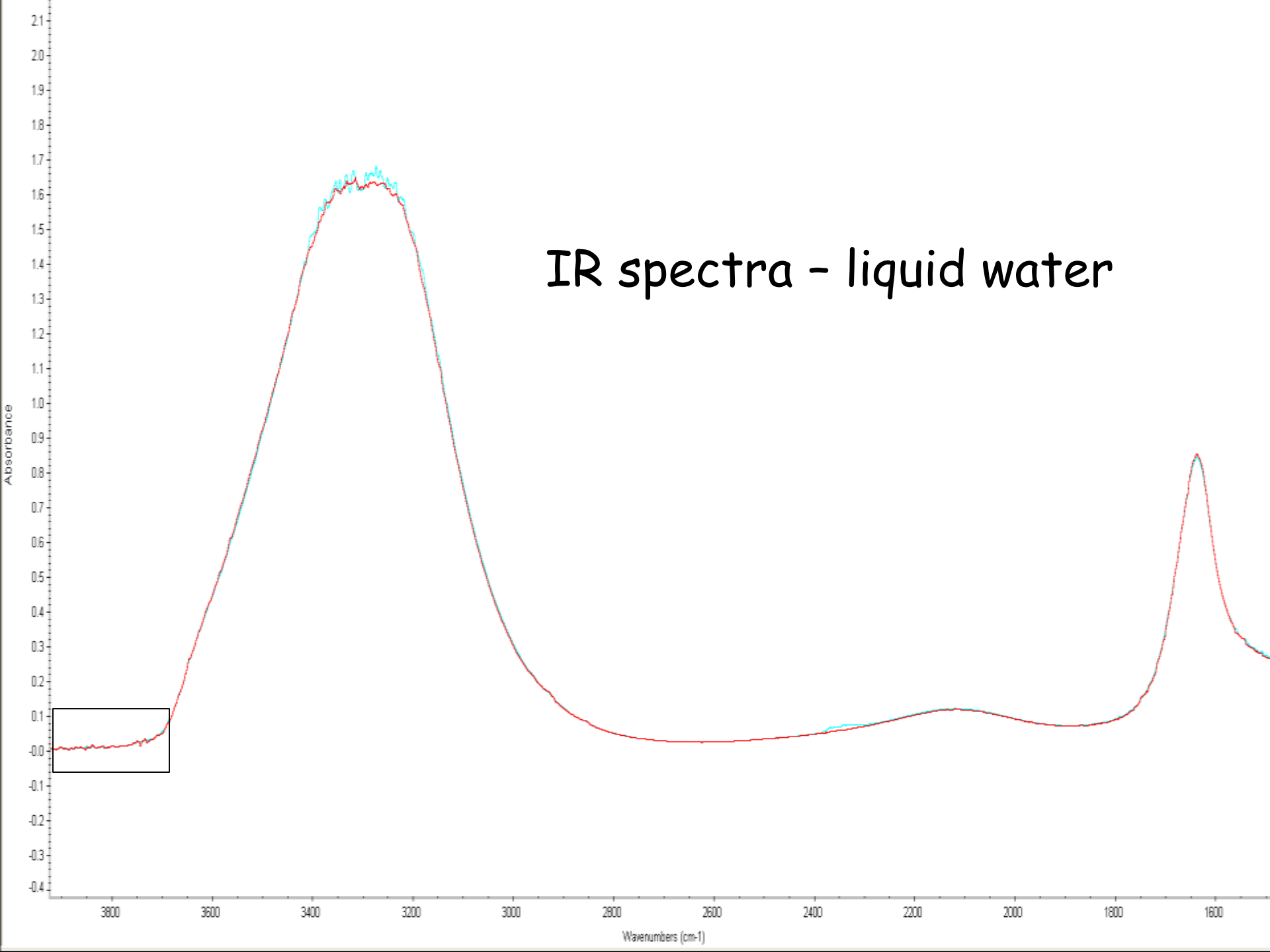


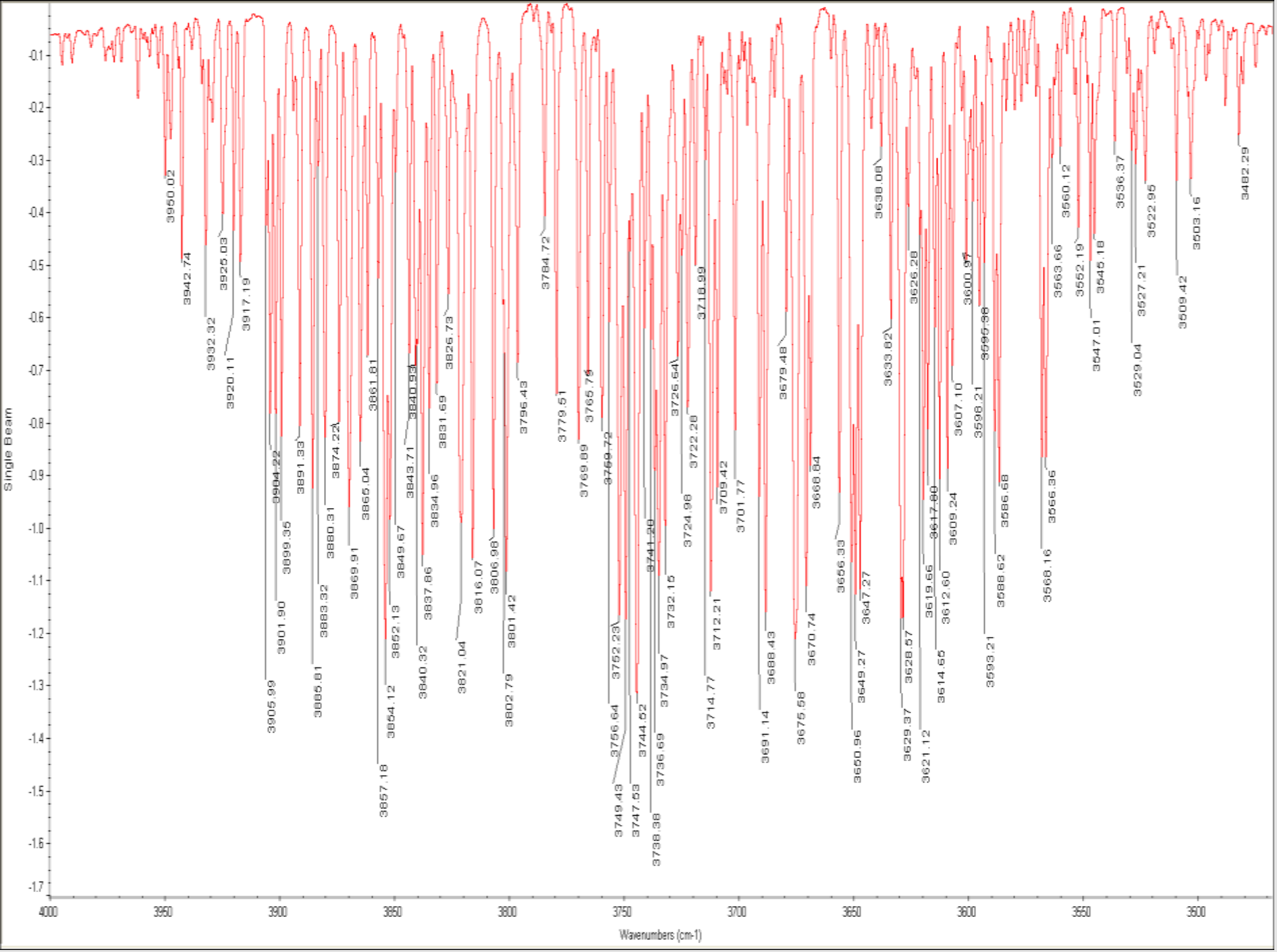
Will information storage in EZ water impact health?

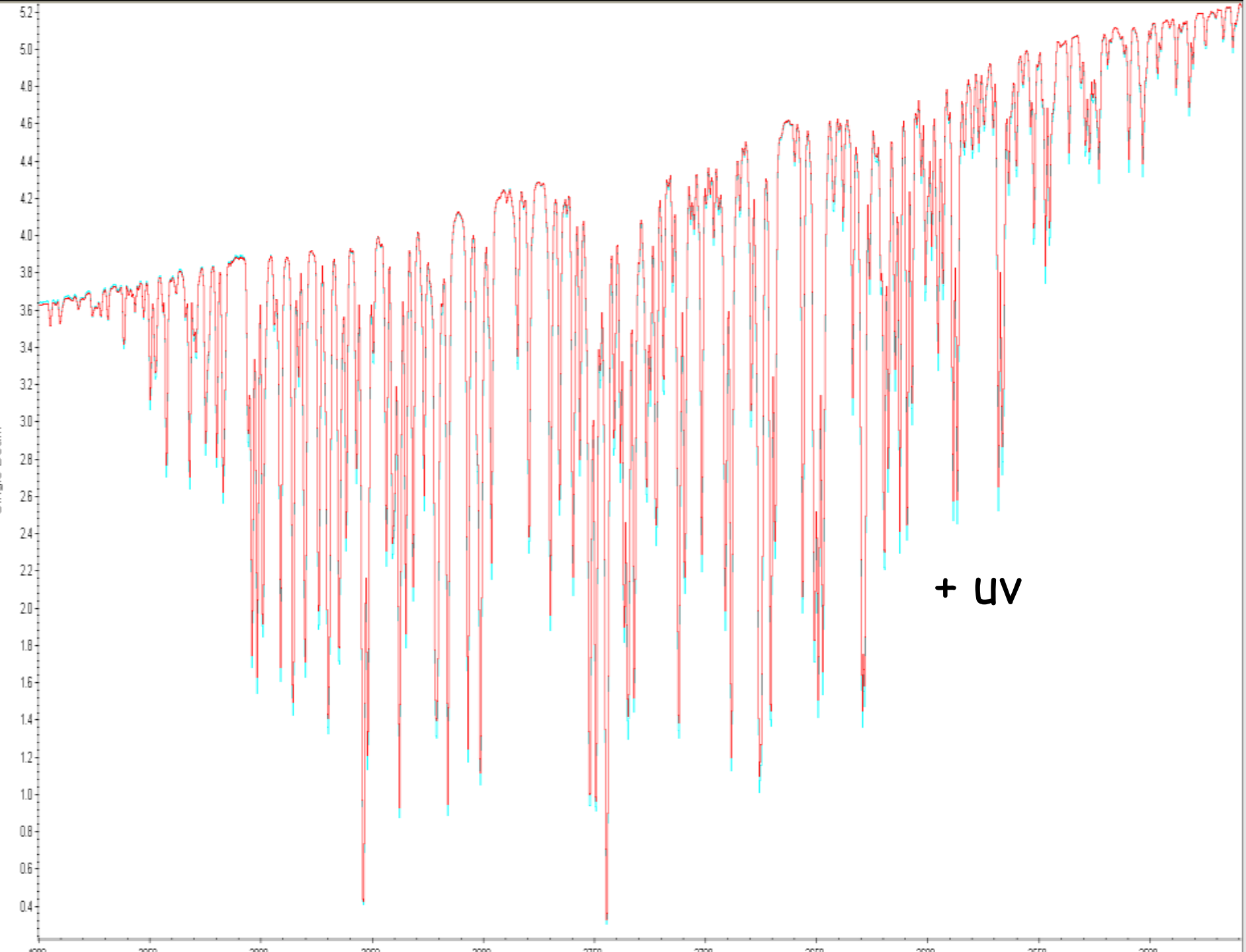
WATER VESICLE

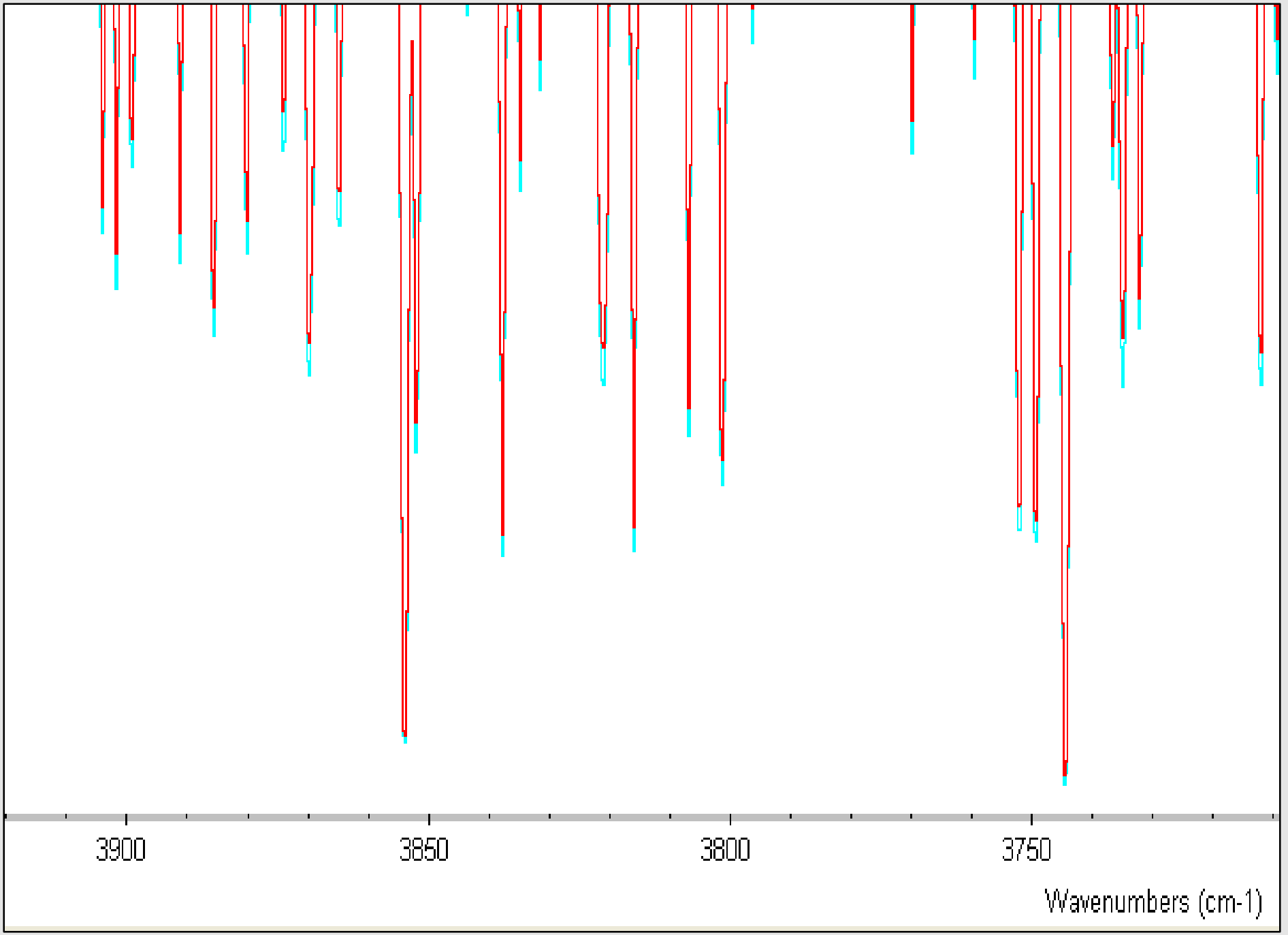


IR spectra – liquid water




Single Beam
Wavenumbers (cm-1)
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
3950.02
3942.74
3932.32
3925.03
3920.11
3917.19
3905.99
3901.90
3899.35
3894.22
3891.33
3885.81
3883.32
3880.31
3874.22
3869.91
3865.04
3861.81
3857.18
3854.12
3852.13
3849.67
3843.71
3840.99
3840.32
3837.86
3834.96
3831.69
3826.73
3821.04
3816.07
3806.98
3802.79
3801.42
3796.43
3784.72
3779.51
3769.89
3765.76
3759.72
3752.23
3749.43
3747.53
3744.52
3741.28
3738.38
3736.69
3734.97
3732.15
3726.64
3724.98
3722.28
3718.99
3714.77
3712.21
3709.42
3701.77
3691.14
3688.43
3679.48
3675.58
3670.74
3668.84
3656.33
3650.96
3649.27
3647.27
3638.08
3633.82
3629.37
3628.57
3625.28
3621.12
3619.66
3617.80
3614.65
3612.60
3609.24
3607.10
3600.97
3598.21
3595.36
3593.21
3588.62
3586.68
3568.16
3566.36
3563.66
3560.12
3552.19
3547.01
3545.18
3536.37
3529.04
3527.21
3522.95
3509.42
3503.16
3482.29


+ uv


3900
3850
3800
3750
Wavenumbers (cm-1)

Answer to Question #2
Is EZ physically distinct from bulk?

Yes

Layered honeycomb structure with many implications

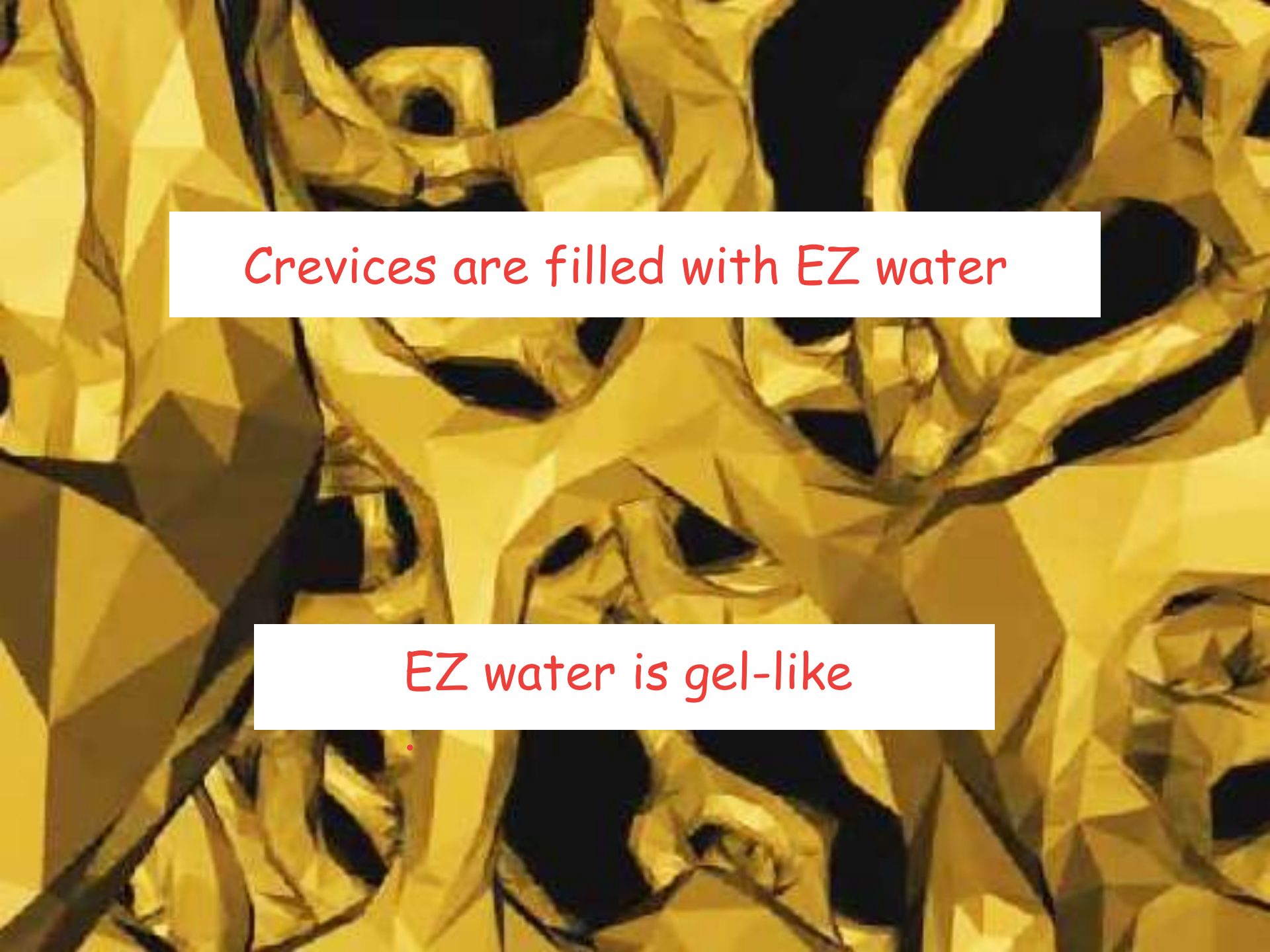
Question #3: Can crystalline water explain counter-intuitive anomalies?

What behavior do we expect from a crystal?

Crystalline elements stick together


gelatin dessert (95% water)…
Why doesn't the water dribble out?

M Nydén, N Lorén, M Rudemo and M Kvarnström, Chalmers, Sweden


Crevices are filled with EZ water
EZ water is gel-like

Crystals can be pretty stiff

Water forming a bridge?

Elmar Fuchs, Wetsus


Water structure stiff enough
to keep bridge from collapsing

Answer to Question #3

Yes

Liquid crystalline water explains (many) anomalies

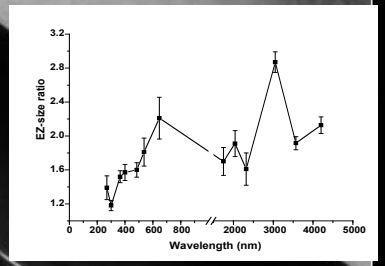
Question #4

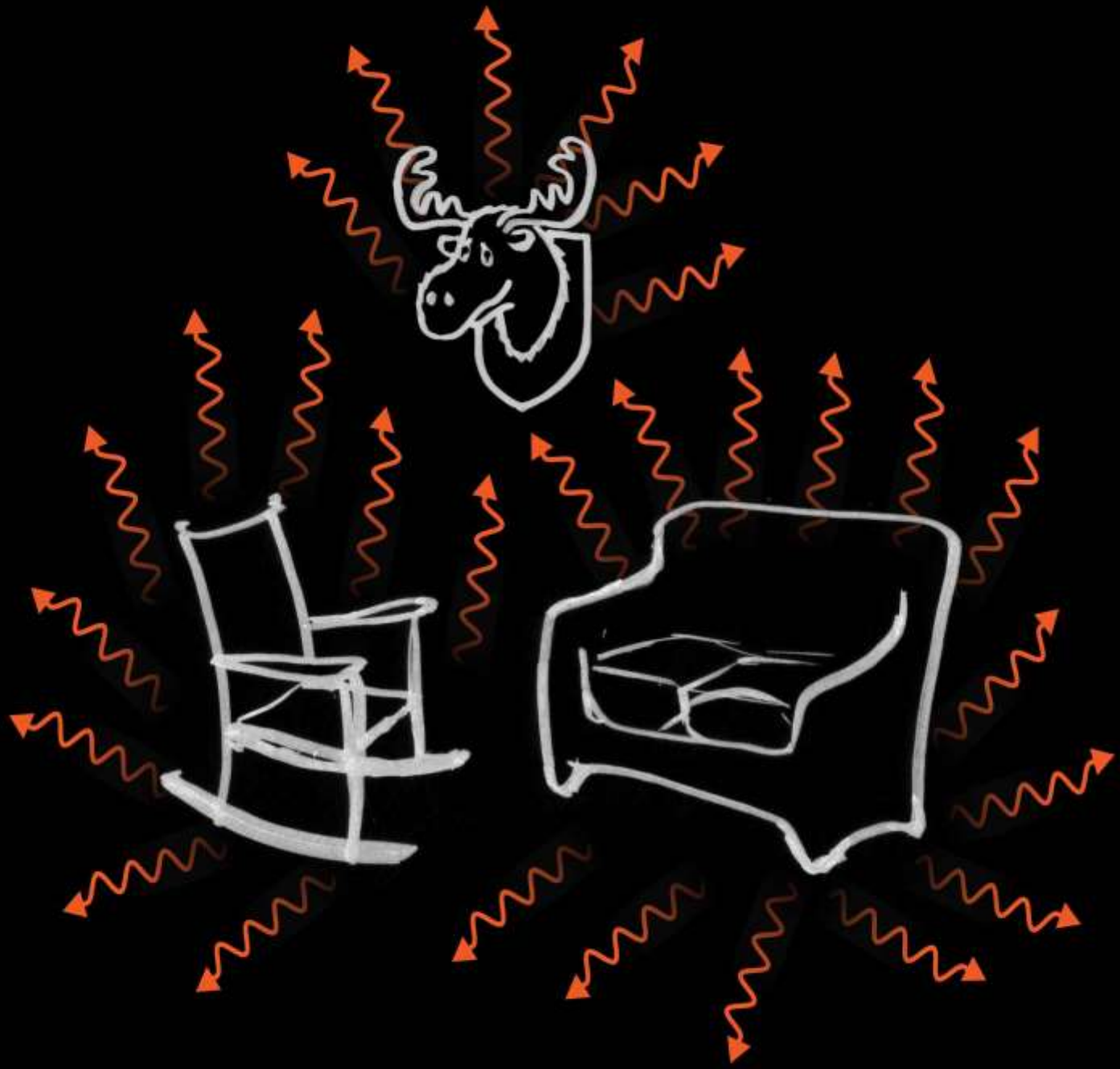
What charges the water battery?

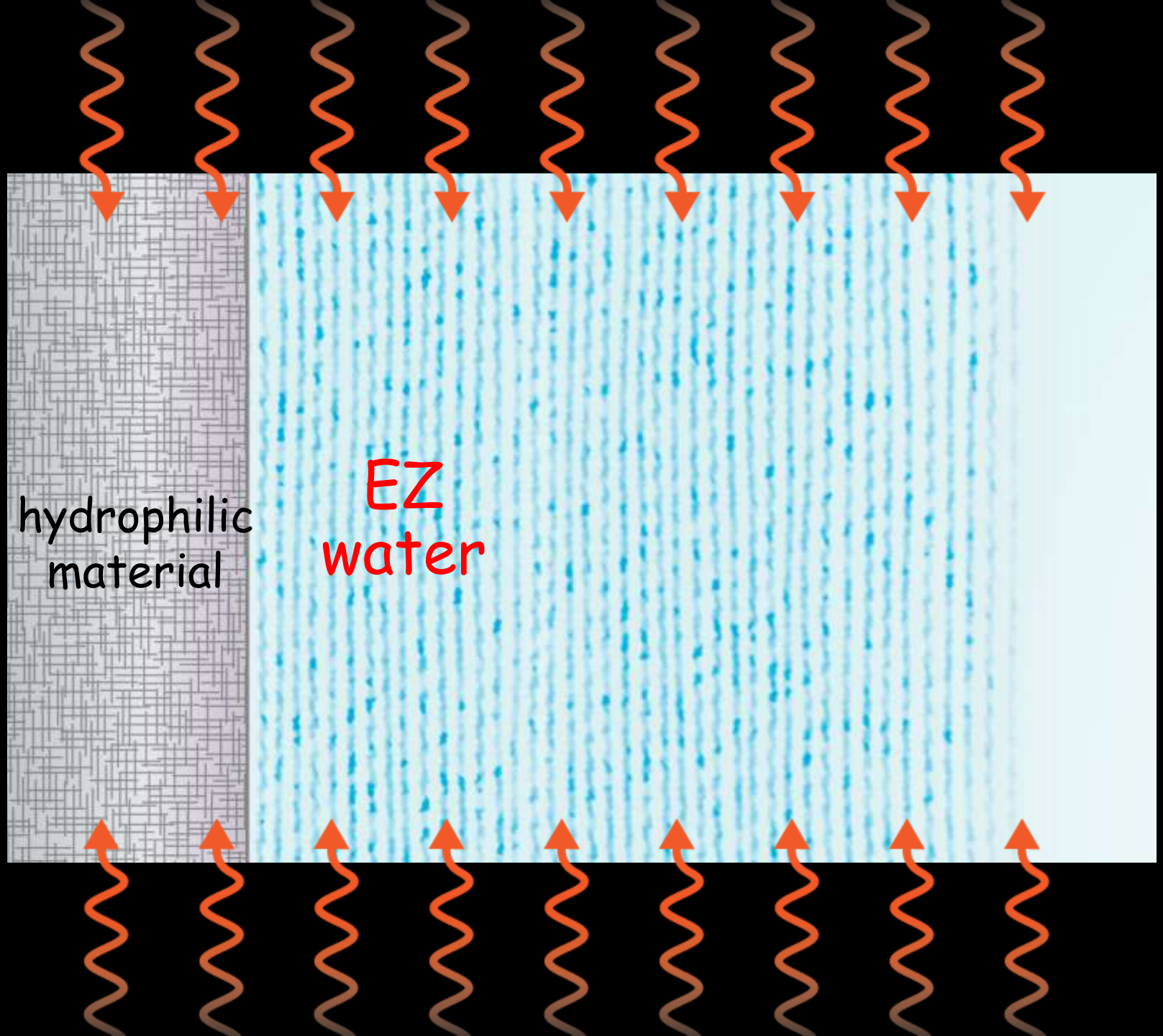
(Incident radiant energy)

Exclusion Zone
expands

Most powerful:
infrared





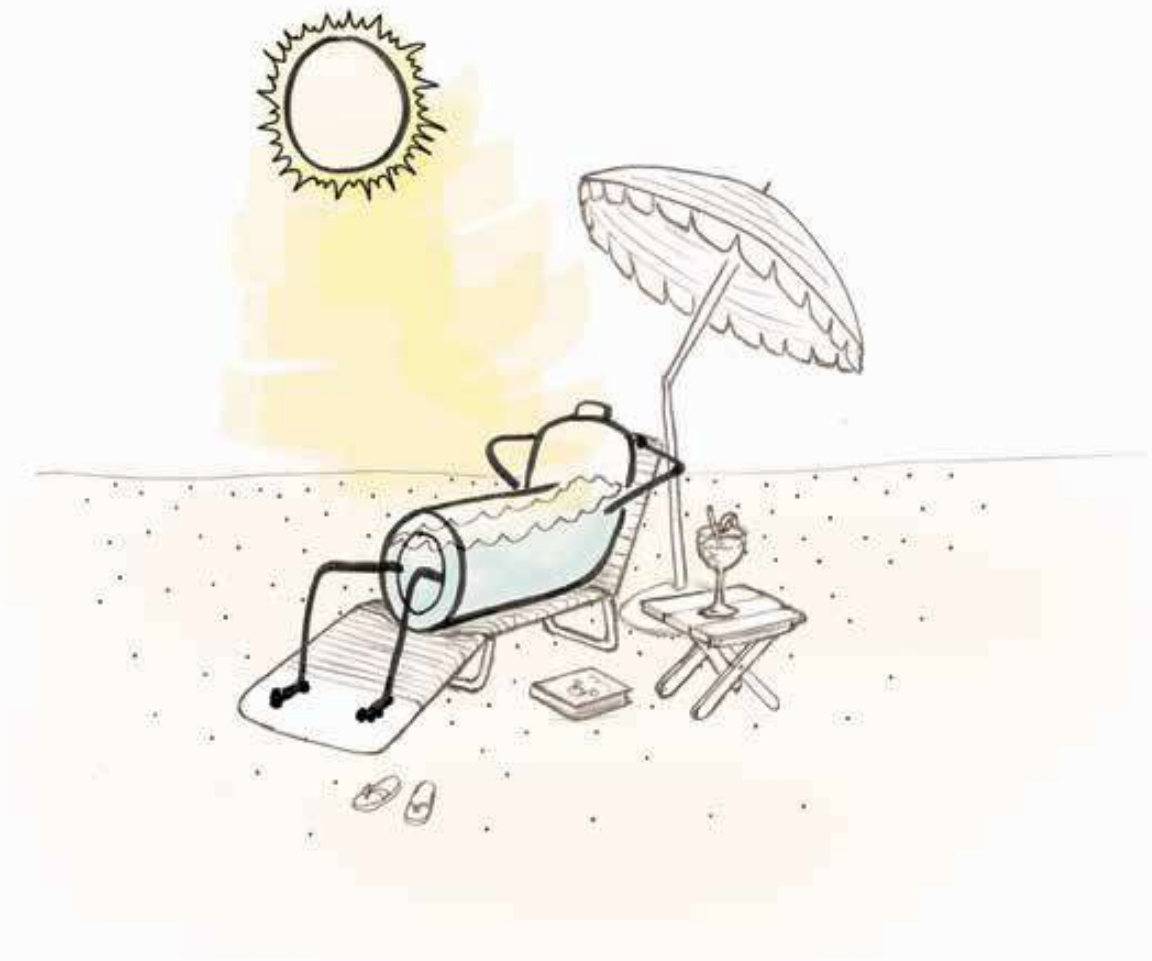

hydrophilic
material
EZ
water

Answer to Question #4
Energy?

EZ buildup powered by photonic energy…

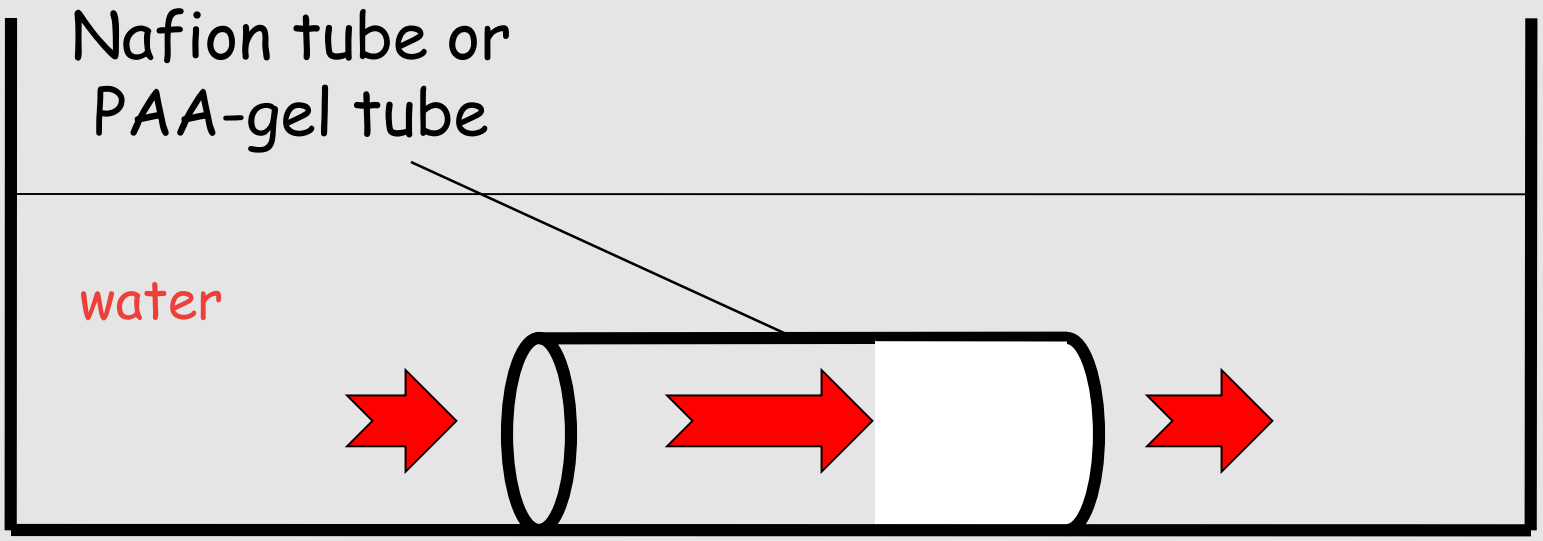
Orders water

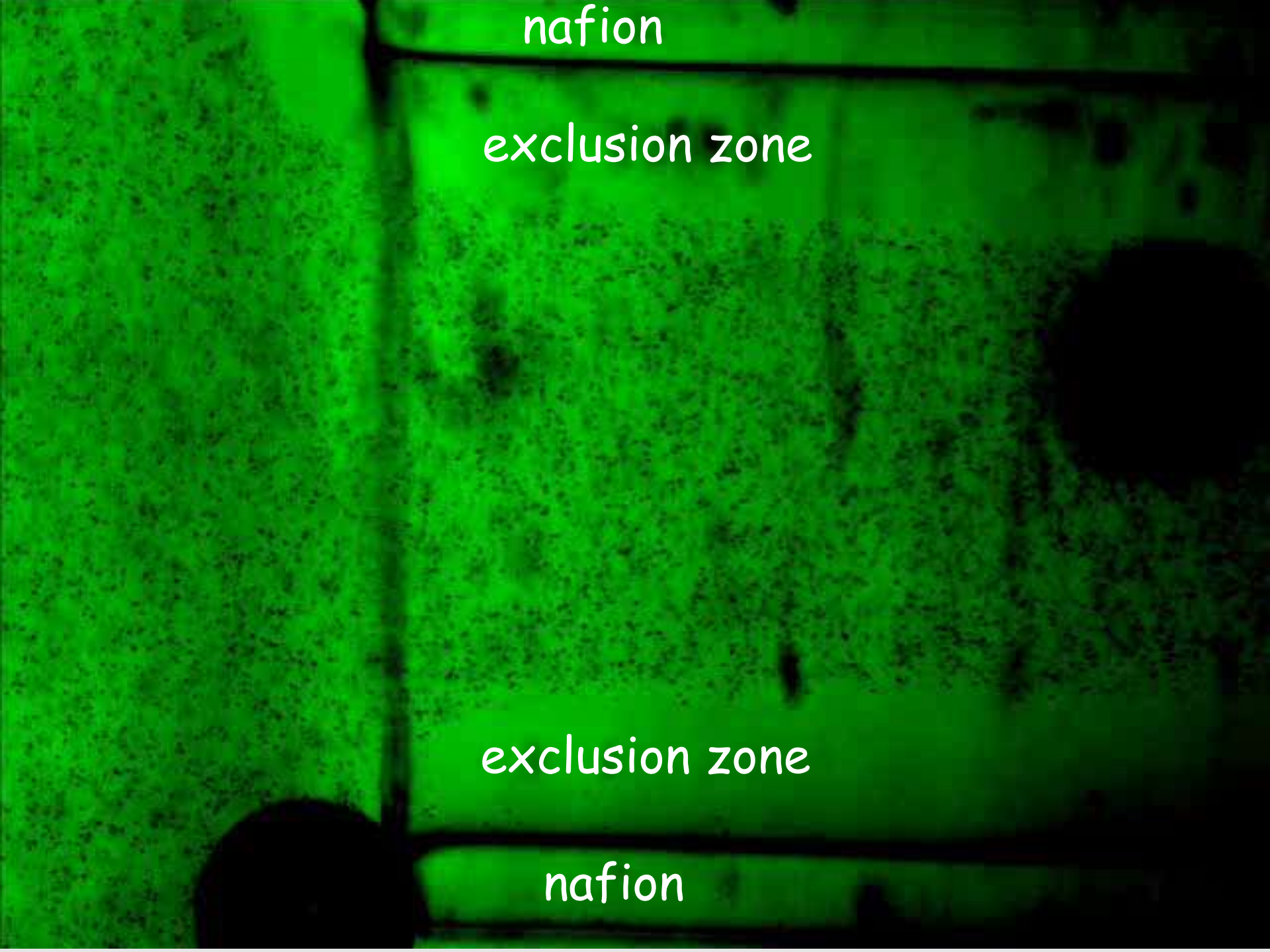
Charges the water battery

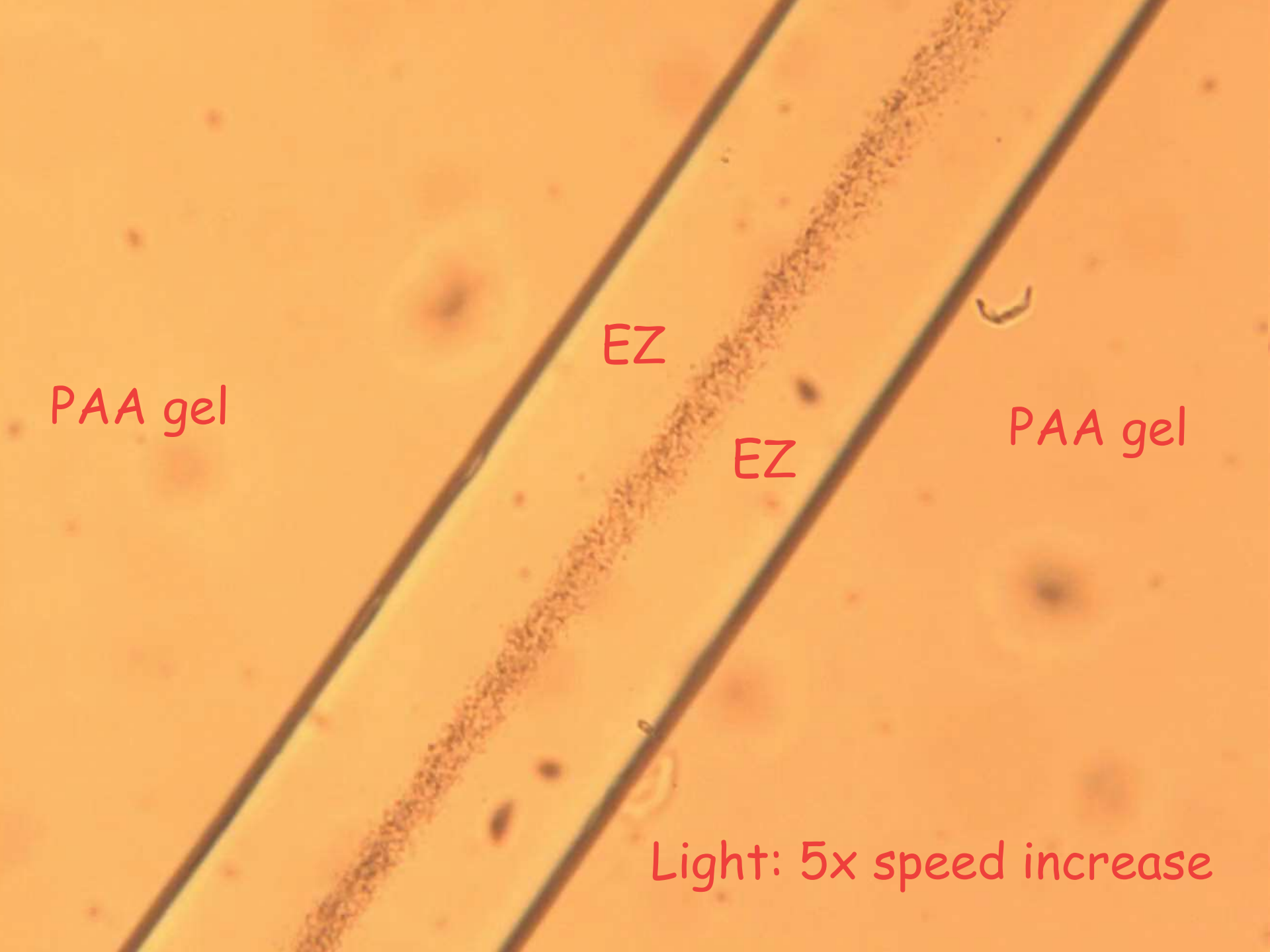


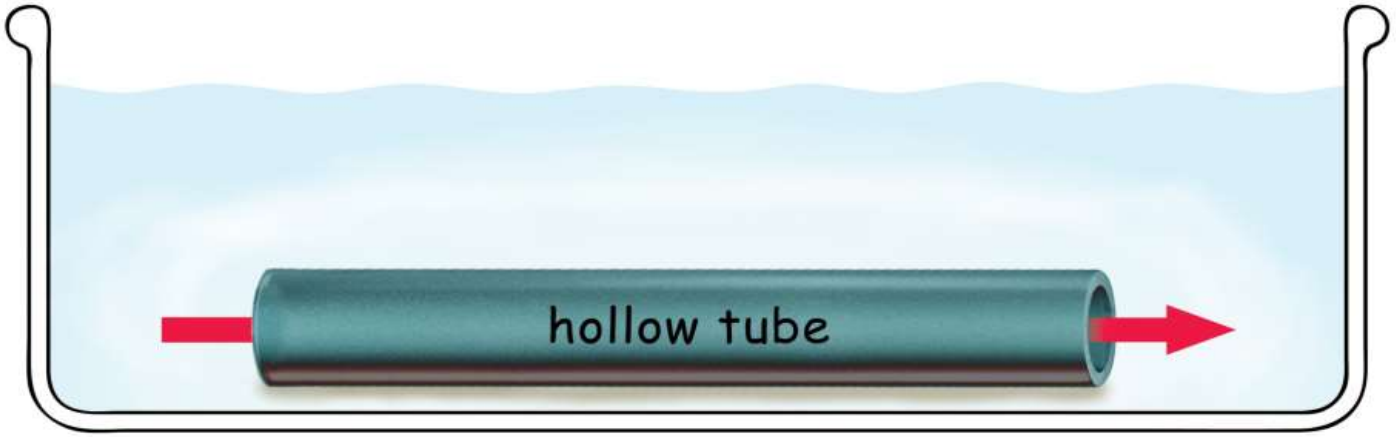
Can this energy be harvested?

Energy **can** be harvested…




nafion
exclusion zone
exclusion zone
nafion

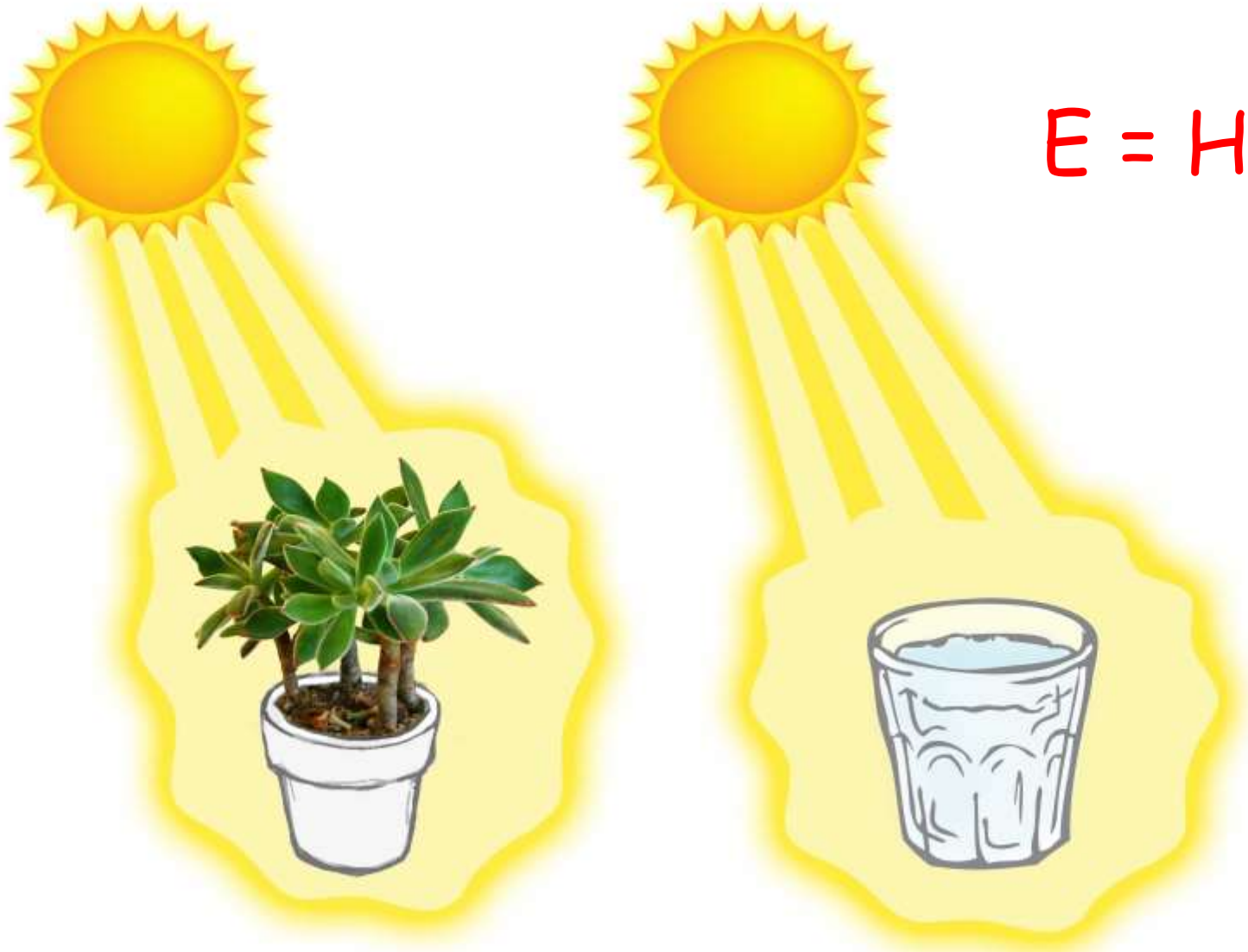

EZ
PAA gel
EZ
PAA gel
Light: 5x speed increase



work done -- energy required

energy absorption NECESSARY

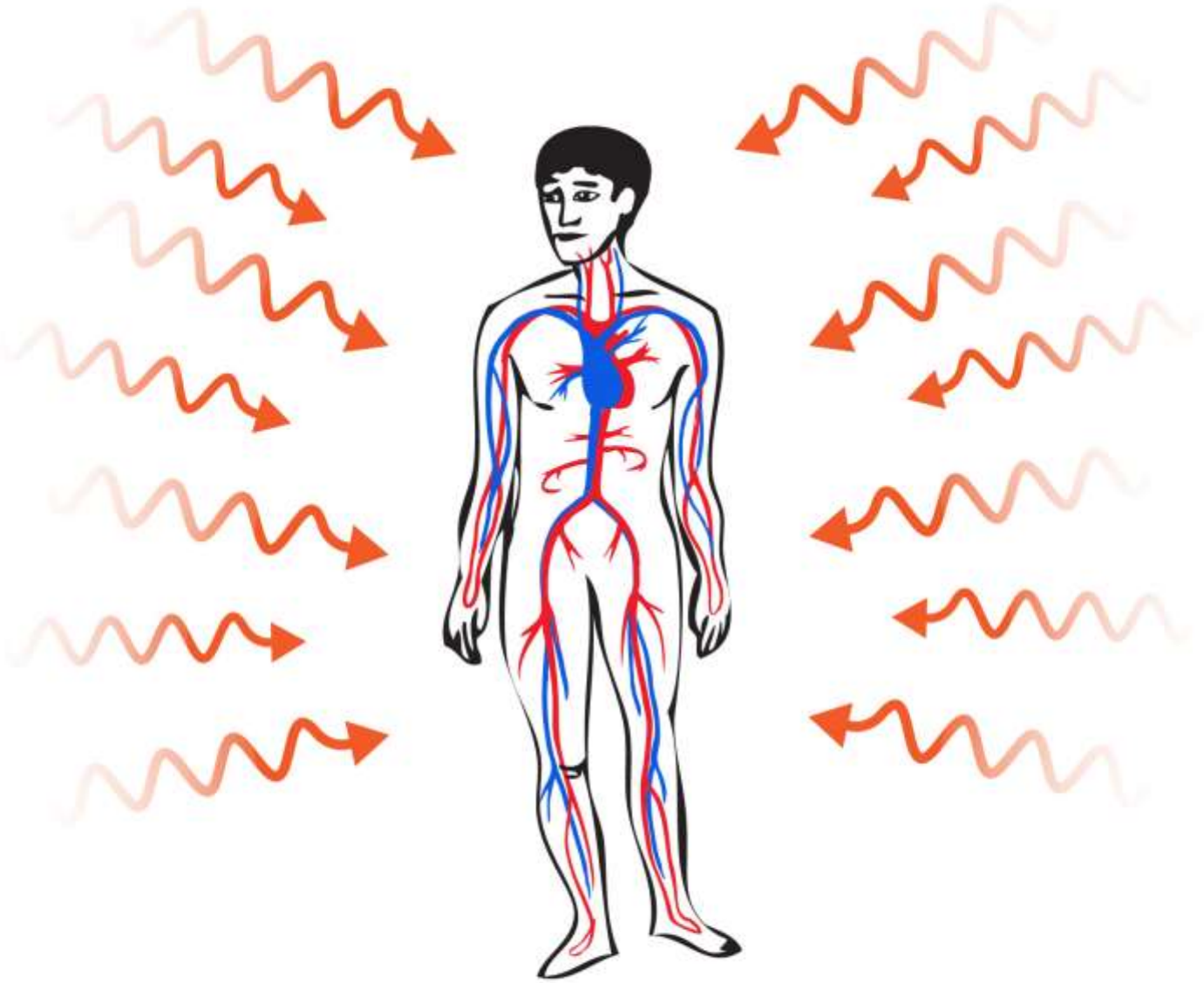
water transduces light energy

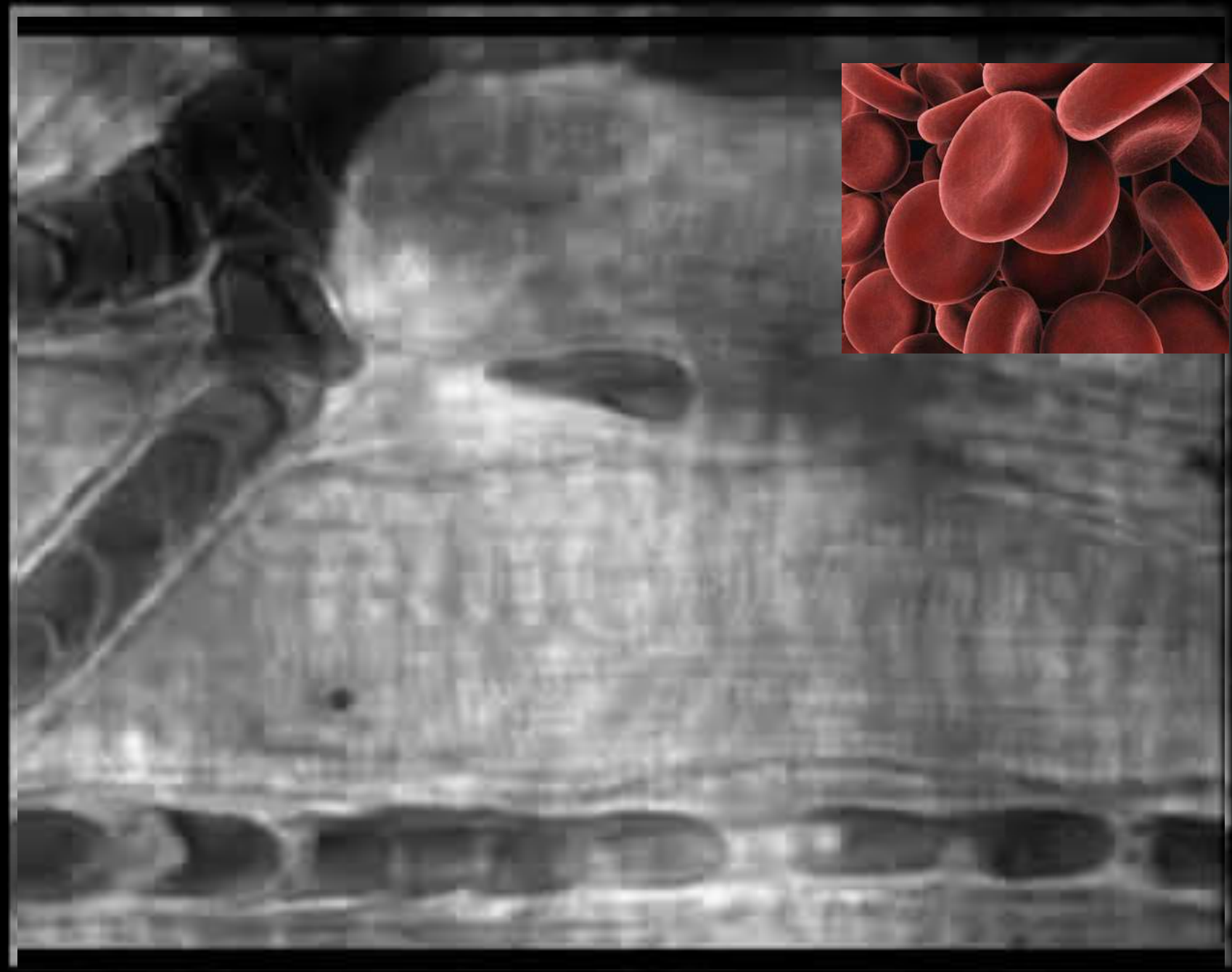

E = H_2O

Question #5
Is all of this important for health?

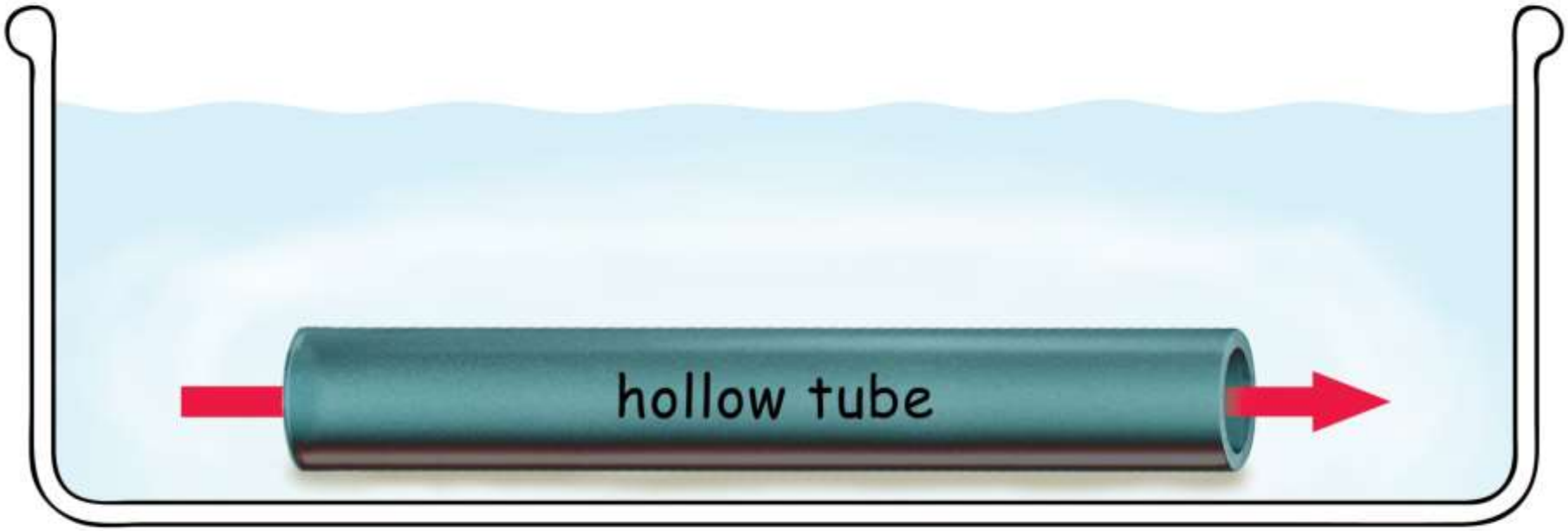
- Foundational for any/all science involving water, molecules, and light
- Foundational for biological function, health

Does Human Biology Use Radiant Energy?





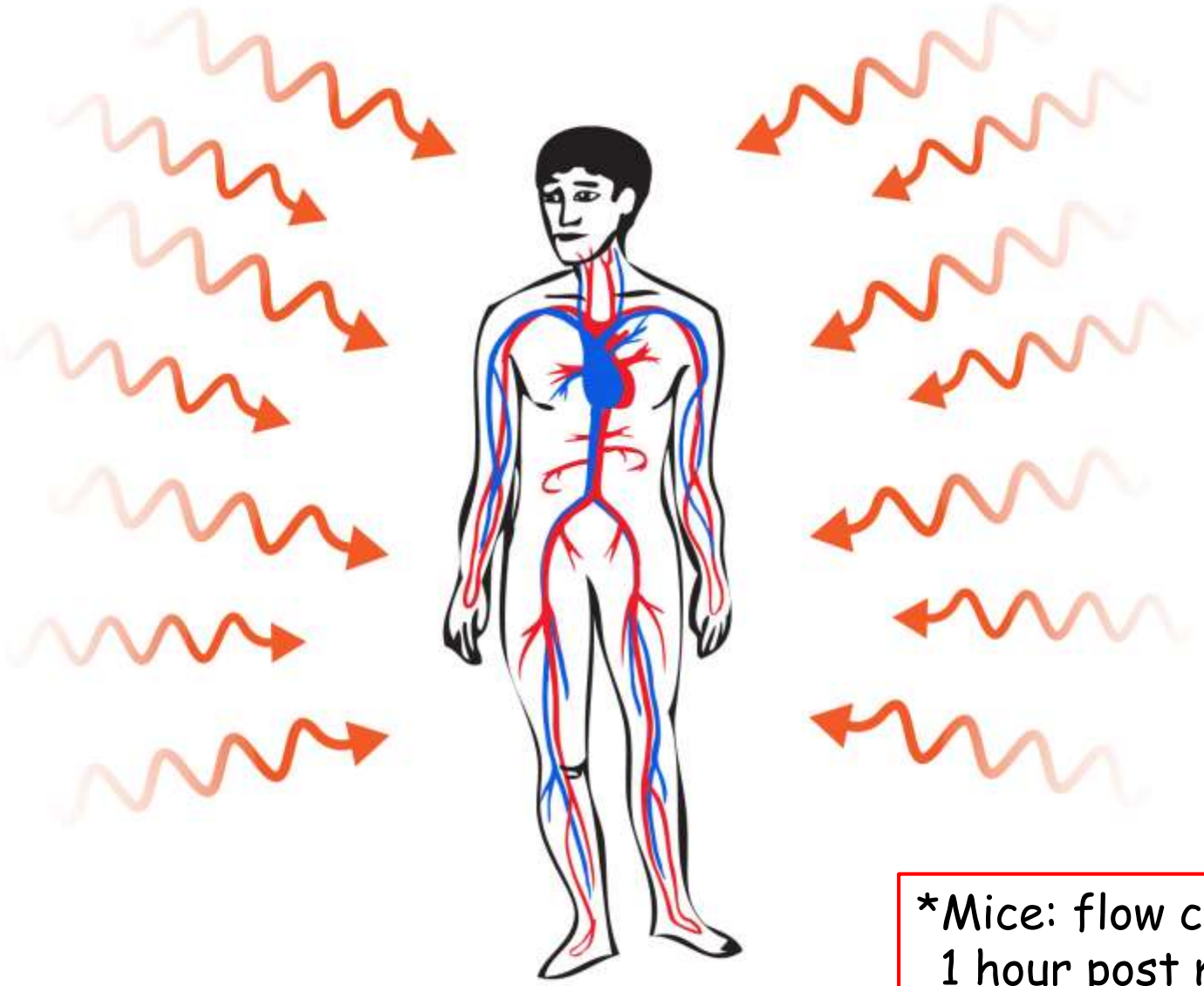
Pedro Cabrales UCSD



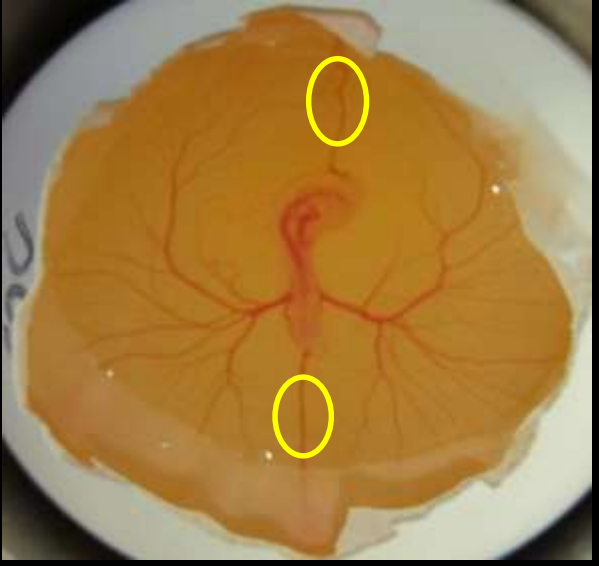
Radiant energy drives flow

Might radiant energy help drive blood flow?

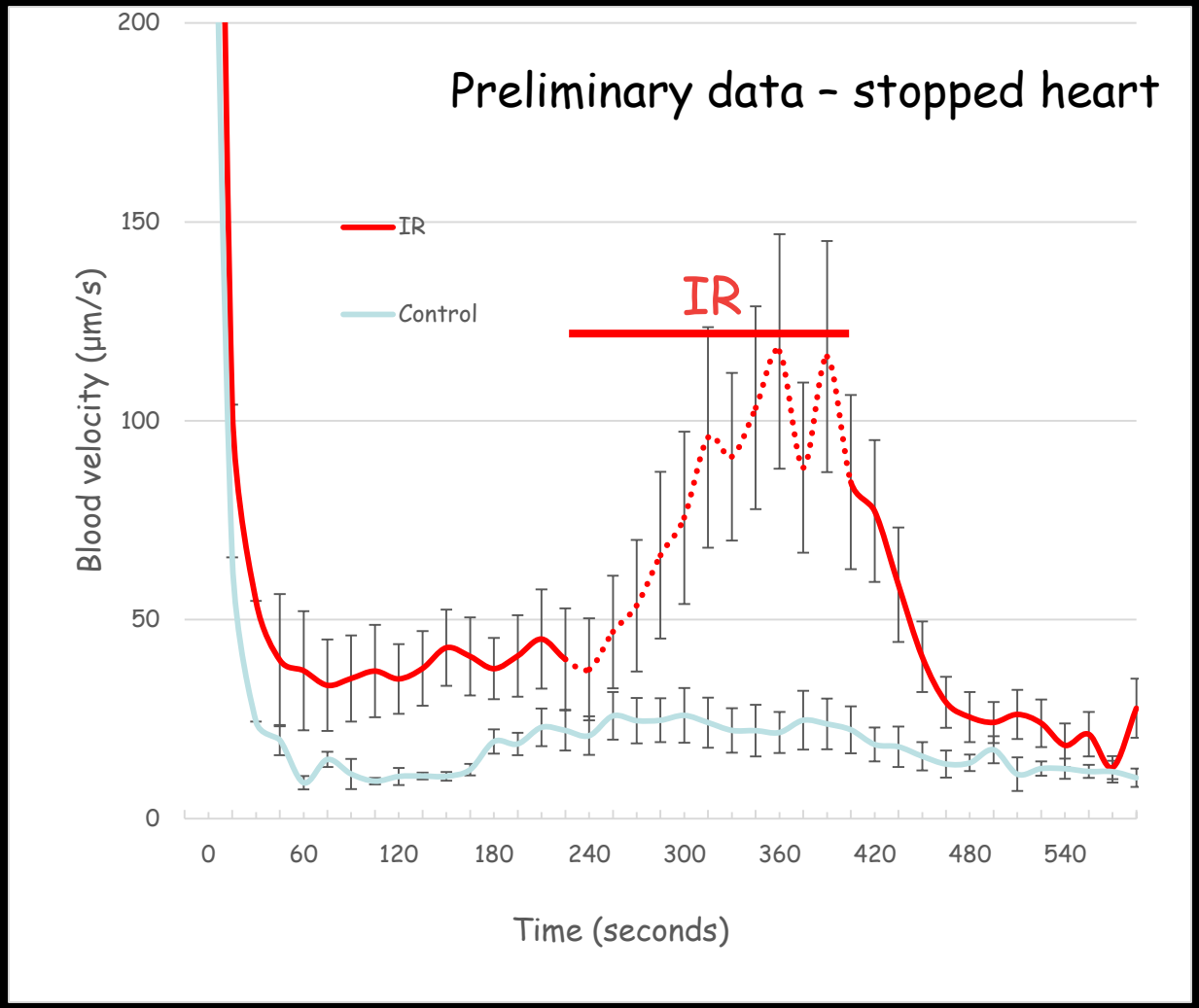
Absorbed external energy may assist blood flow*



*Mice: flow continues 1 hour post mortem

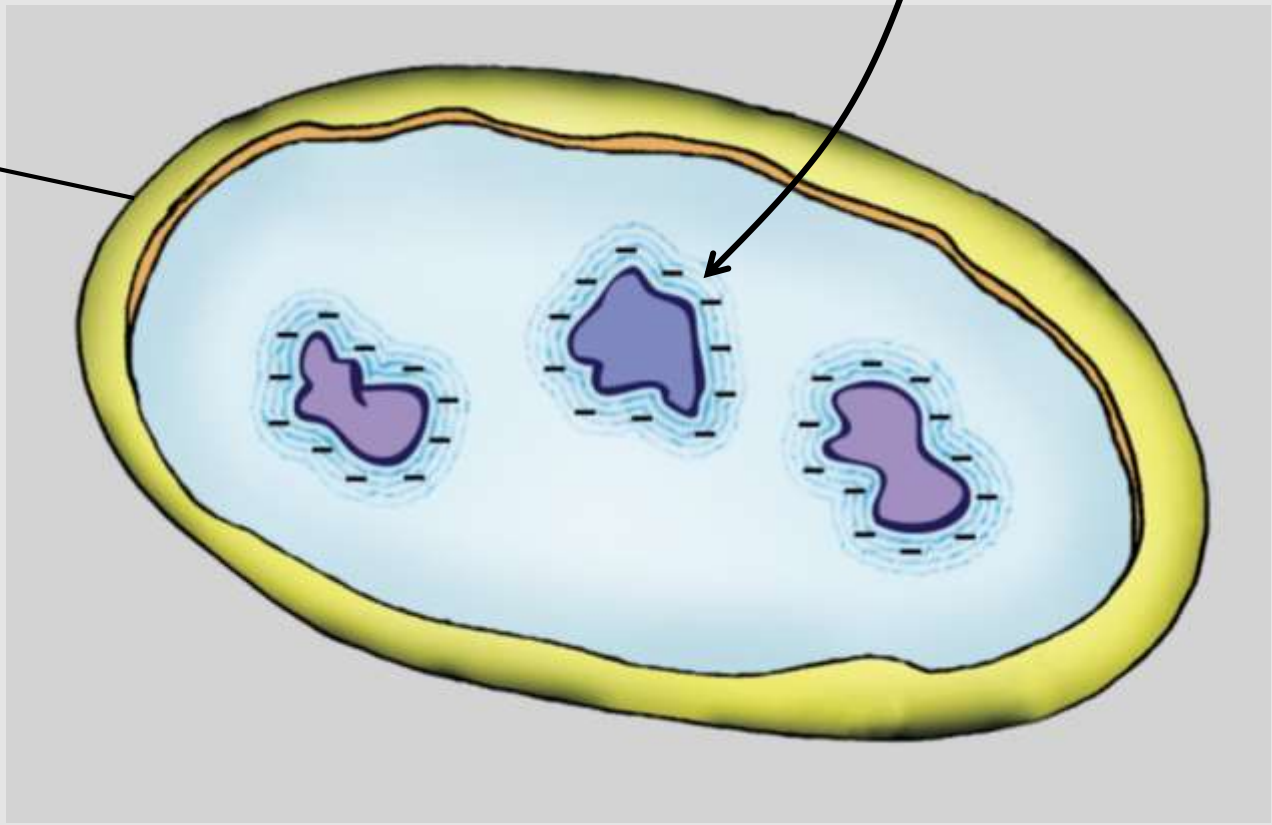


Chick embryo - 3 days

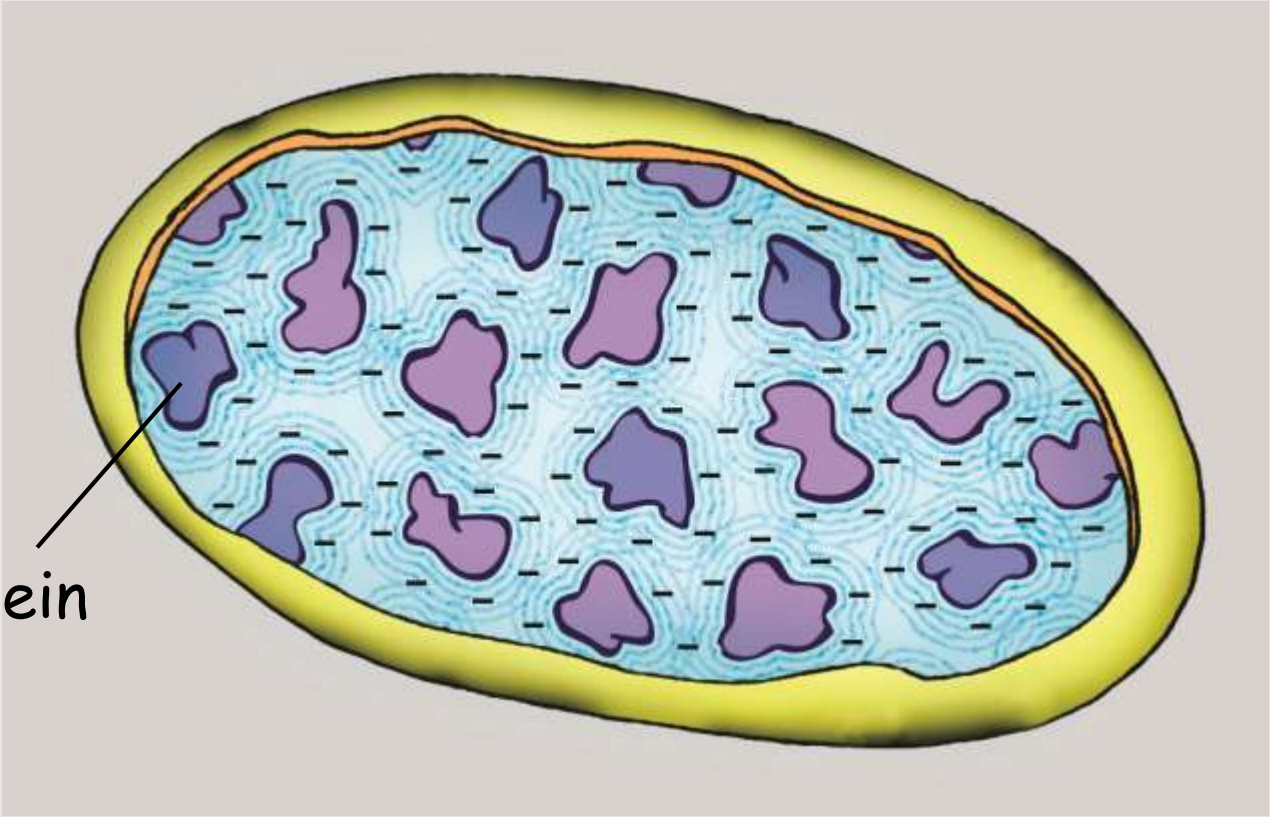


EZ water has negative charge

Cell



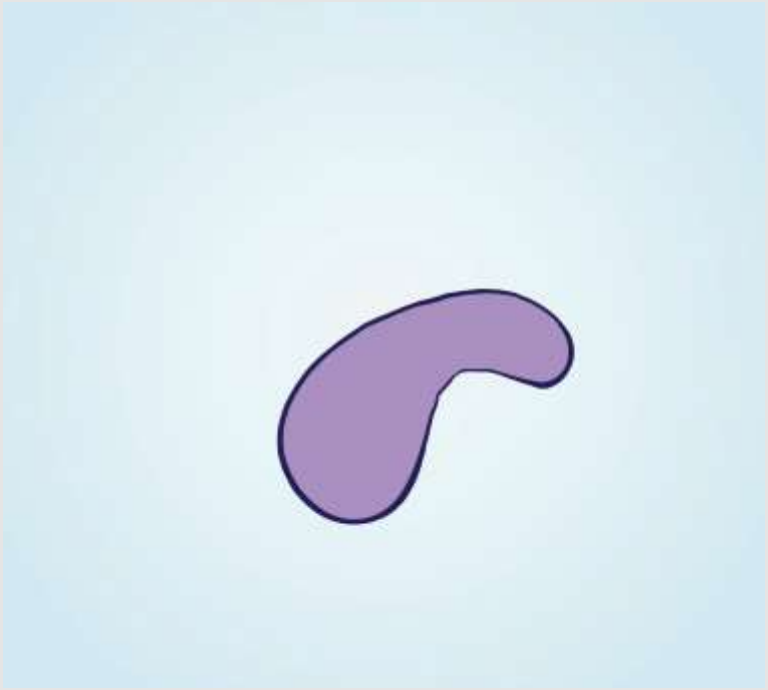
Crowded: Negative EZ practically fills the cell



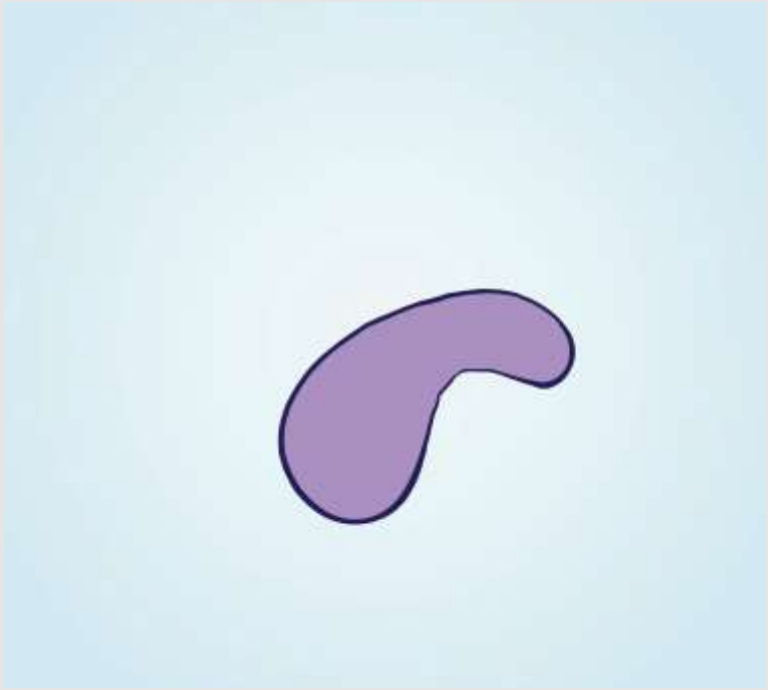
Negative charges repel → potential energy

protein folding

Folding/unfolding need EZ water

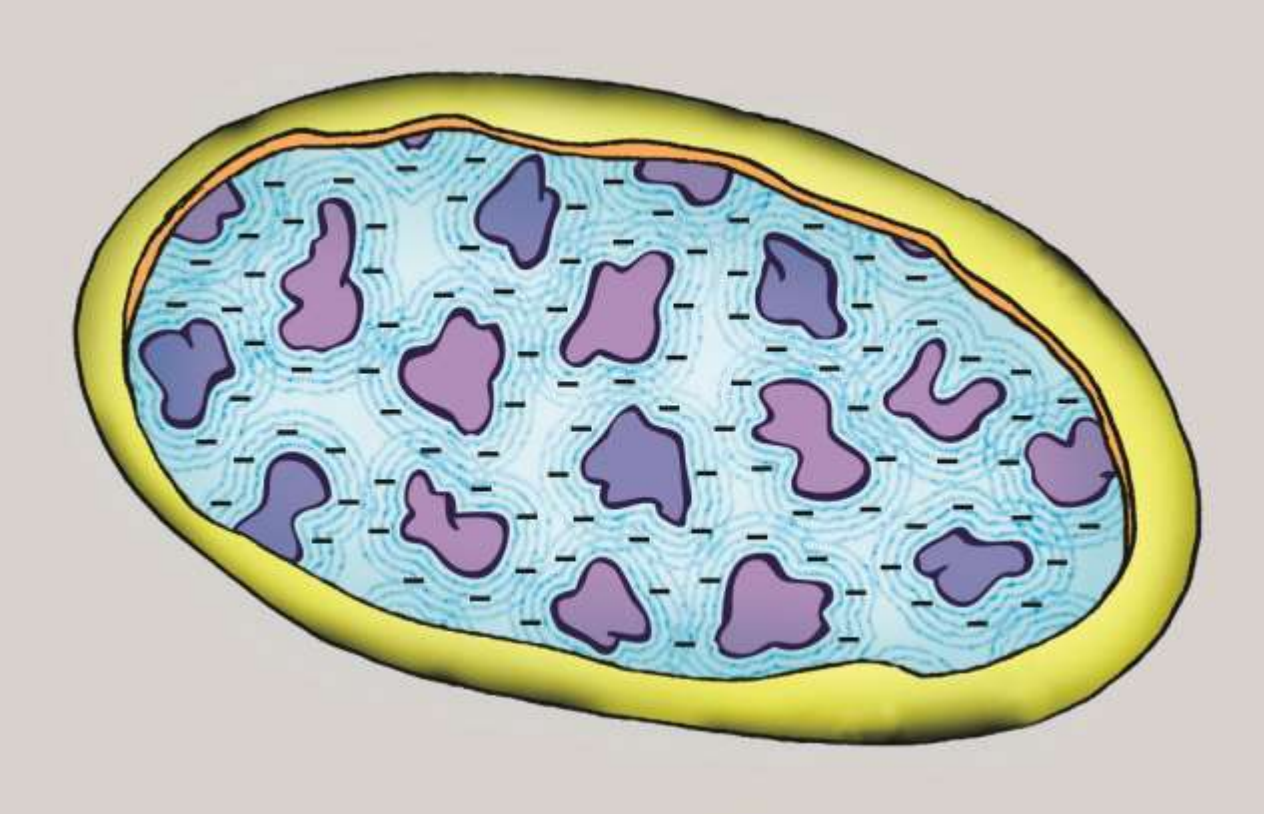


with EZ



no EZ

Potential energy (from EZ) drives work



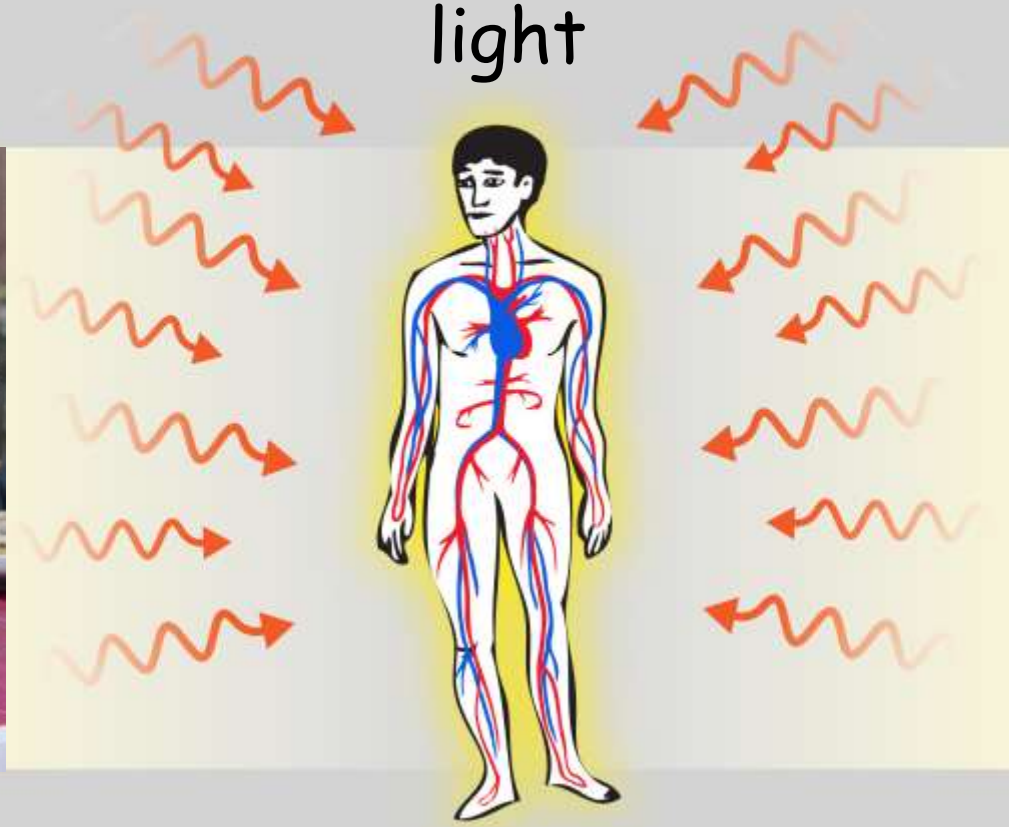
Light builds EZ → negative charge → energy

Energy → work/folding

Where do we get our energy?

food

light



absorbed by water

Builds EZ ⟶ energy

Should this matter to you?

- Light matters
- Water matters

What builds EZ water in your cells?

Water: raw material for building EZ water

Green juicing: plant-cell water – contains EZ

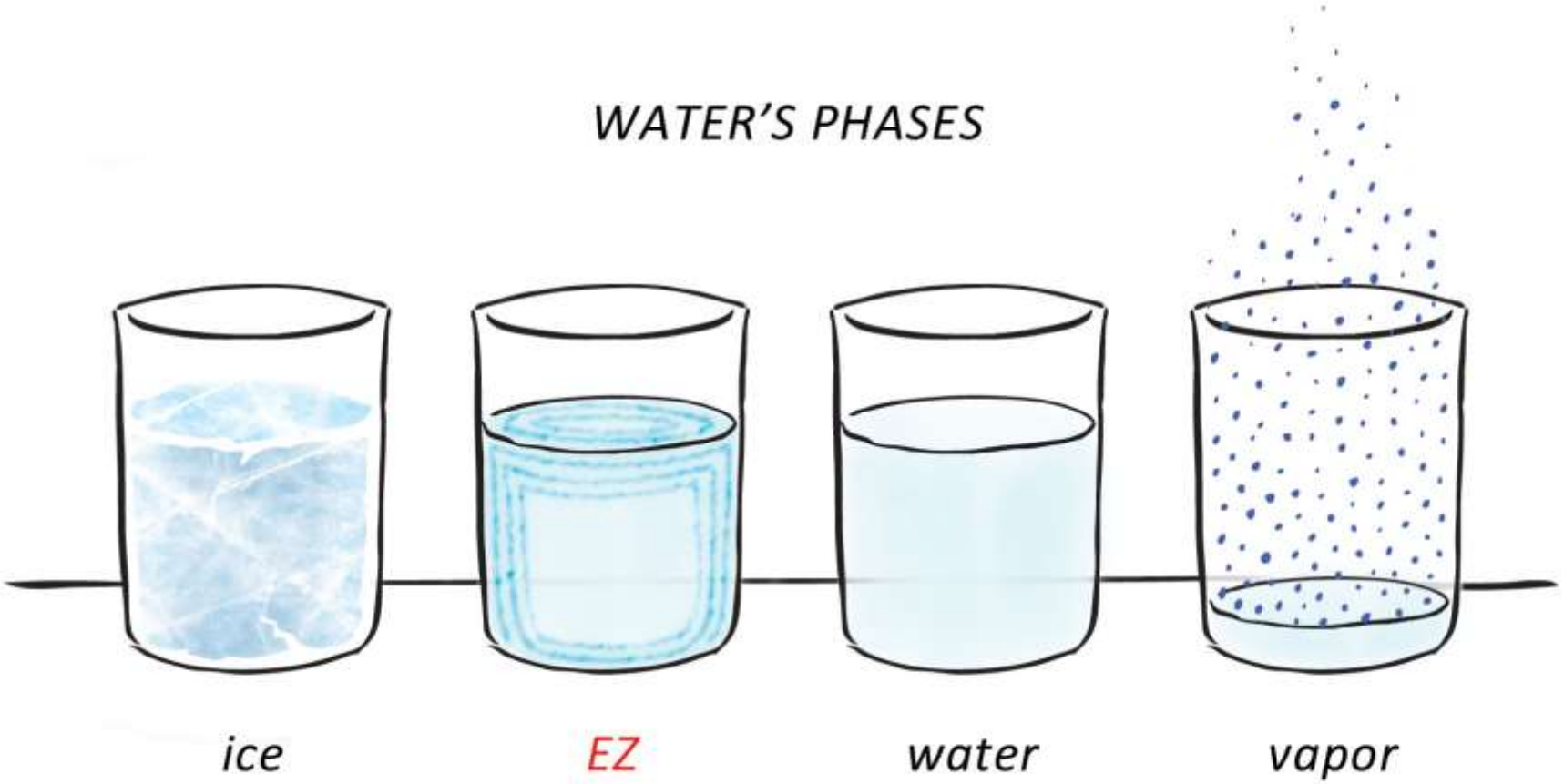
Turmeric, coconut water, etc.: build EZ

Sunshine: light builds EZ

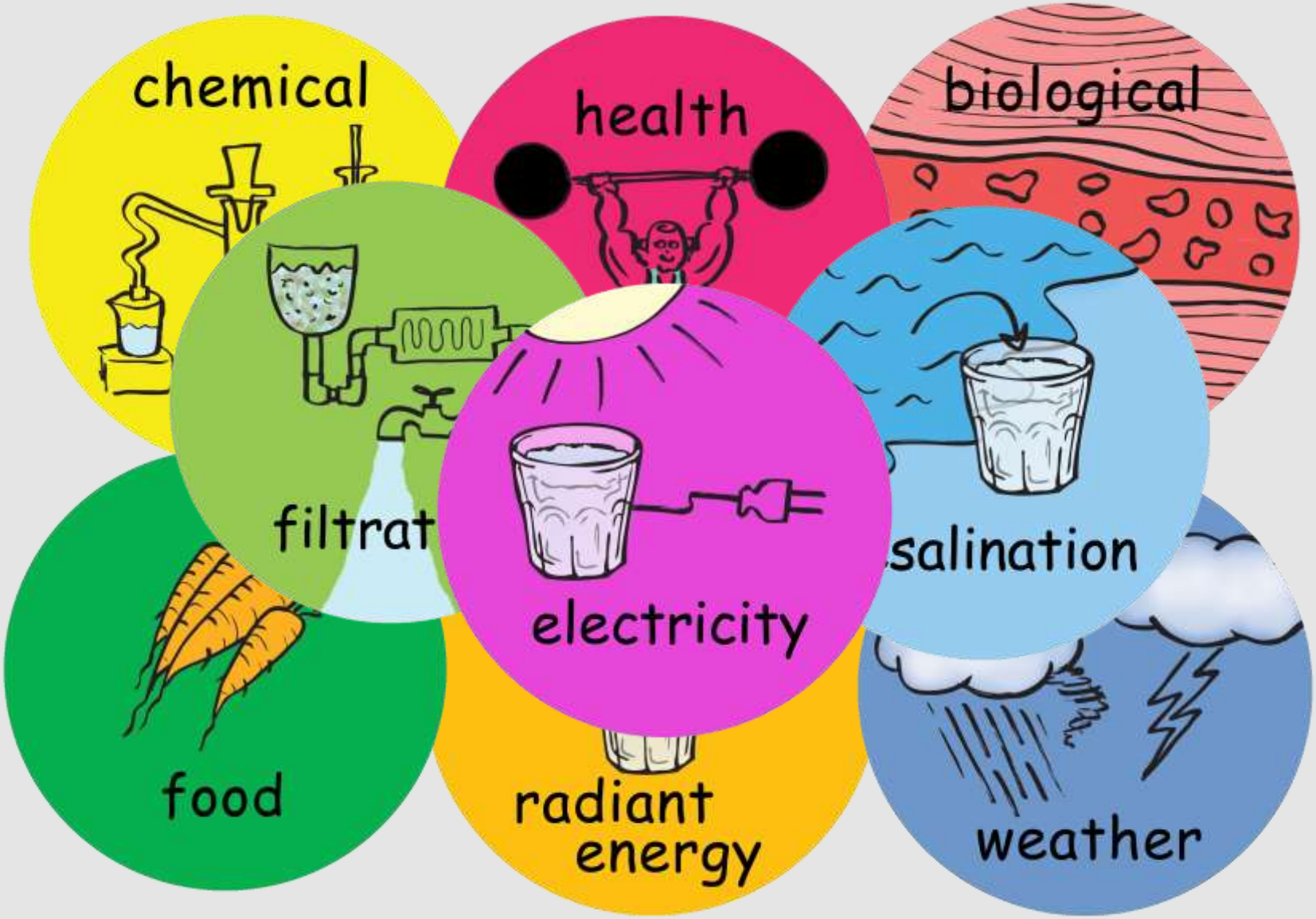
Sauna: infrared light builds EZ

Grounding: negative charge builds EZ

Conclusions


WATER'S PHASES
ice
EZ
water
vapor

Broad implications…



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