A Non-Physicist's Intro to MRI

Dylan Tisdall

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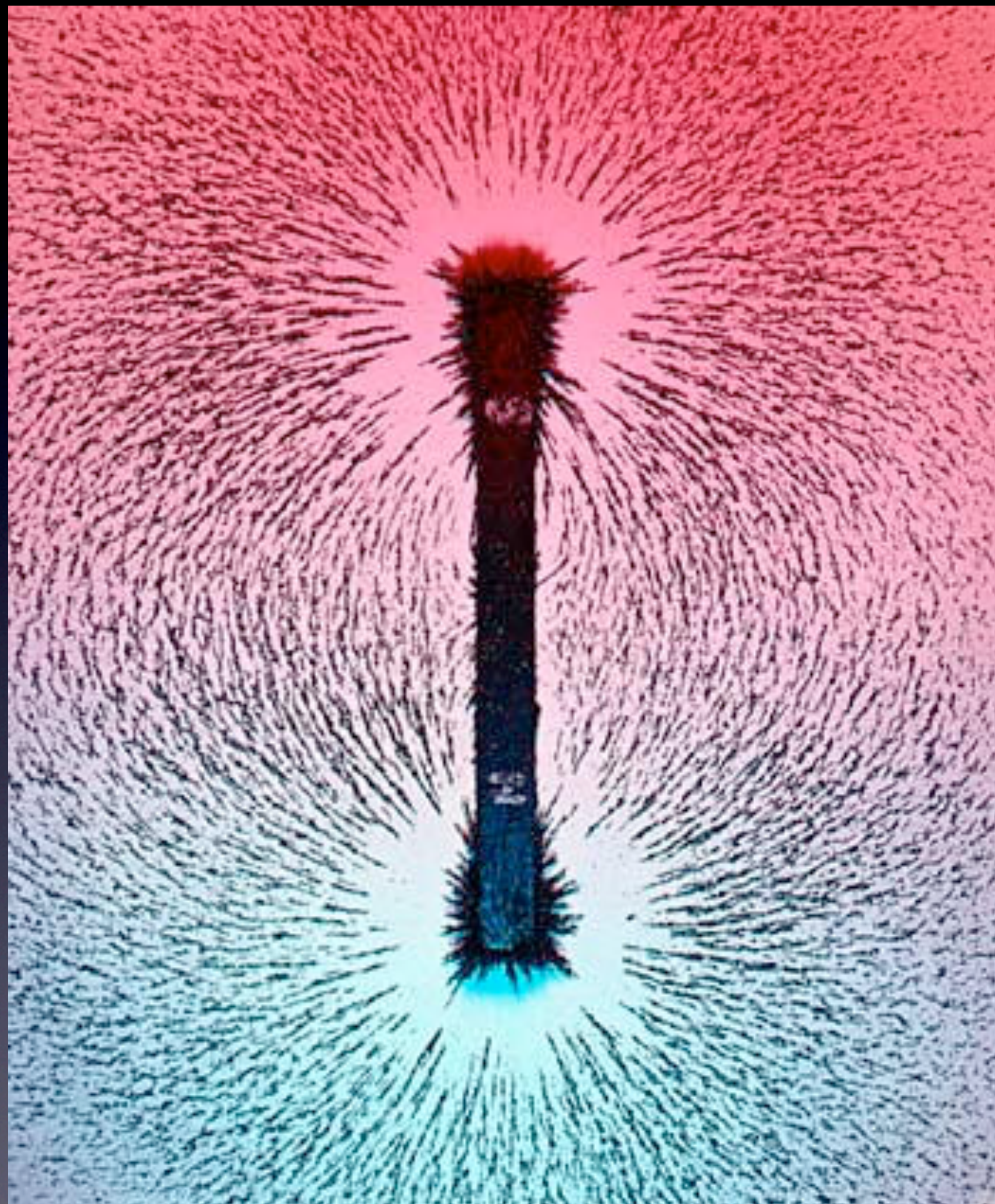
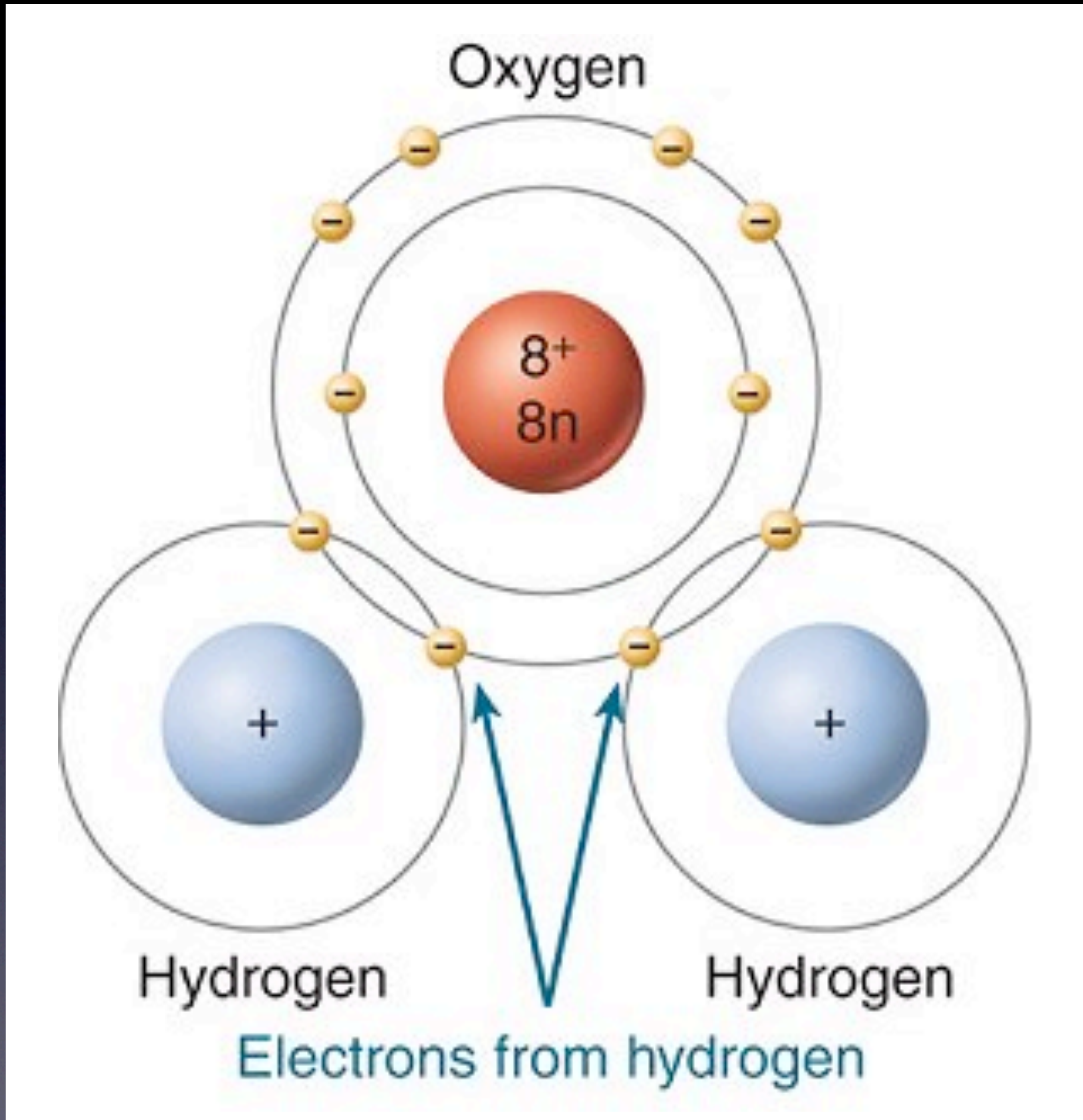
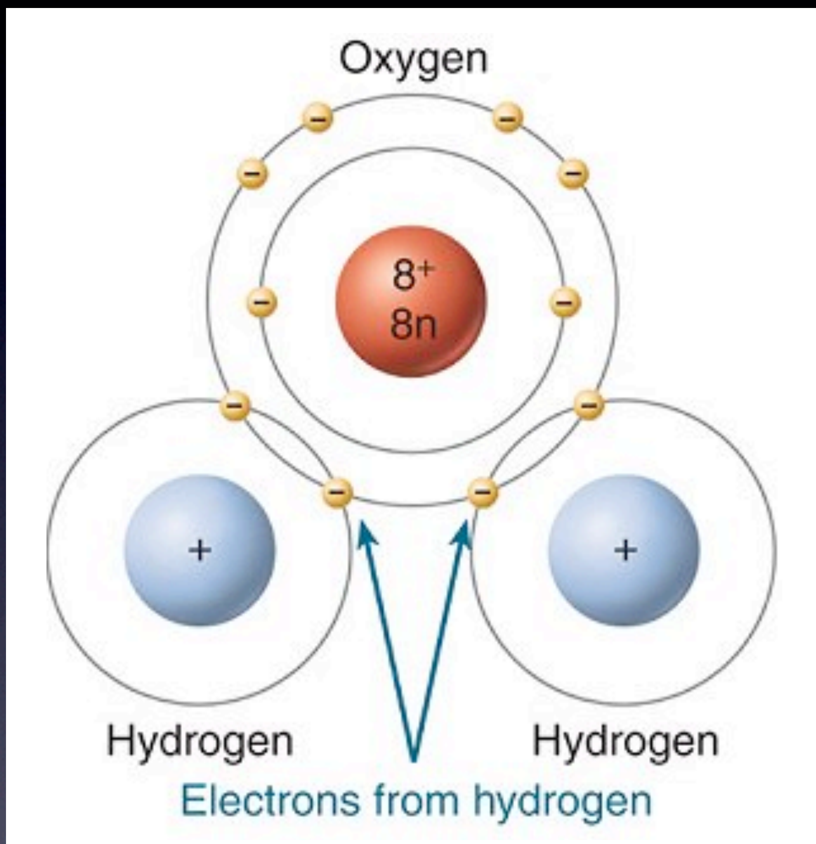
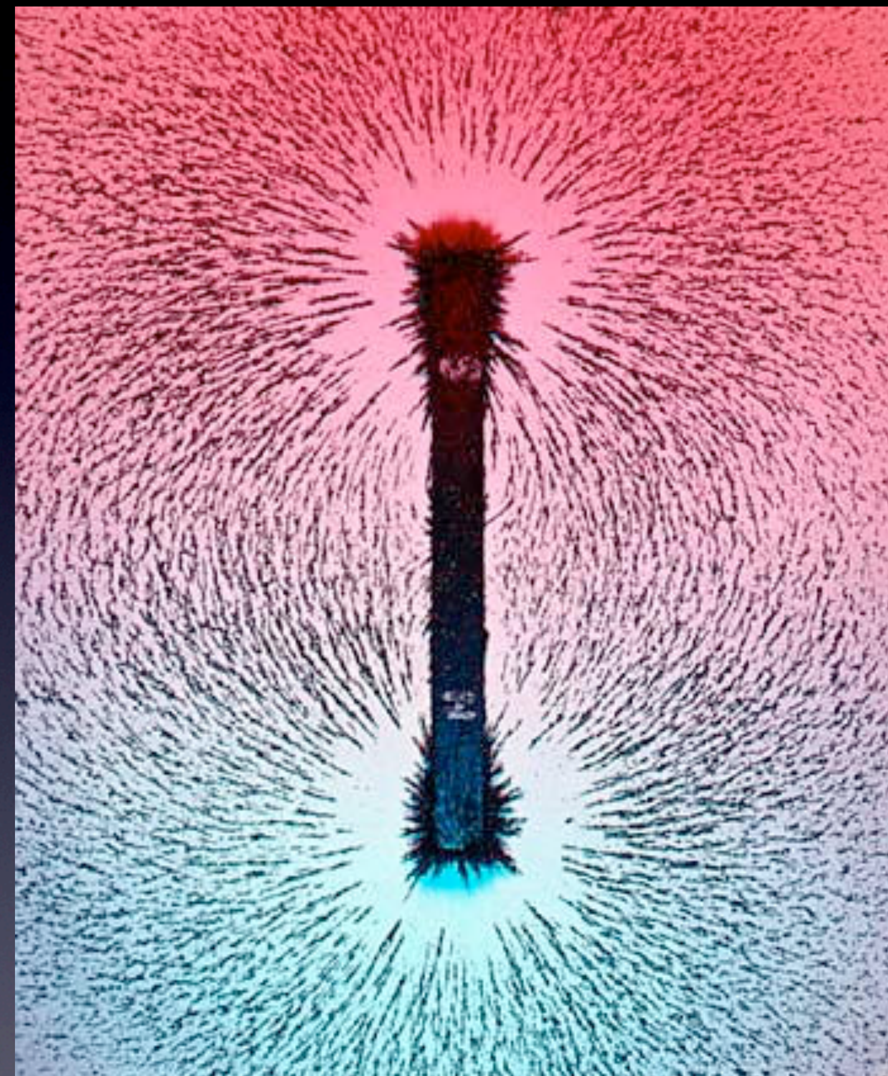
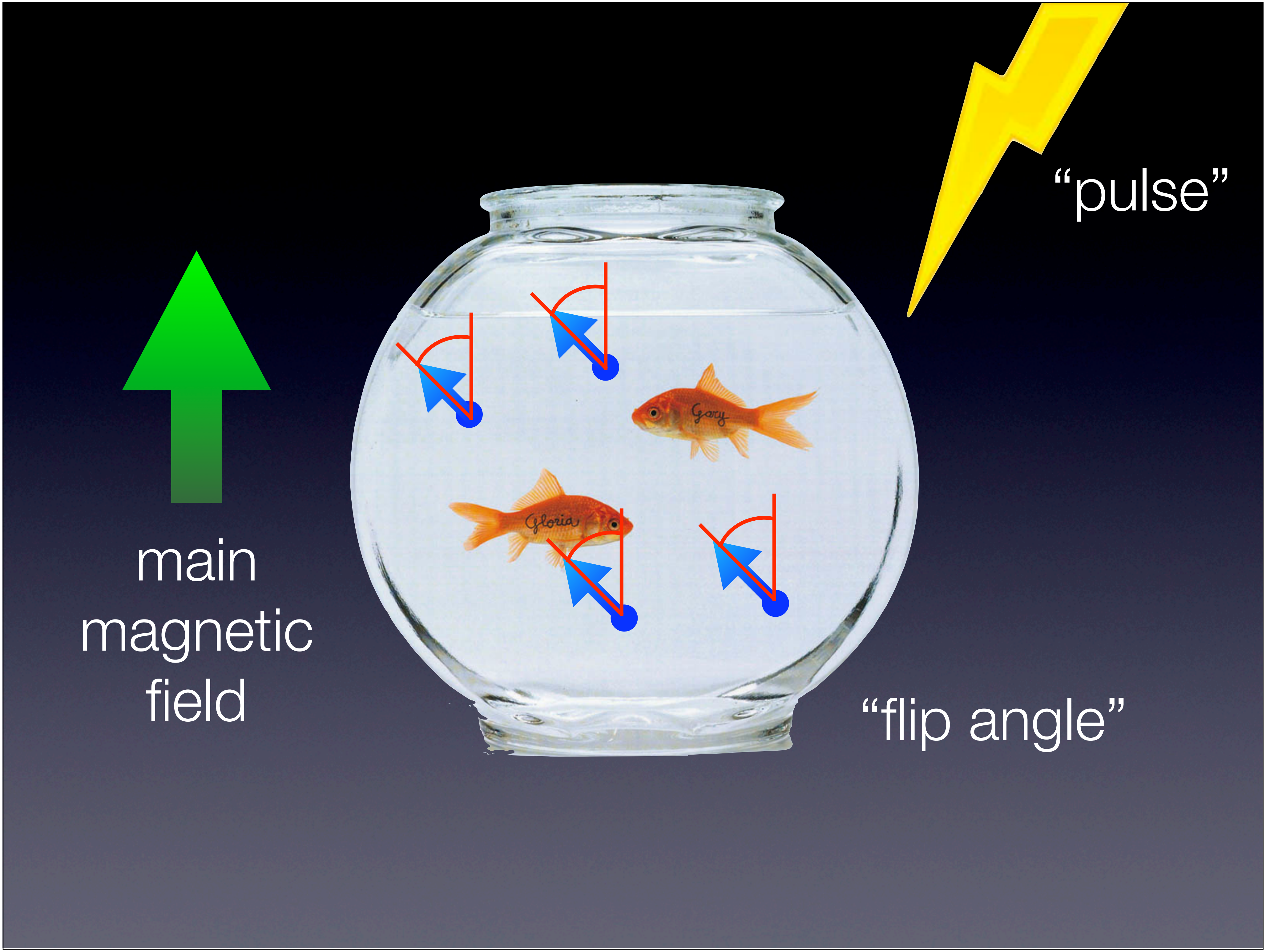


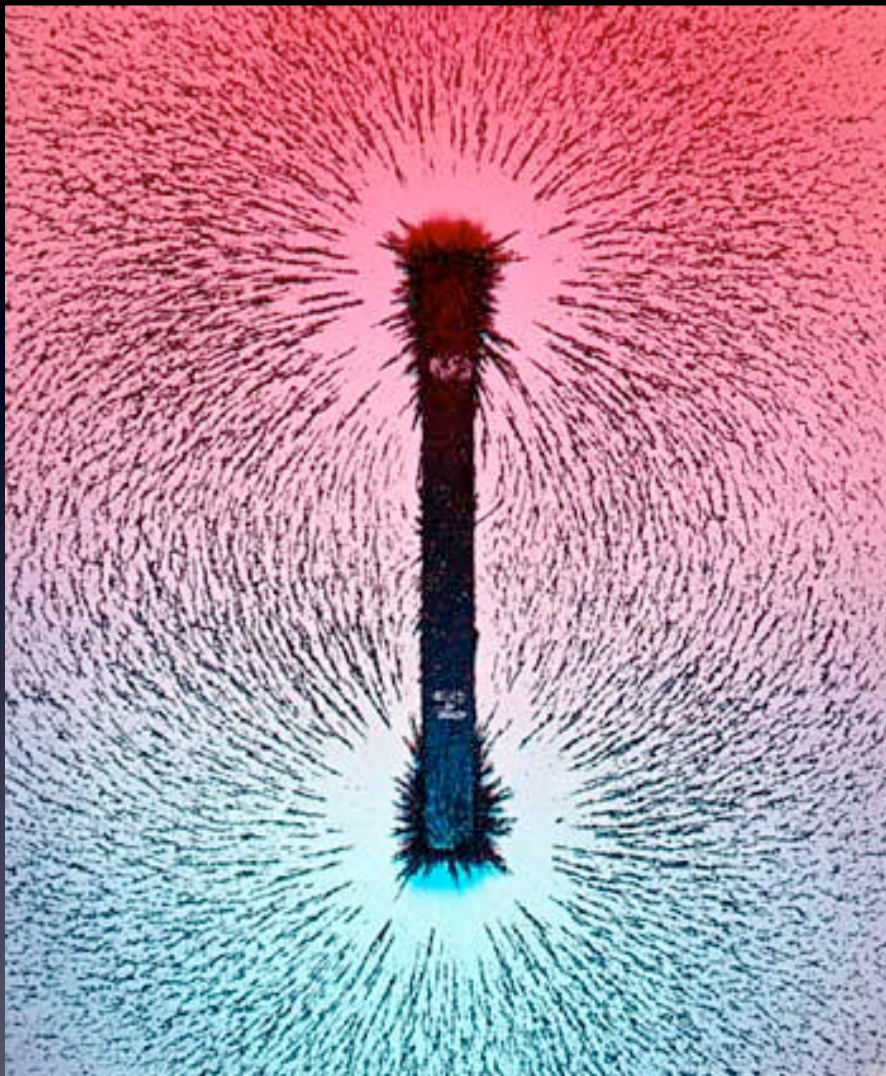
A human head


Oxygen
8^+
8n
+
+
Hydrogen
Hydrogen
Electrons from hydrogen

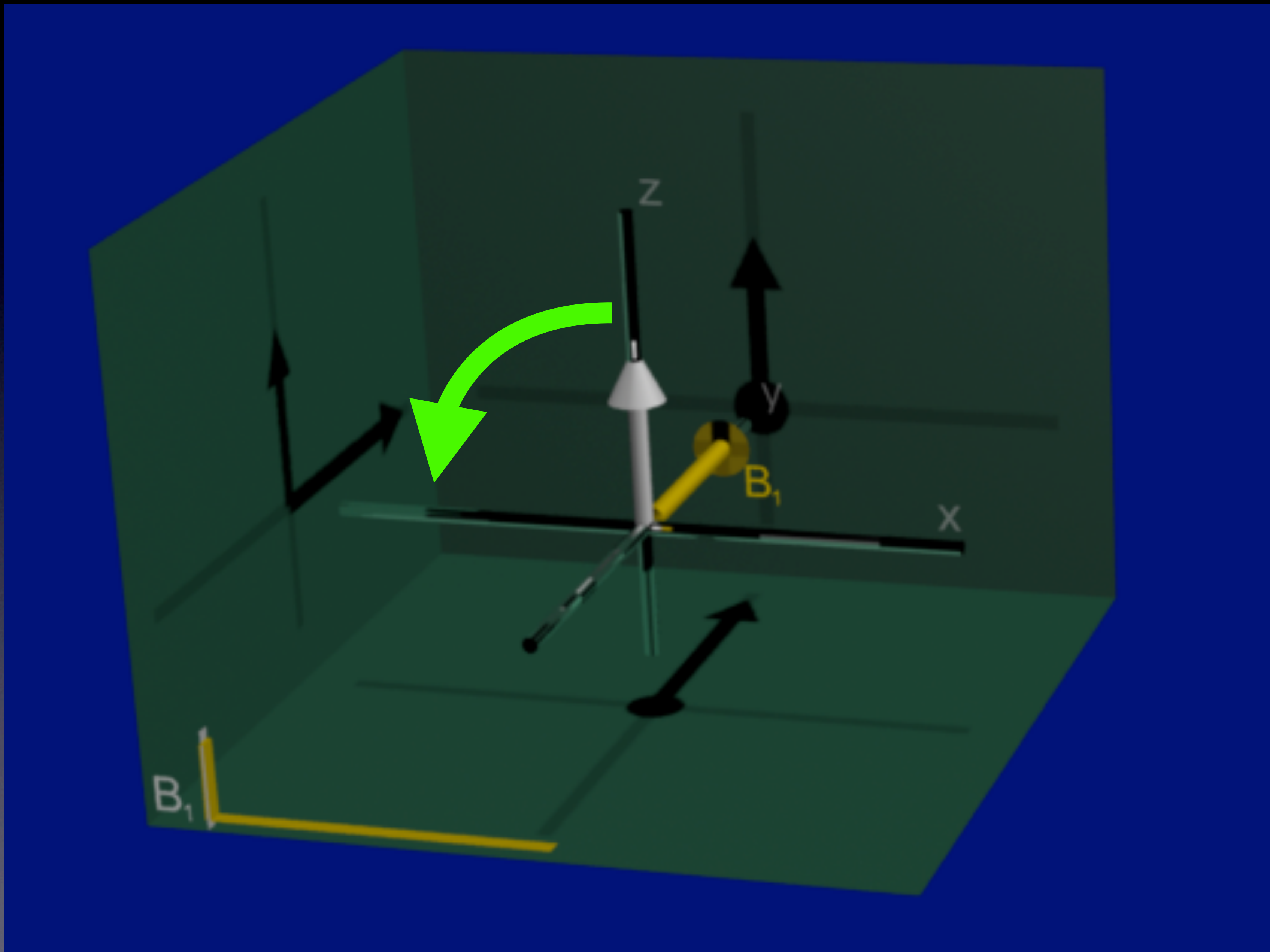

Oxygen
8+
8n
Hydrogen
Hydrogen
Electrons from hydrogen



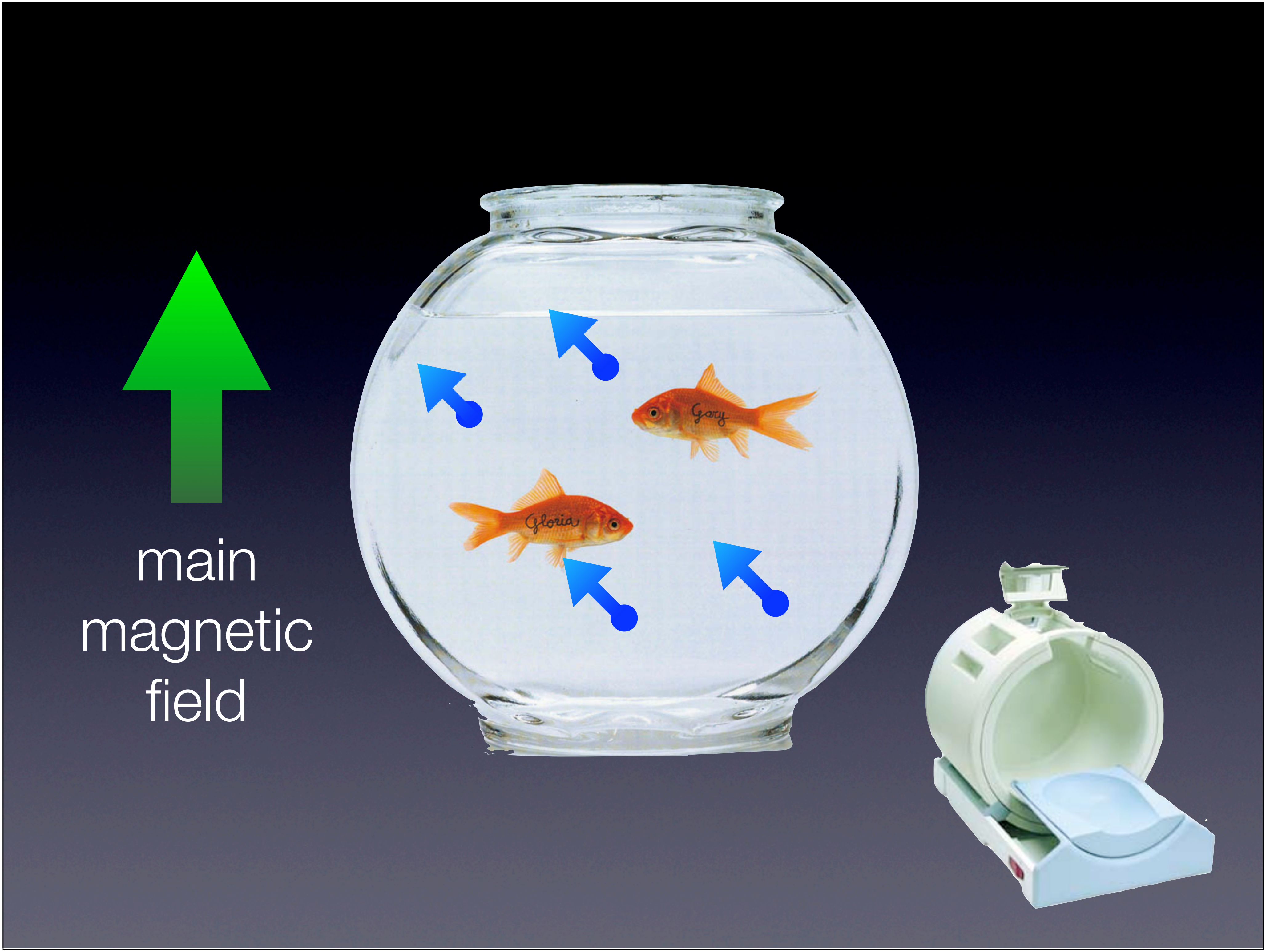

main
magnetic
field
“pulse”
“flip angle”
Gary
Gloria

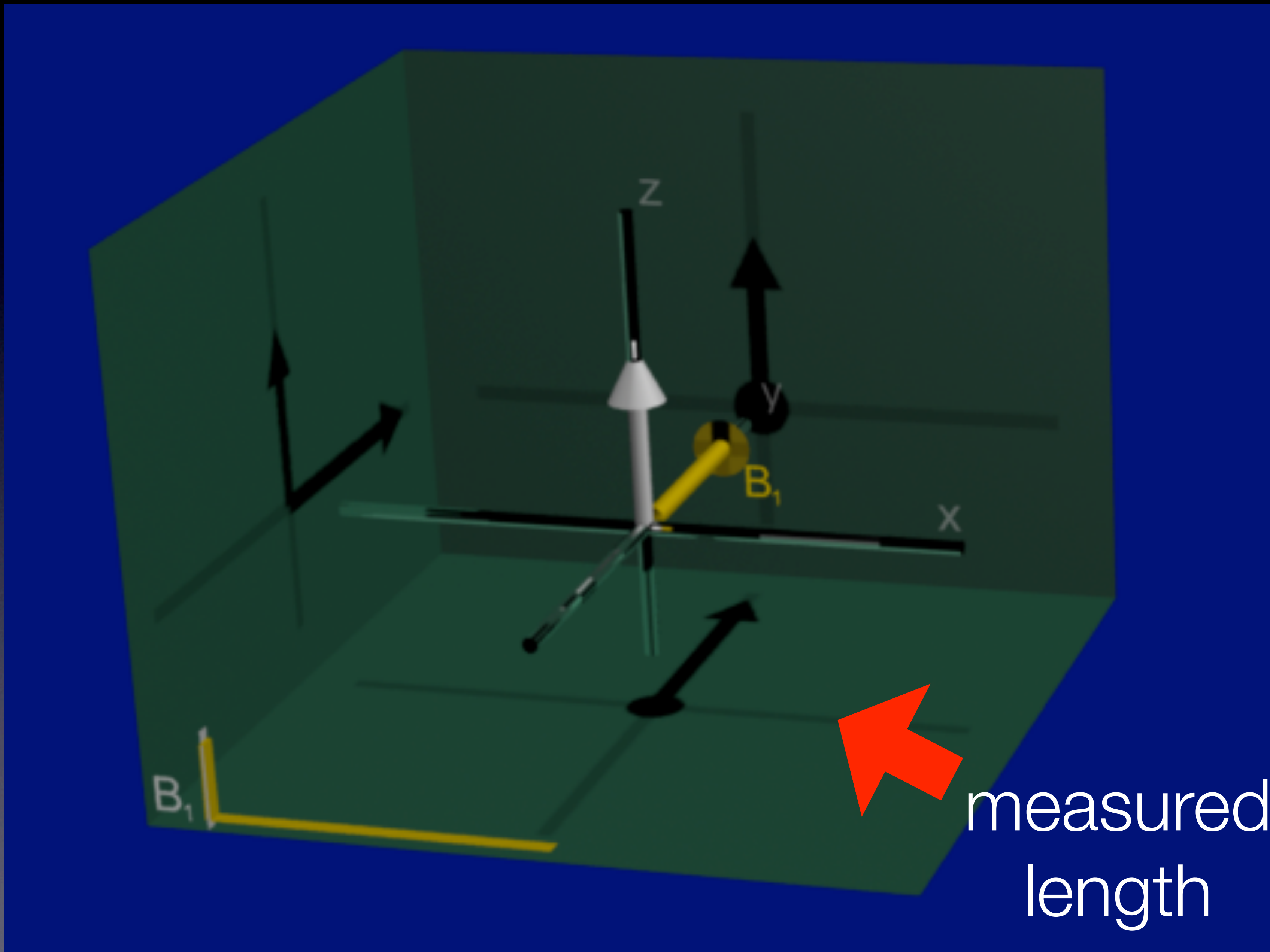


precession

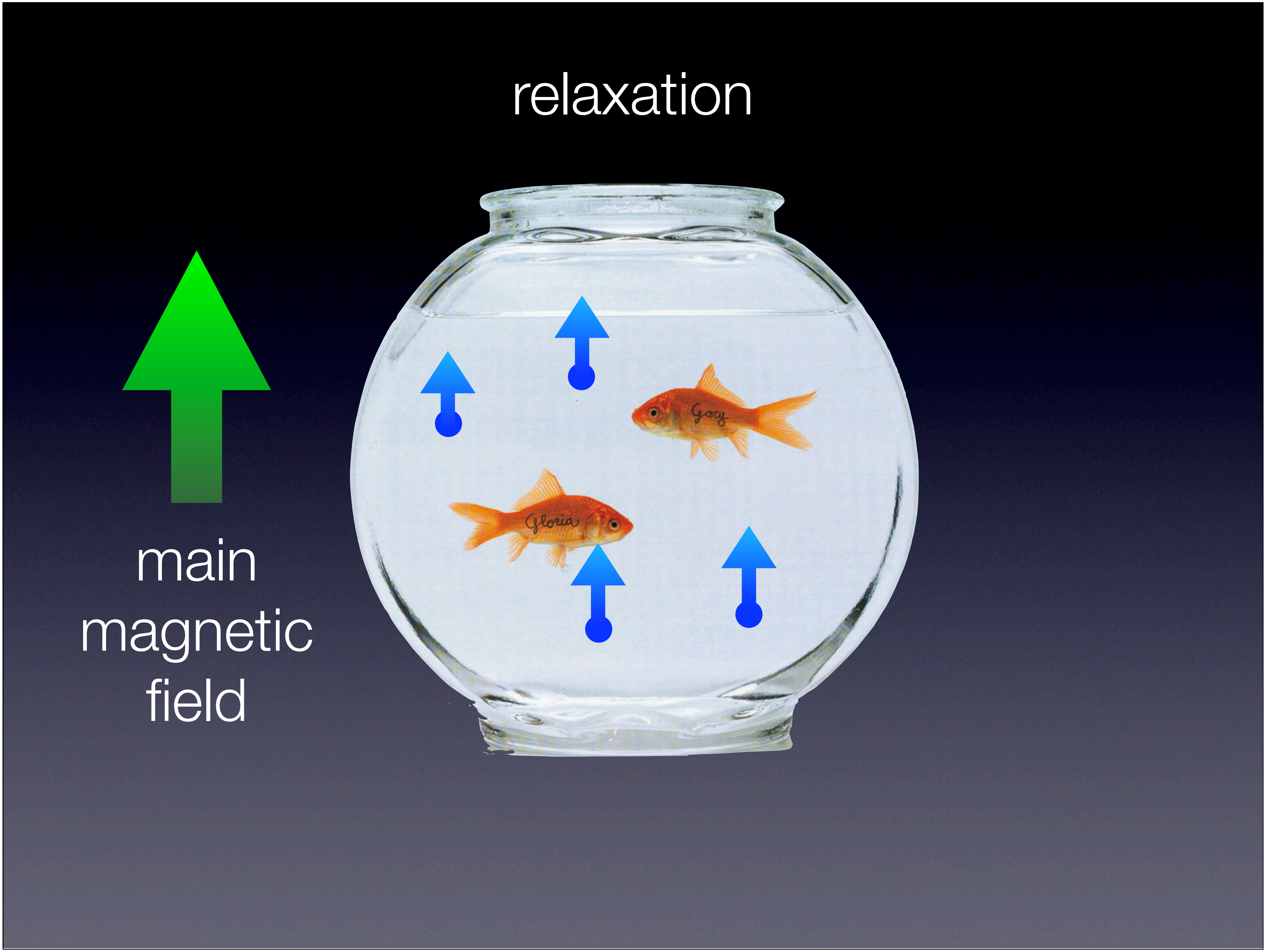


The **rate of precession** changes **linearly** with the strength of the **magnetic field**

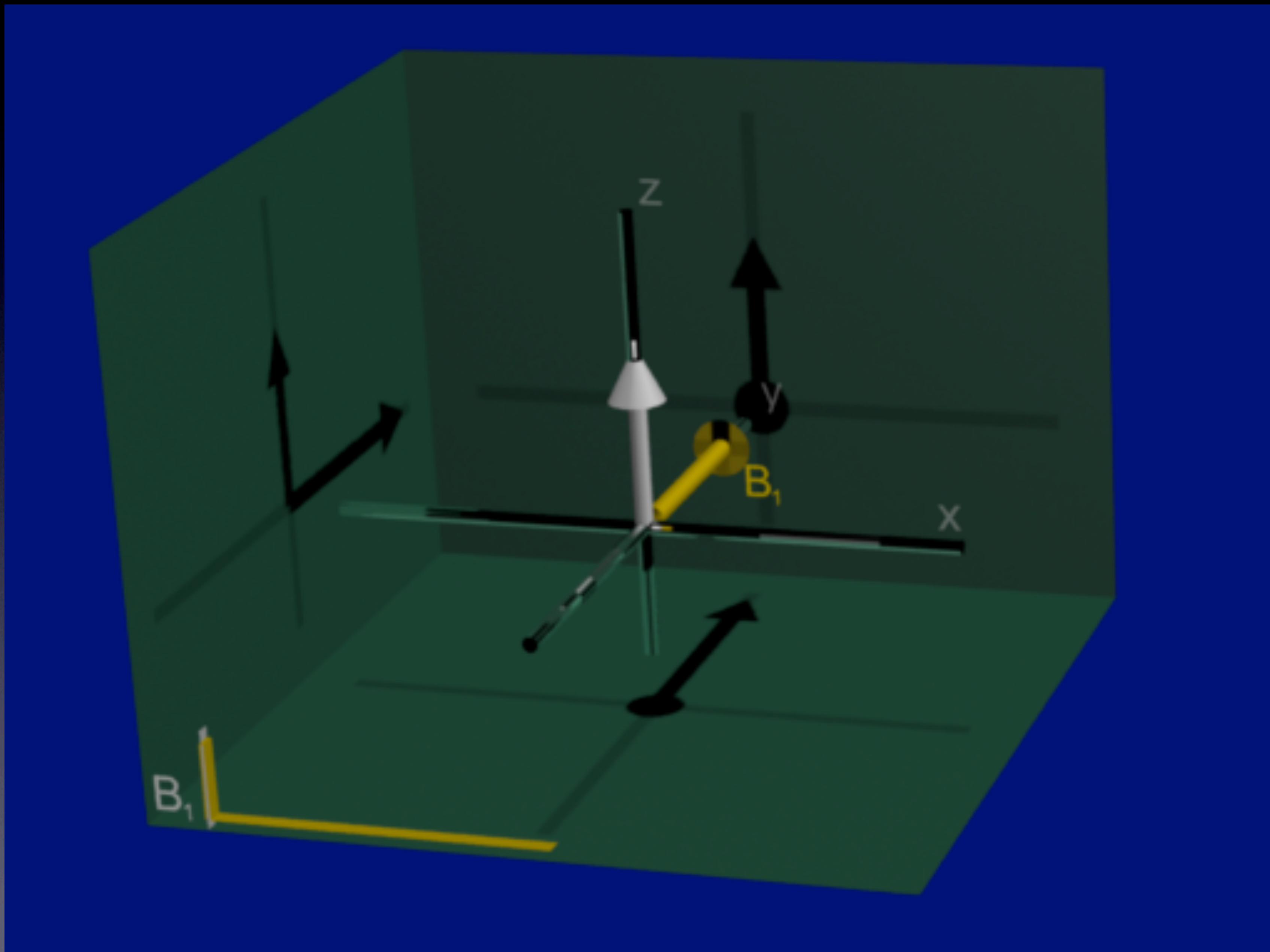

main
magnetic
field
Gary
Gloria


z
y
B_1
x
B_1
measured
length

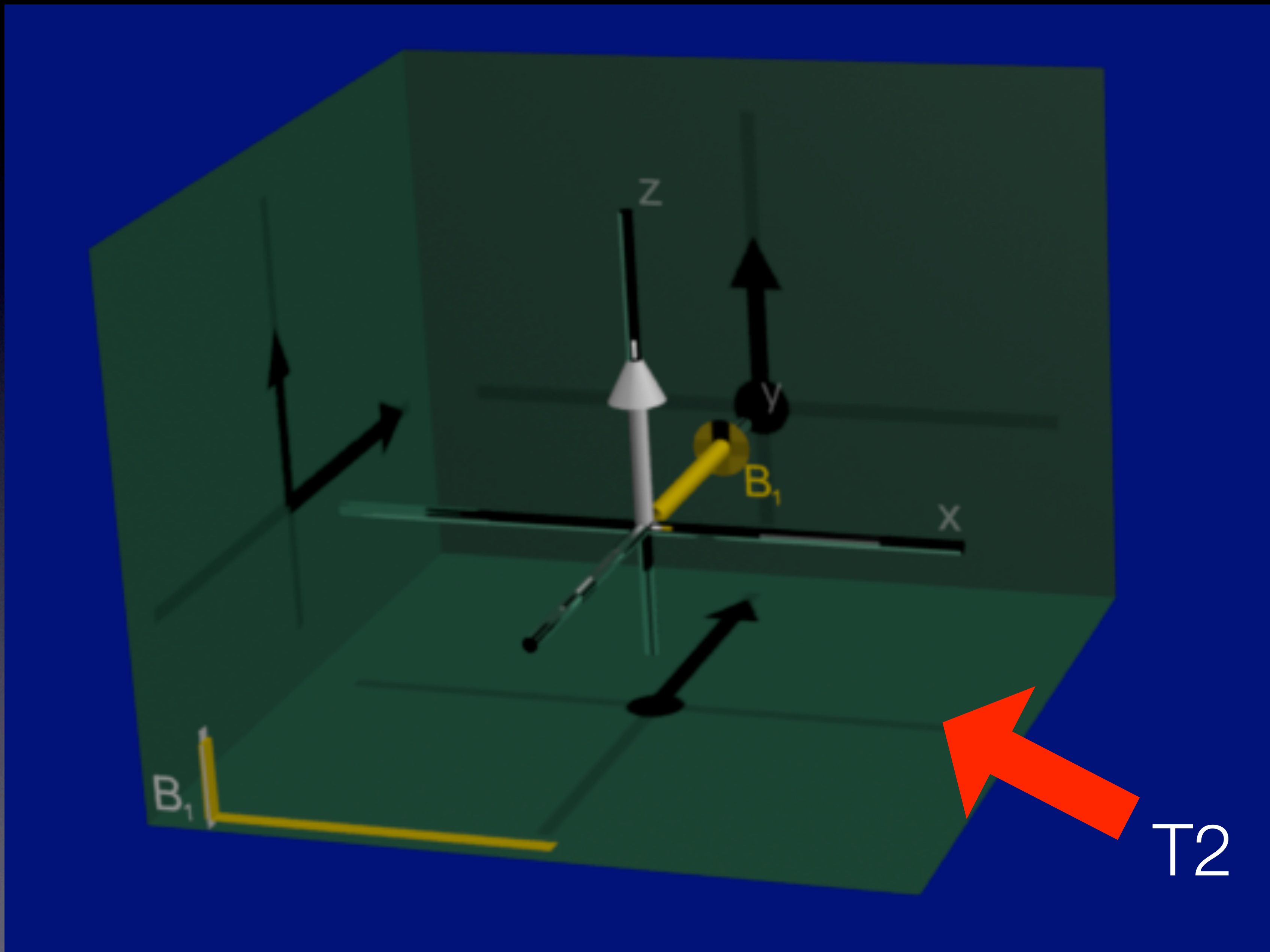
“rotating frame of reference”

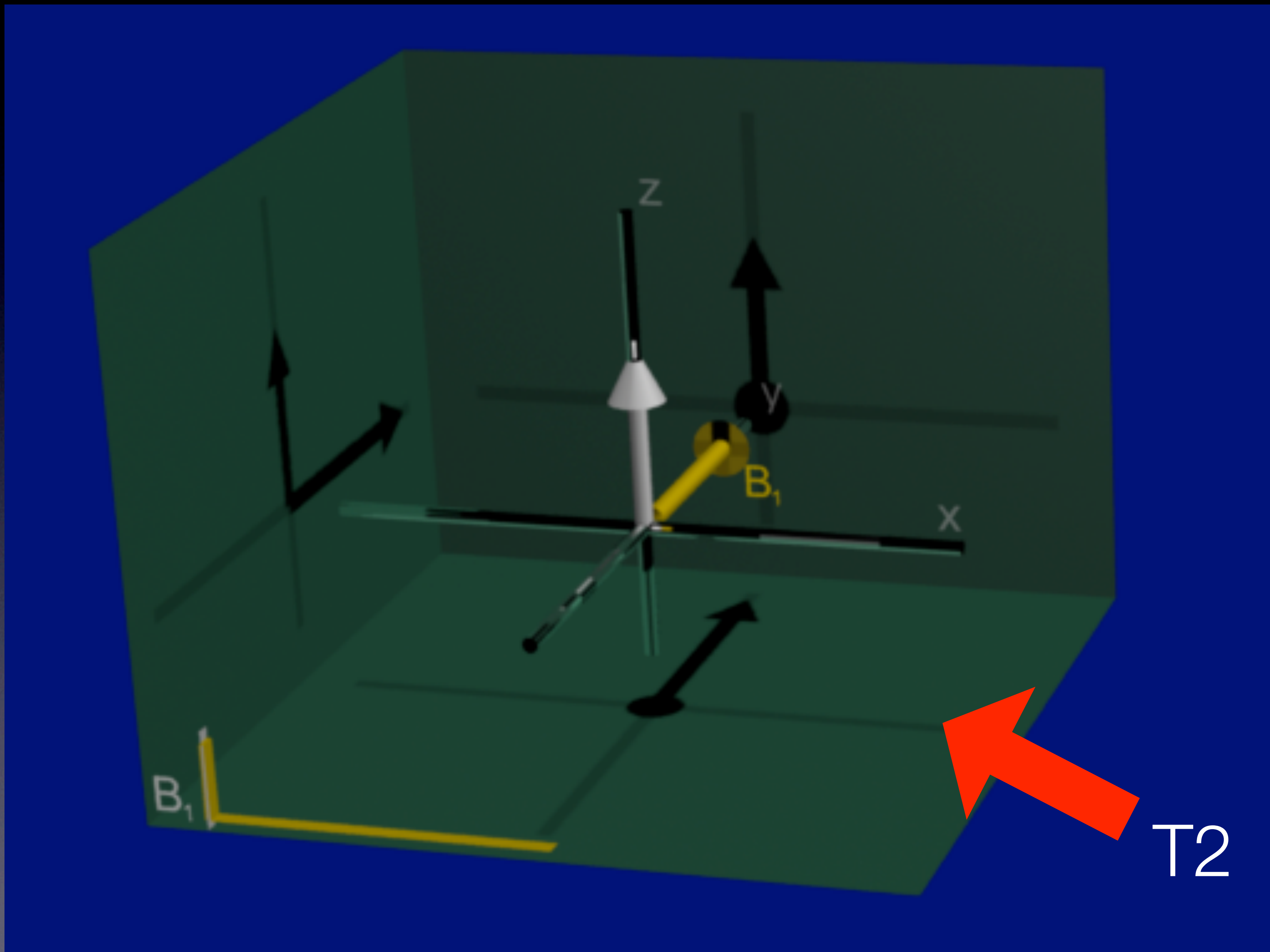

relaxation
main
magnetic
field
Gary
Gloria

T2 is dephasing

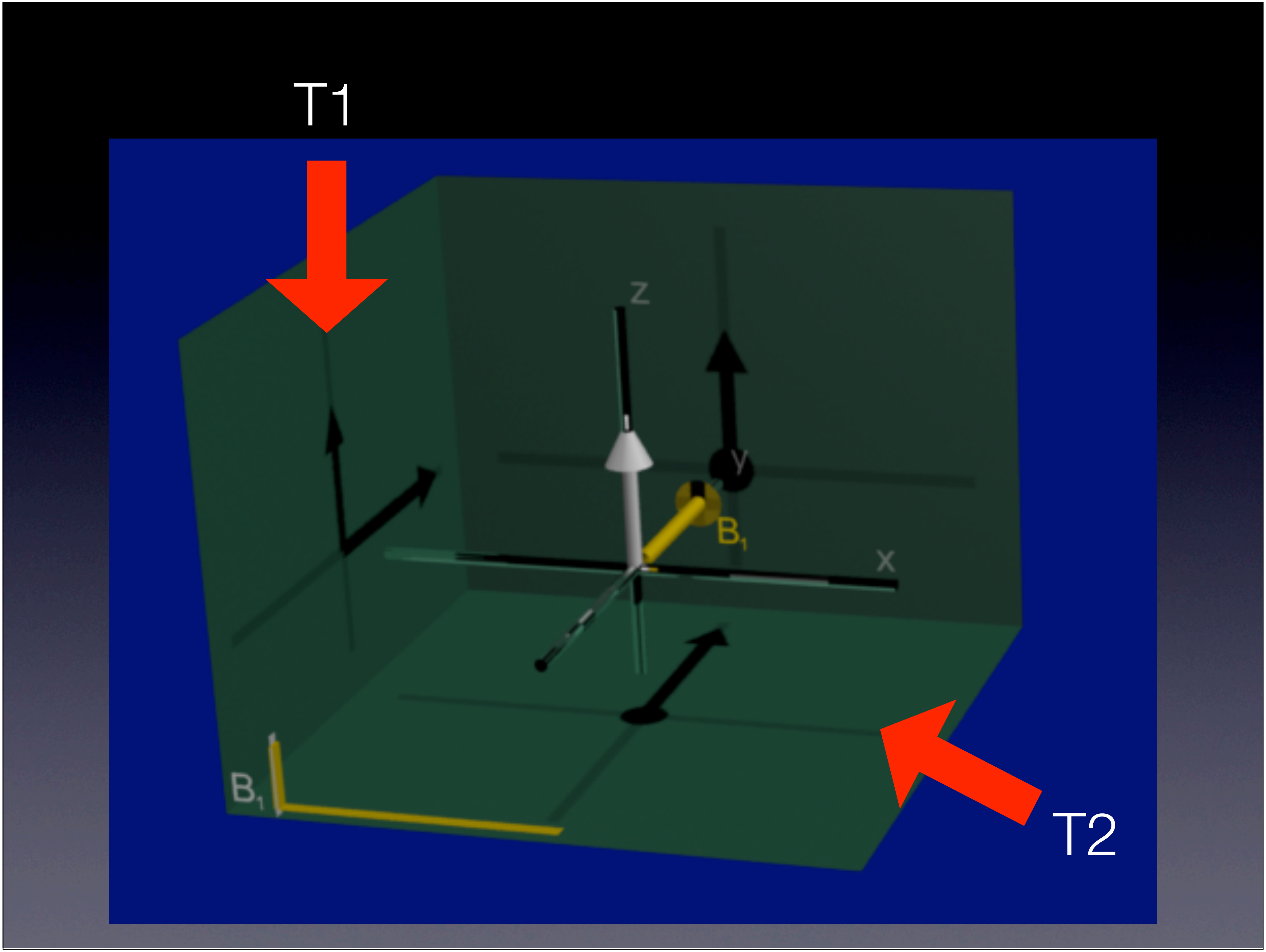


dephasing looks like “less signal”



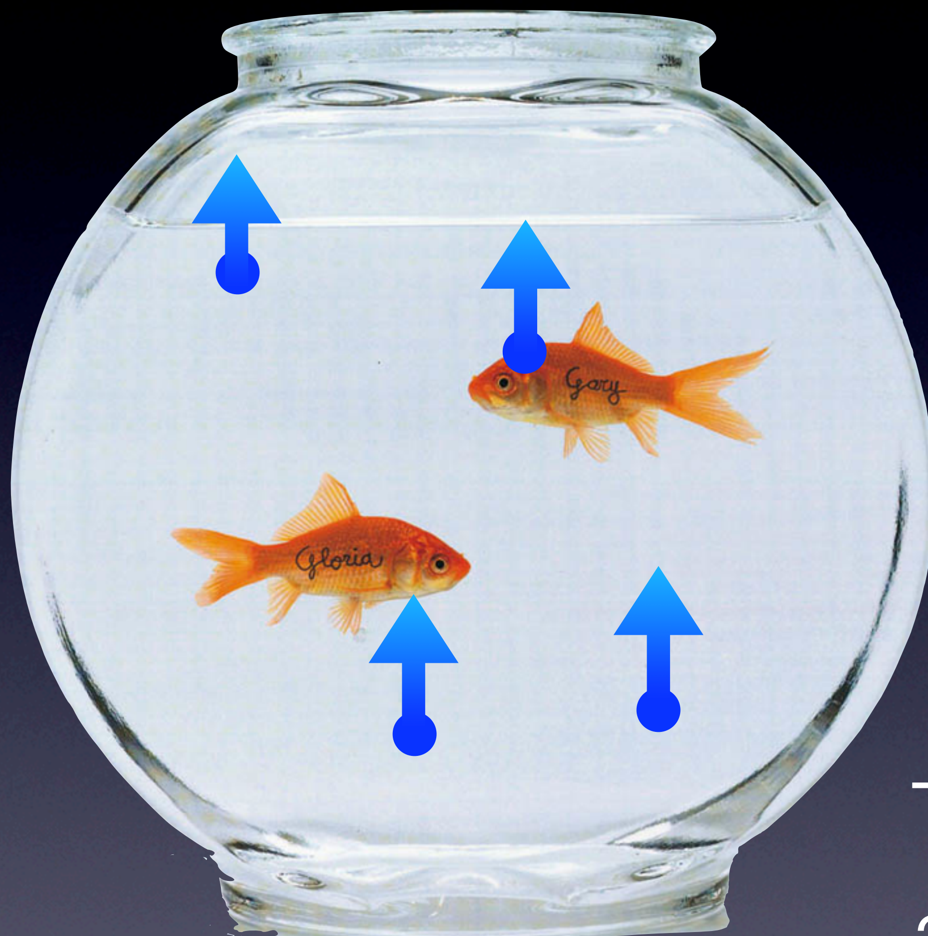


z
y
B1
x
B1
T2



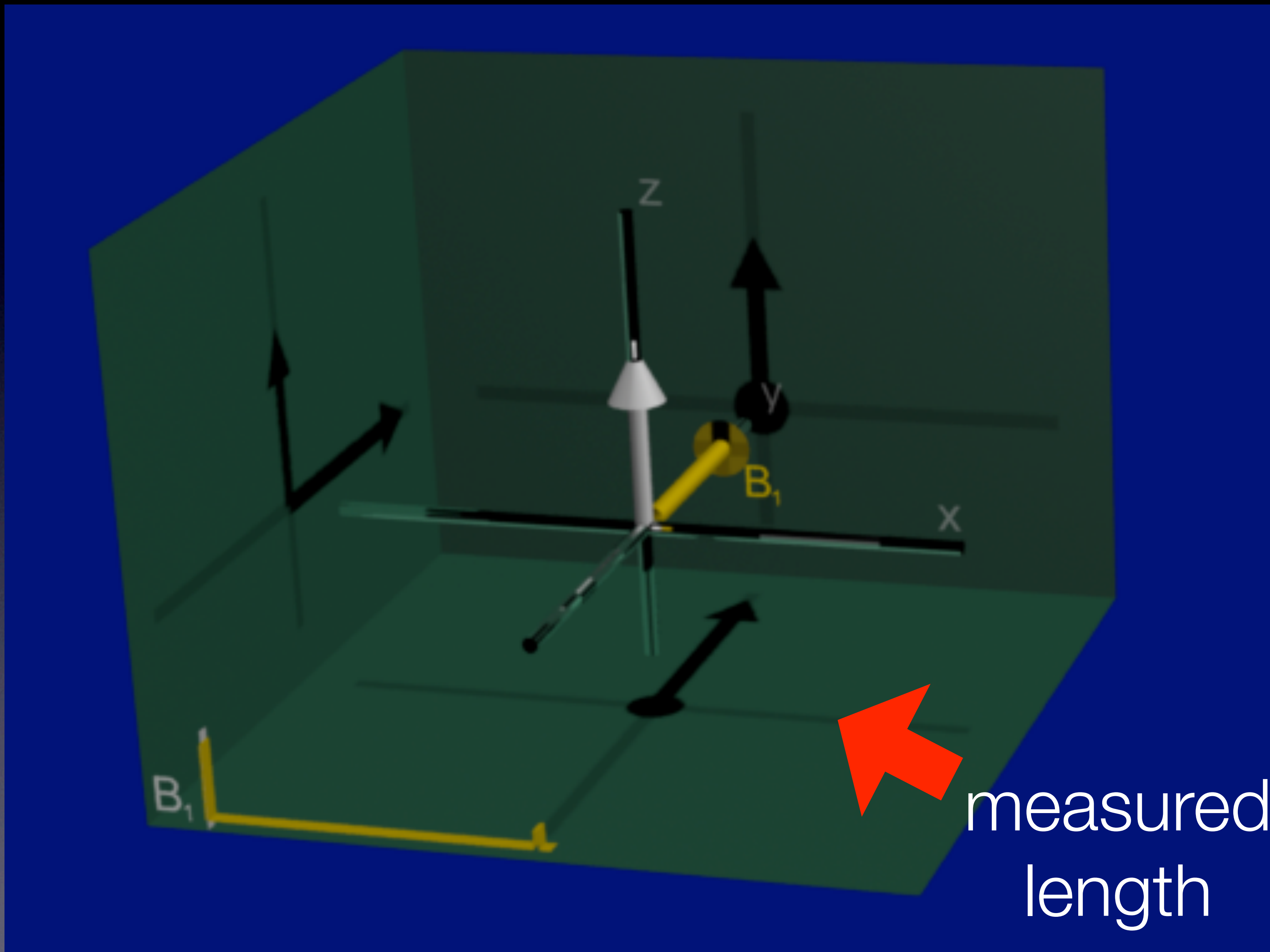
T1
z
y
B1
x
B1
T2

main
magnetic
field



The fish
are what
make it
interesting....

inversion recovery



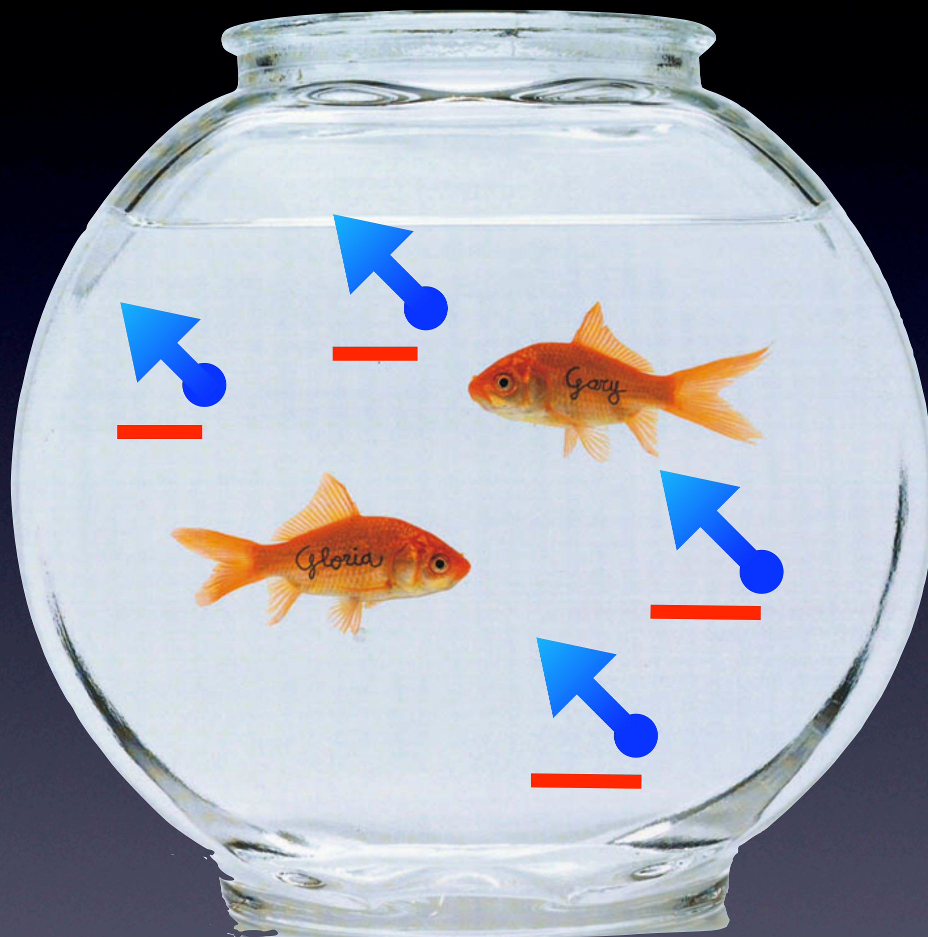
Using **inversion recovery** we can **weight** our measurements for tissues with **specific T1**

How do we get

spatial information?

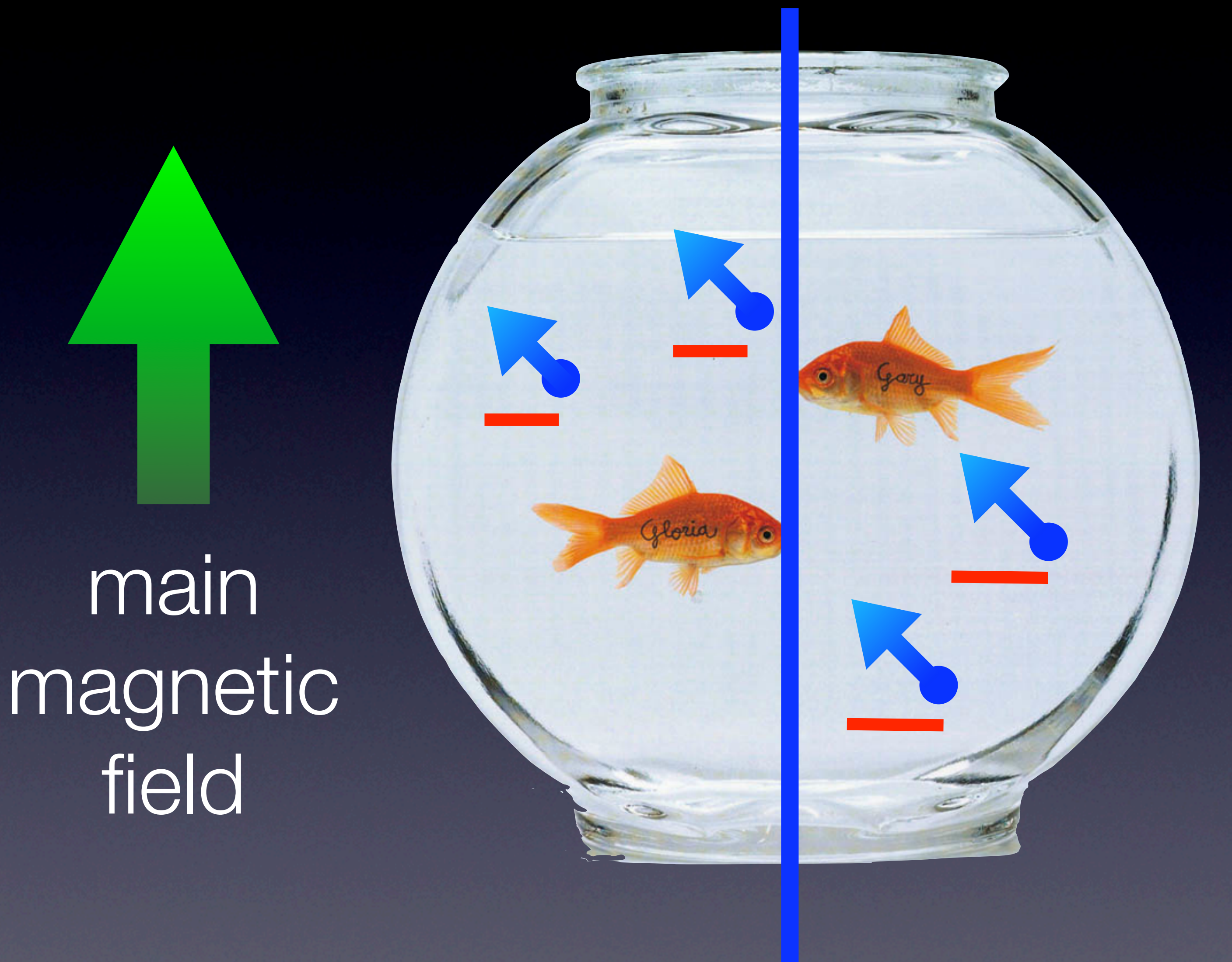
what do we measure?

main magnetic field



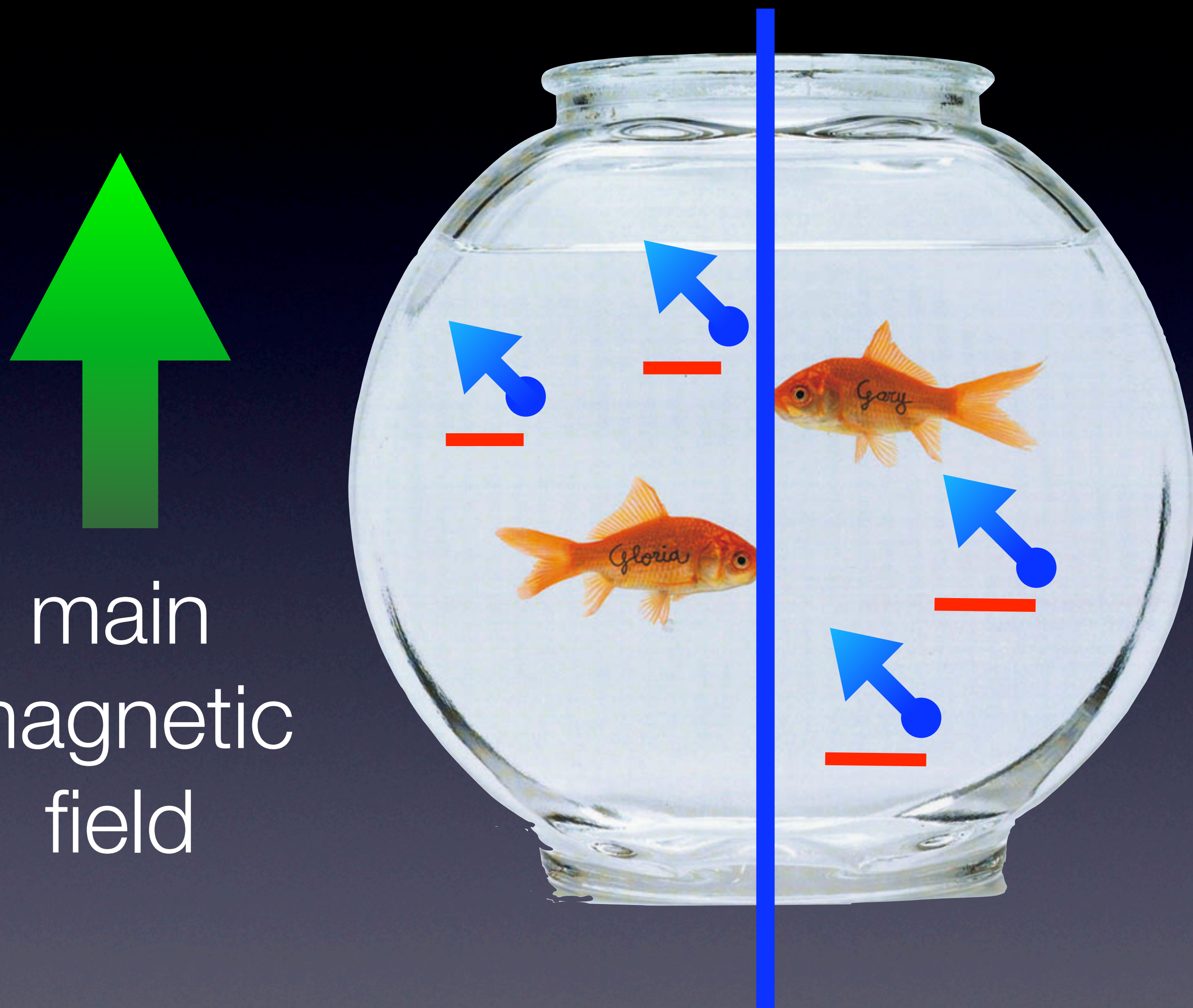
add up the red lines

two voxels (left and right)



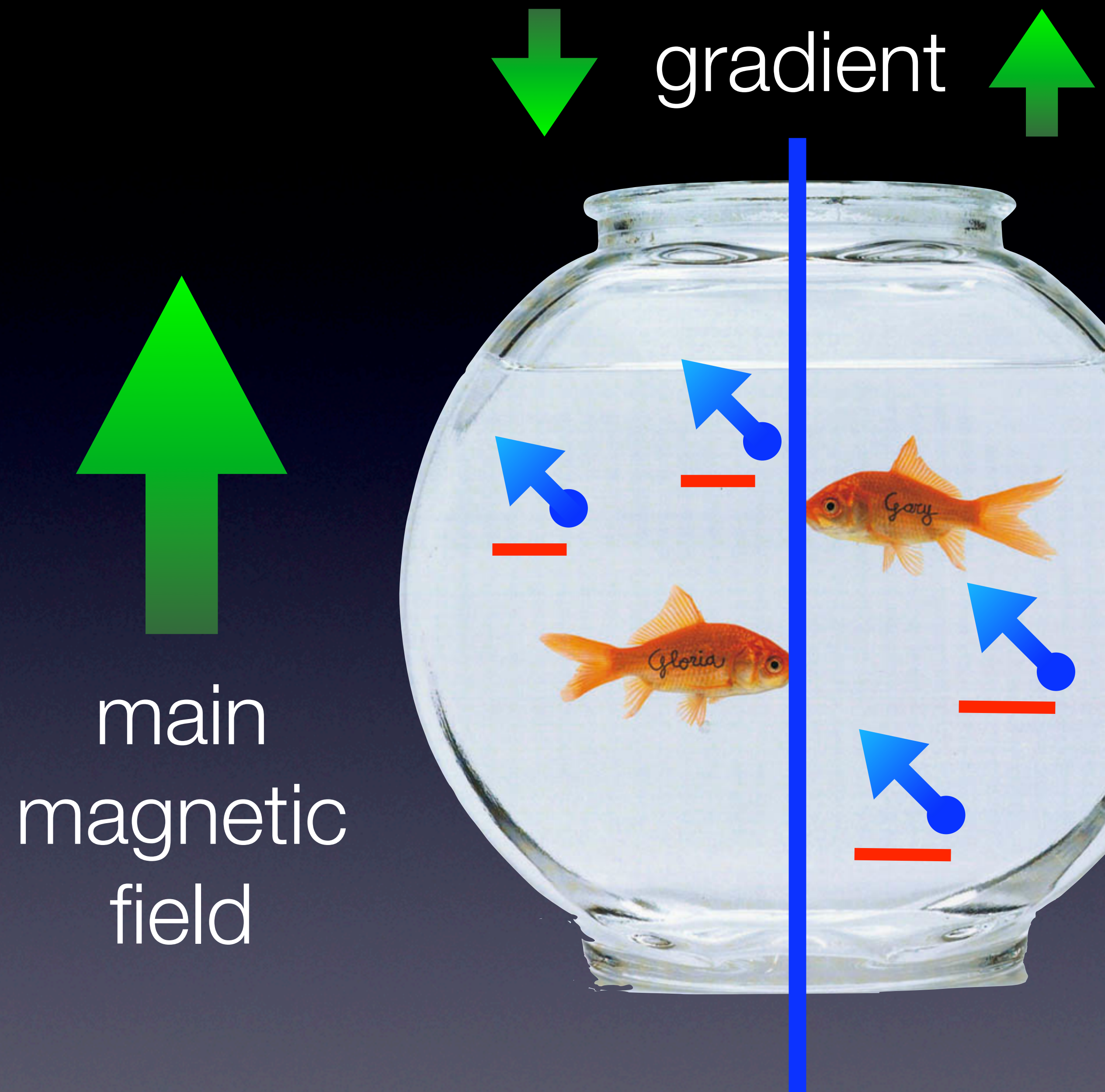
take one measurement (sum)

two voxels (left and right)

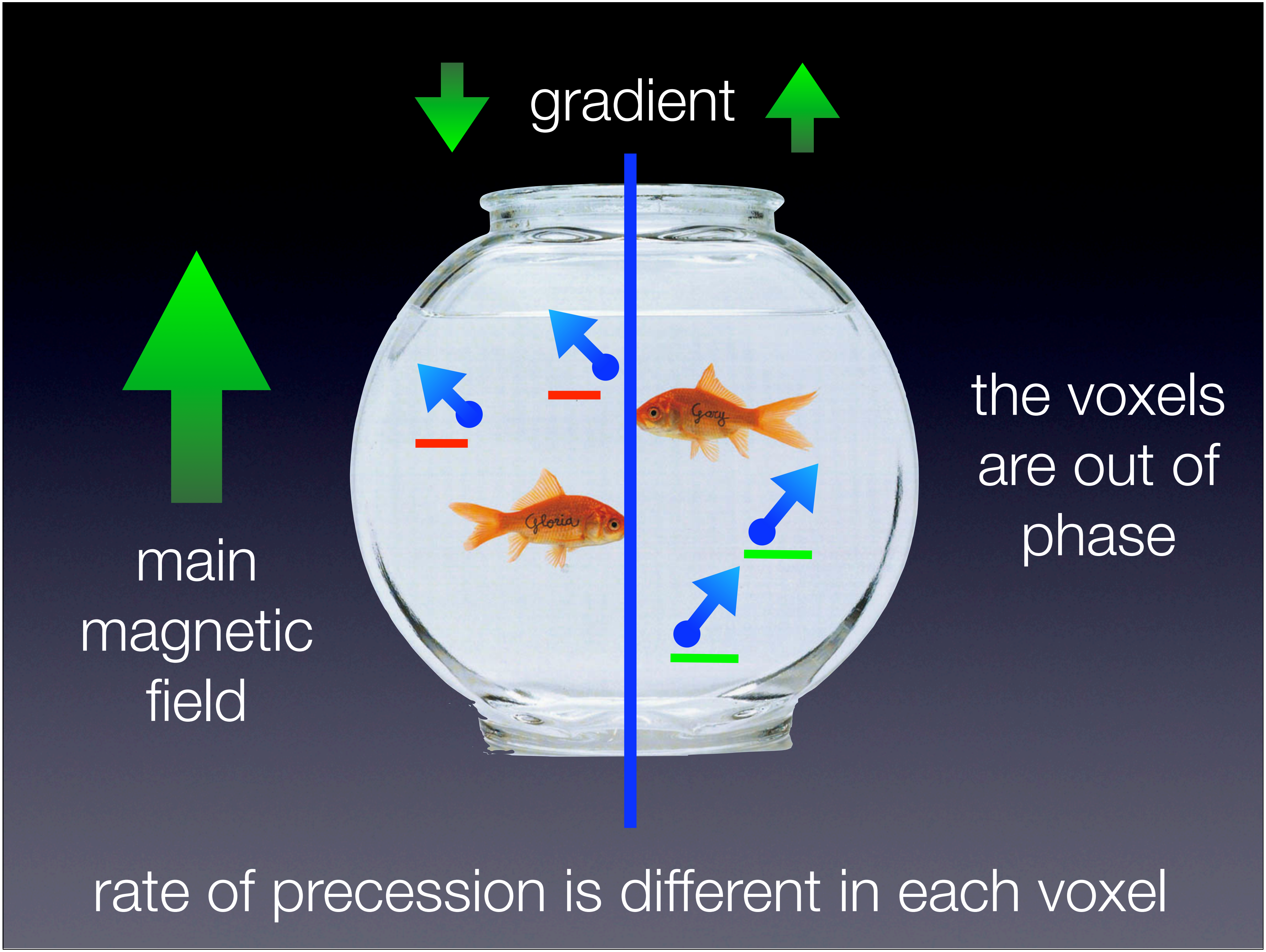


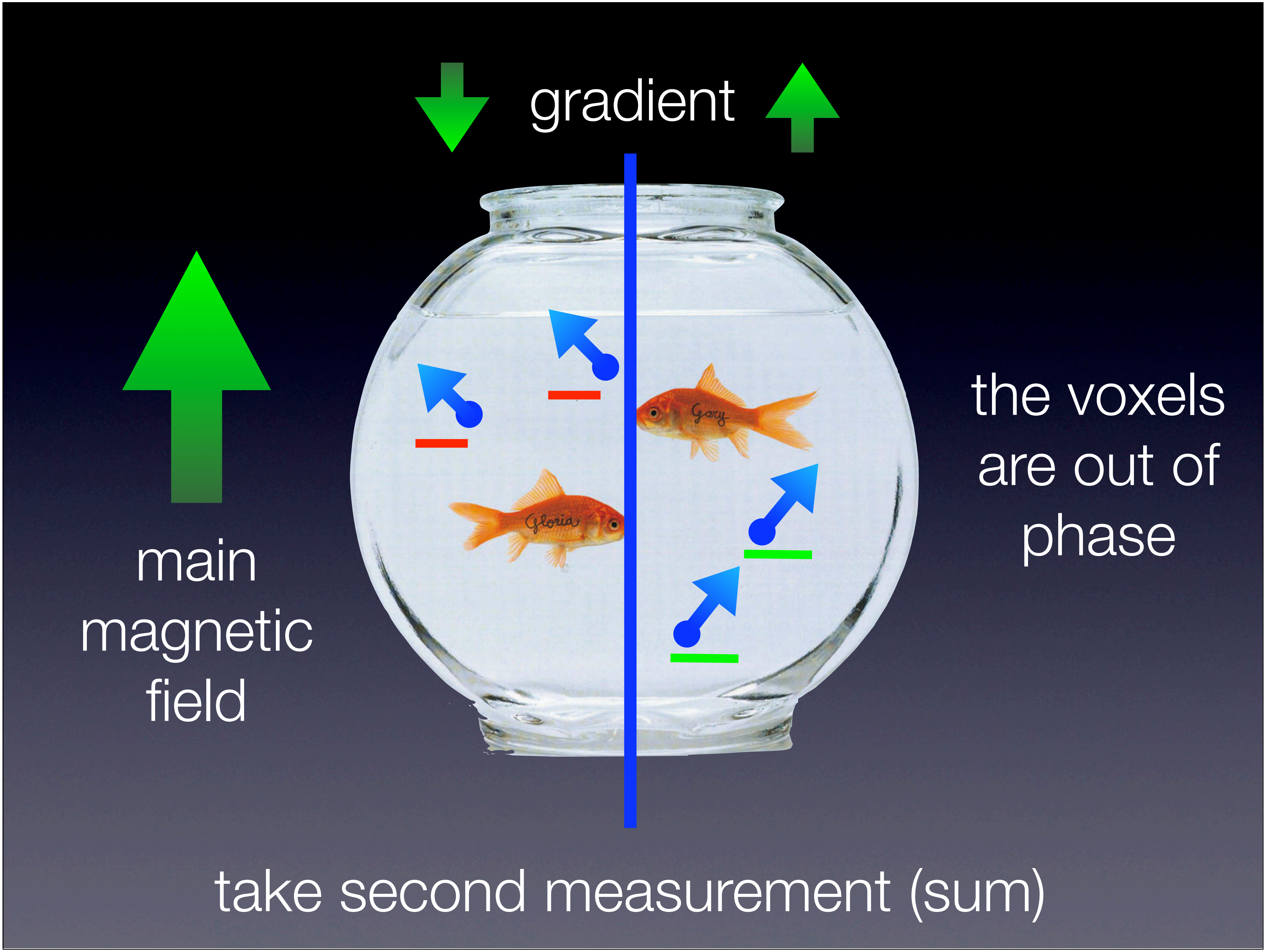
main
magnetic
field

apply a different magnetic field to each half



apply a different magnetic field to each half


gradient
the voxels are out of phase
main magnetic field
Gloria
Gary
rate of precession is different in each voxel


gradient
main
magnetic
field
Gary
Gloria
the voxels
are out of
phase
take second measurement (sum)

1st measurement: left + right

2nd measurement: left - right

1st measurement: left + right

2nd measurement: left - right

---

add them: 2 x left

1st measurement: left + right

2nd measurement: left - right

---

subtract them: 2 x right

Real sequences sum together fractional amounts from all the voxels.

The fractions are changed using the x-, y-, or z-gradients.

The voxels are “unmixed” from all the measurements using an Inverse Fourier Transform.

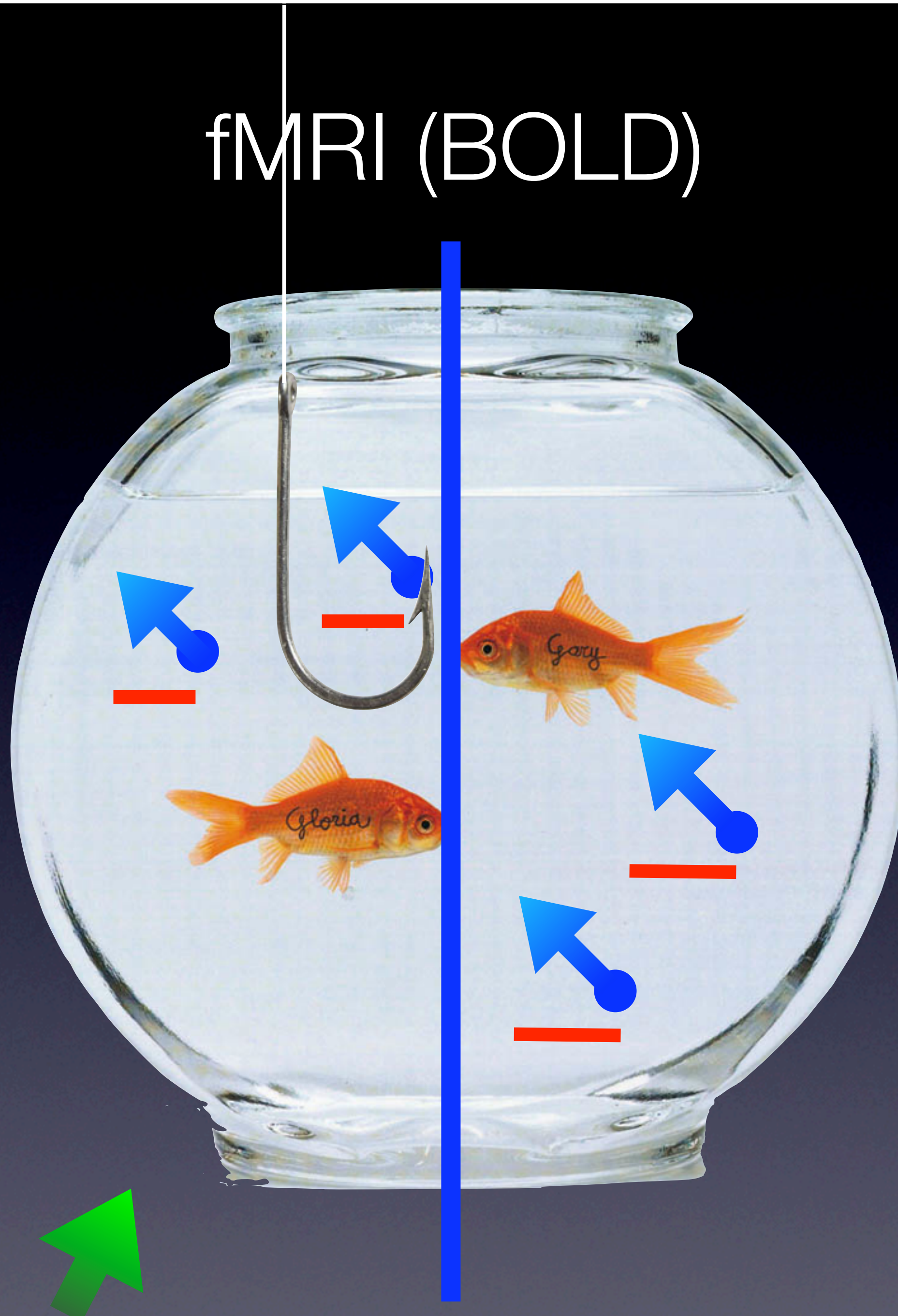
A Pulse Sequence

1. “Prepare” (invert, flip)
2. Localize (Gradients)
3. Measure

repeat

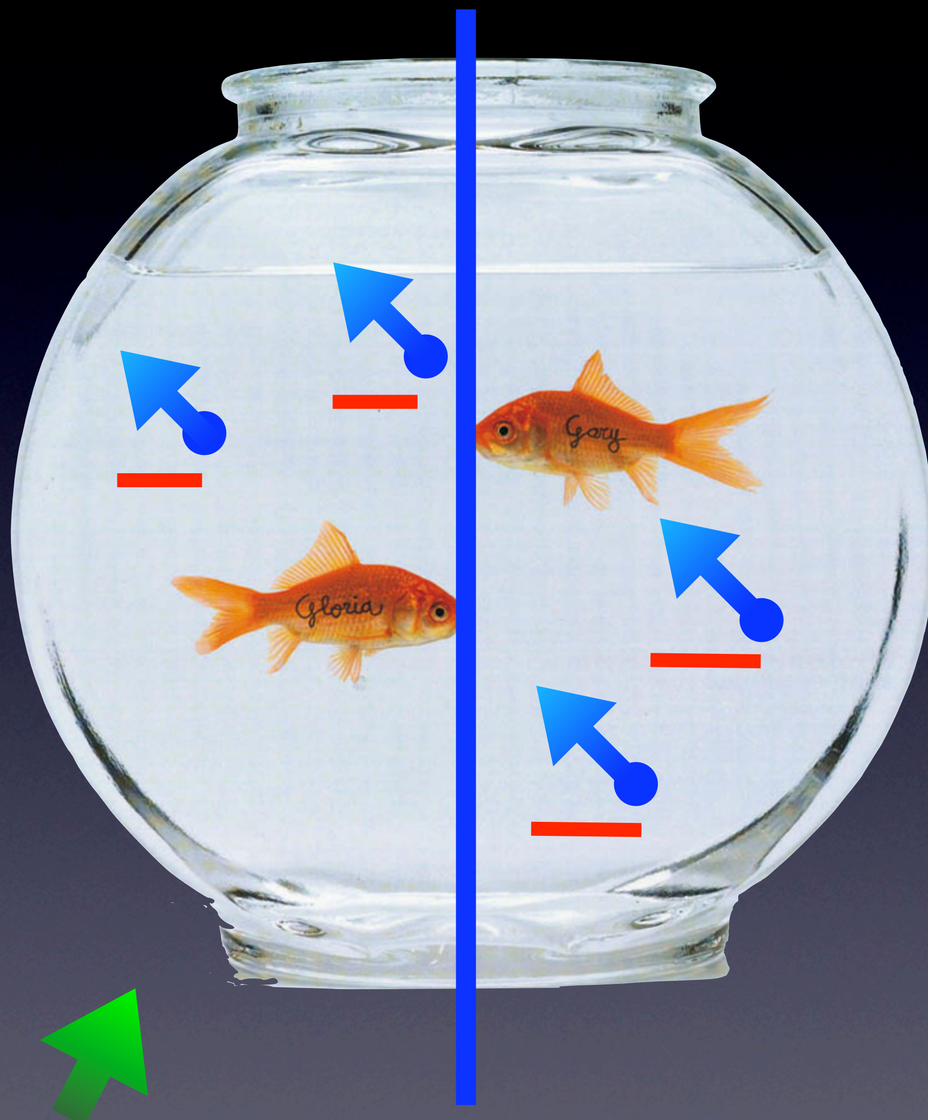
4. Relax
5. Go back to 1.

fMRI (BOLD)



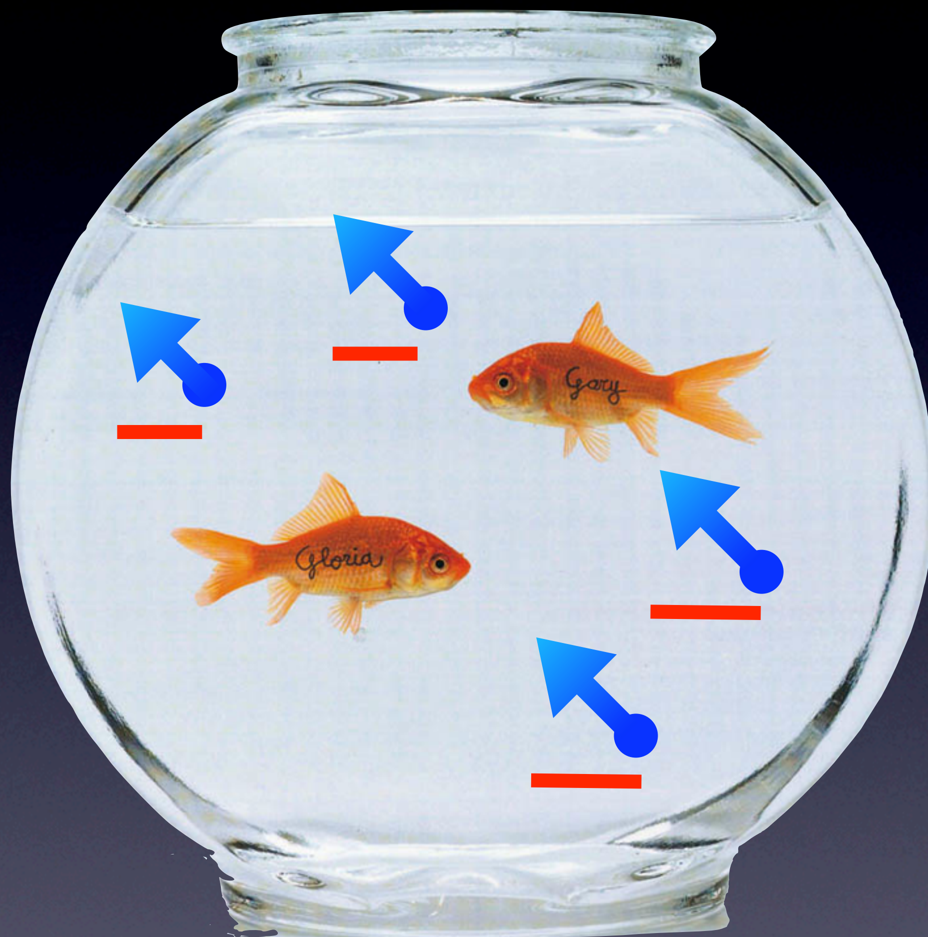
this side dephases faster = less signal

fMRI (BOLD)

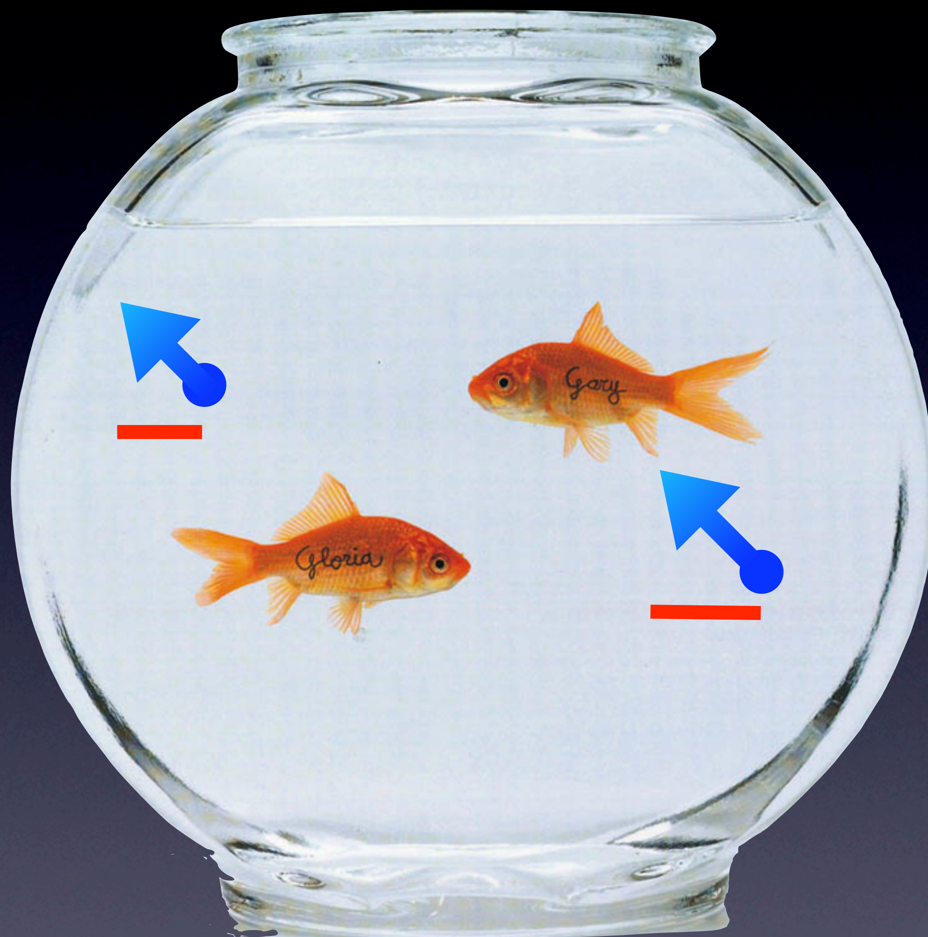


this side's T2 returns to normal

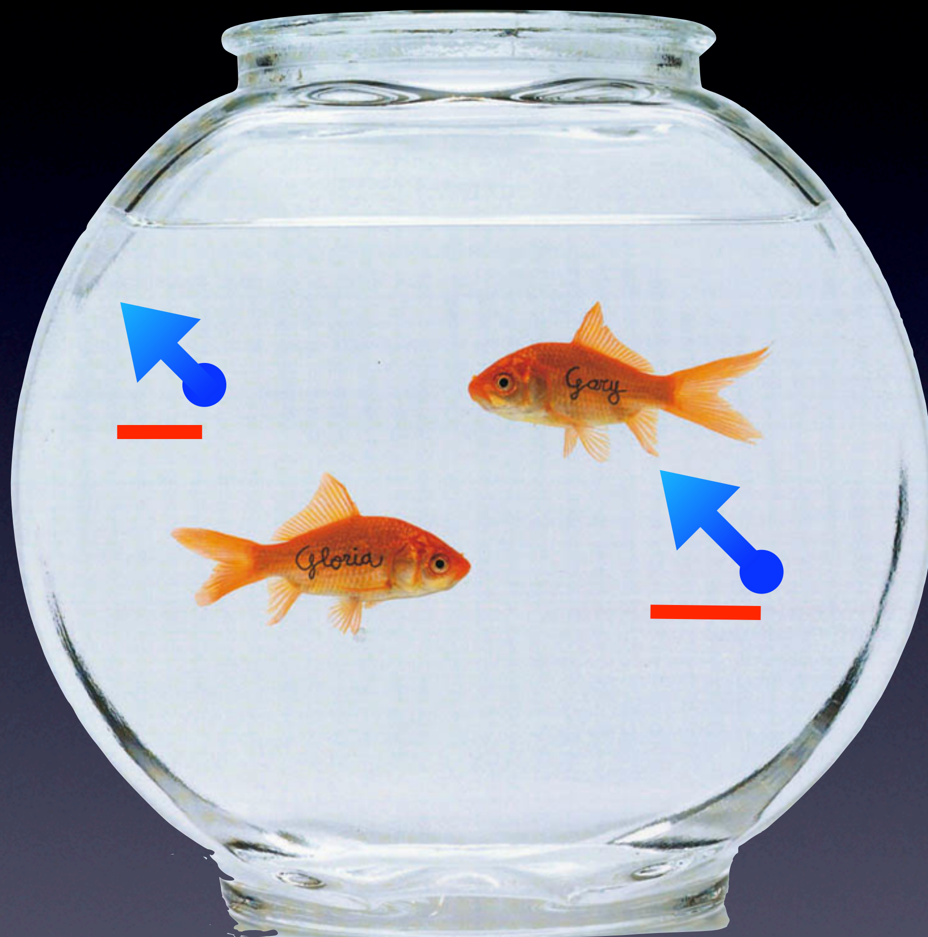
Diffusion



Diffusion

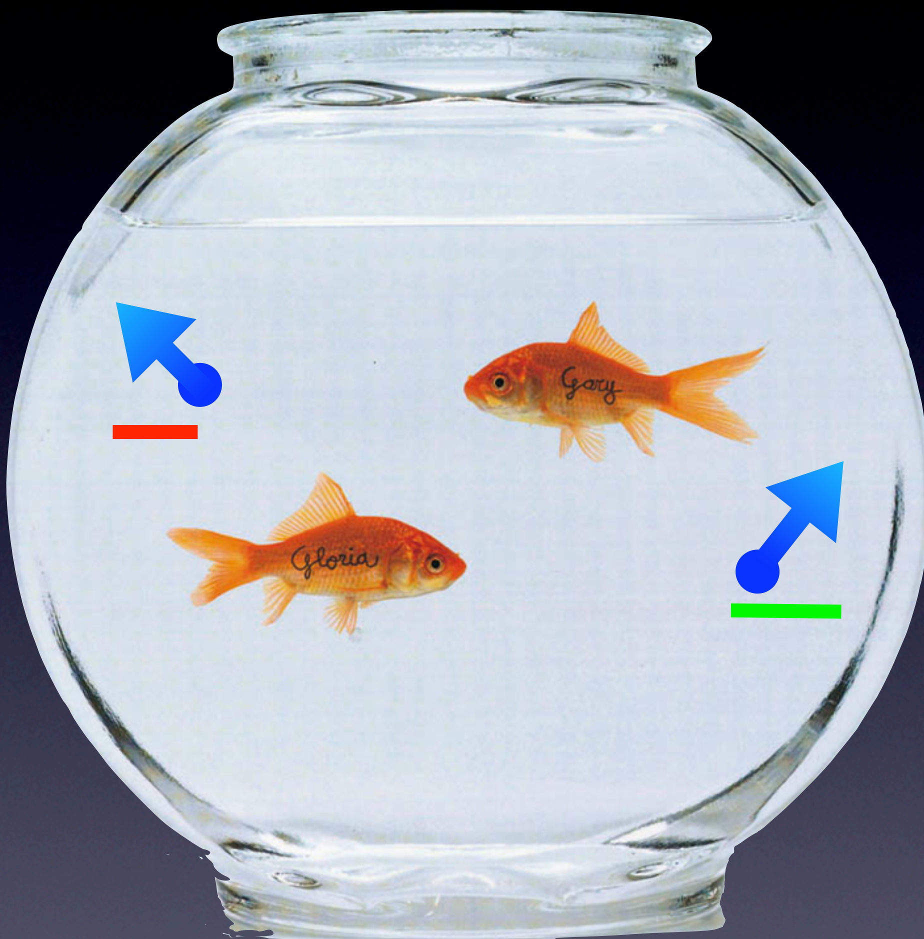


Diffusion



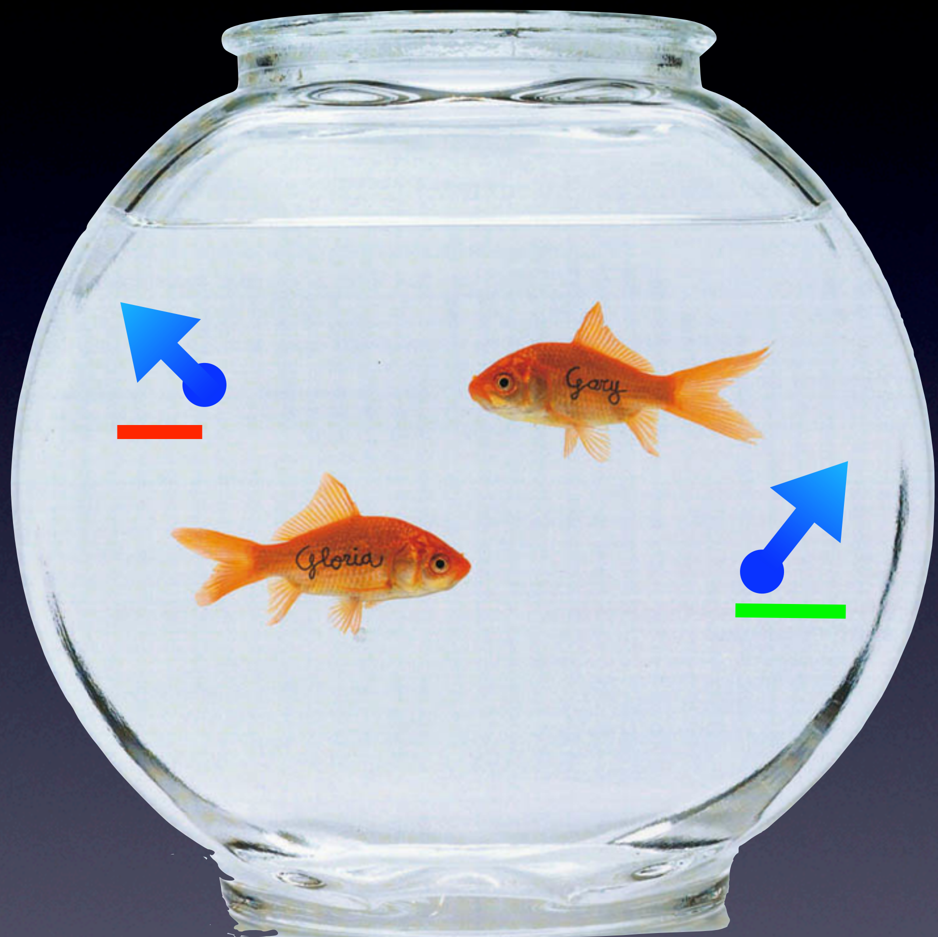
gradient

Diffusion



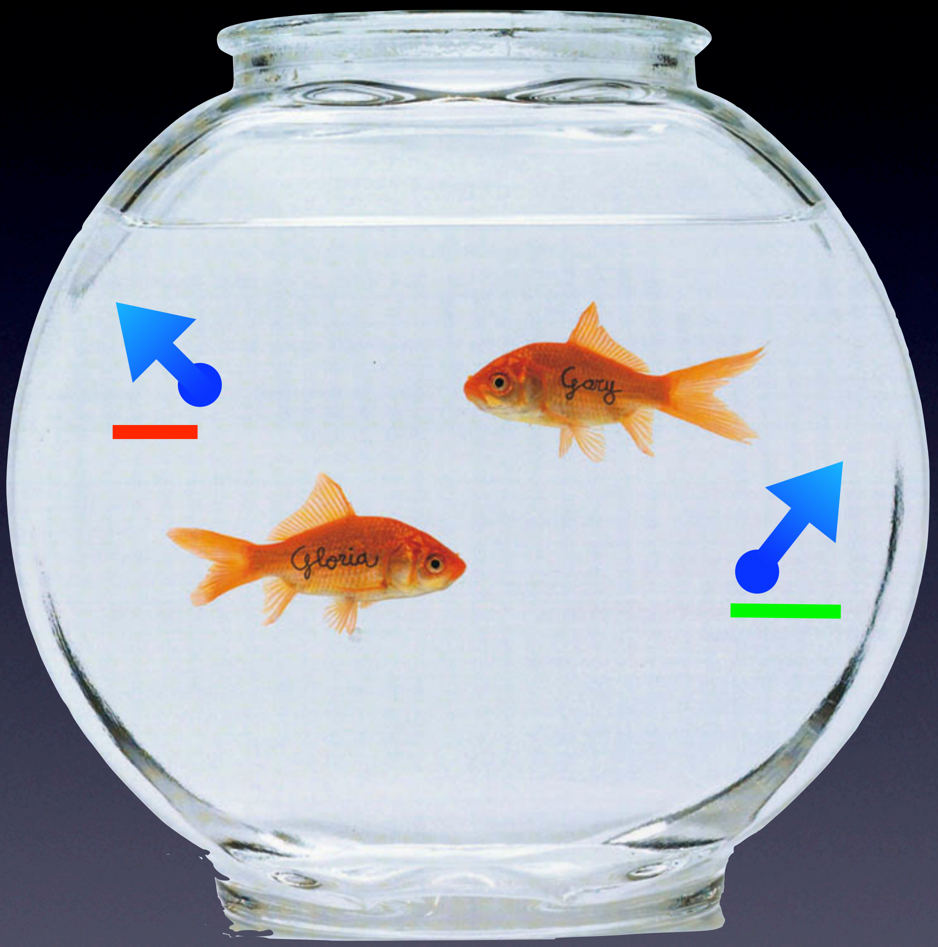
gradient

Diffusion



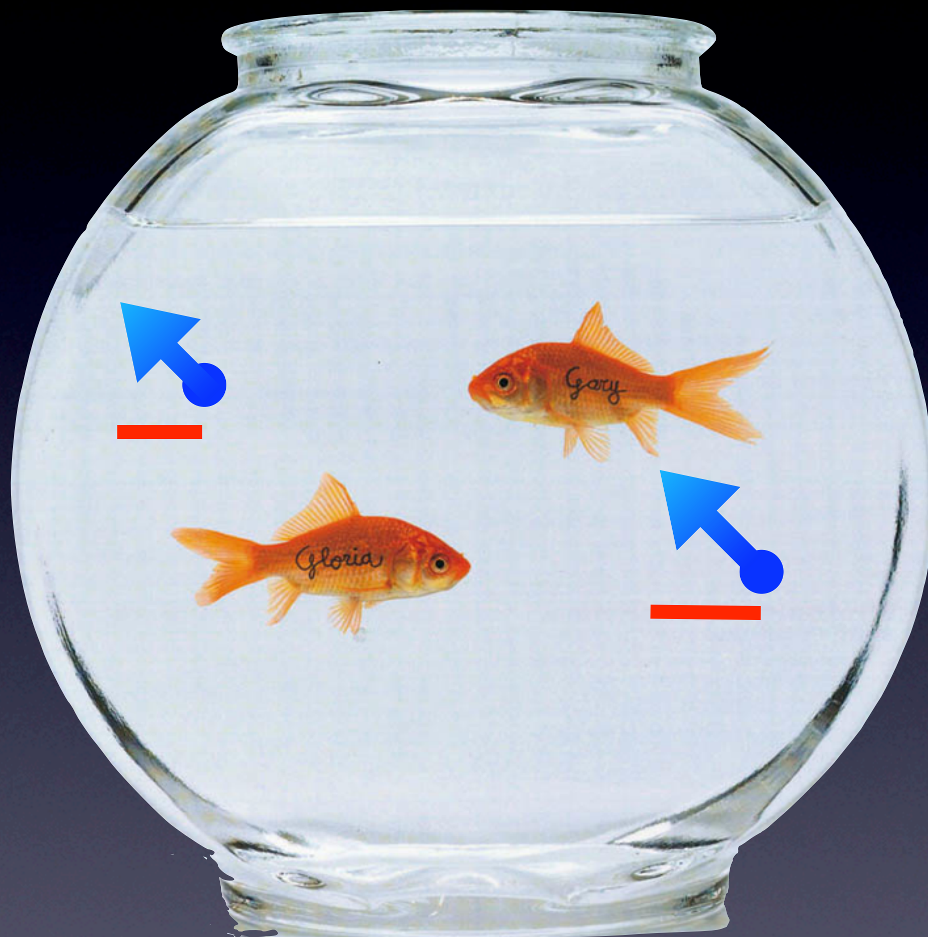
no gradient

Diffusion



opposite gradient

Diffusion



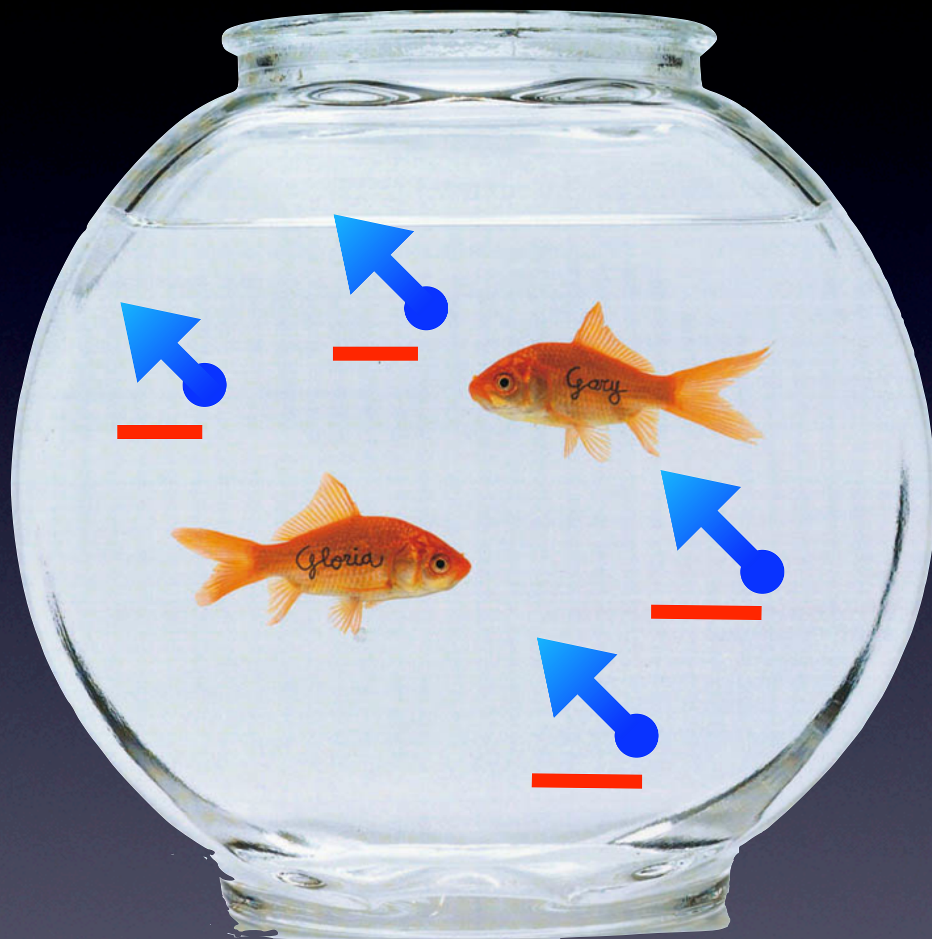
opposite
gradient

Water molecules diffuse (move) inside of all tissues.

At 37 C, water diffuse has diffusion rate of 3×10^{-3} mm^2/s.

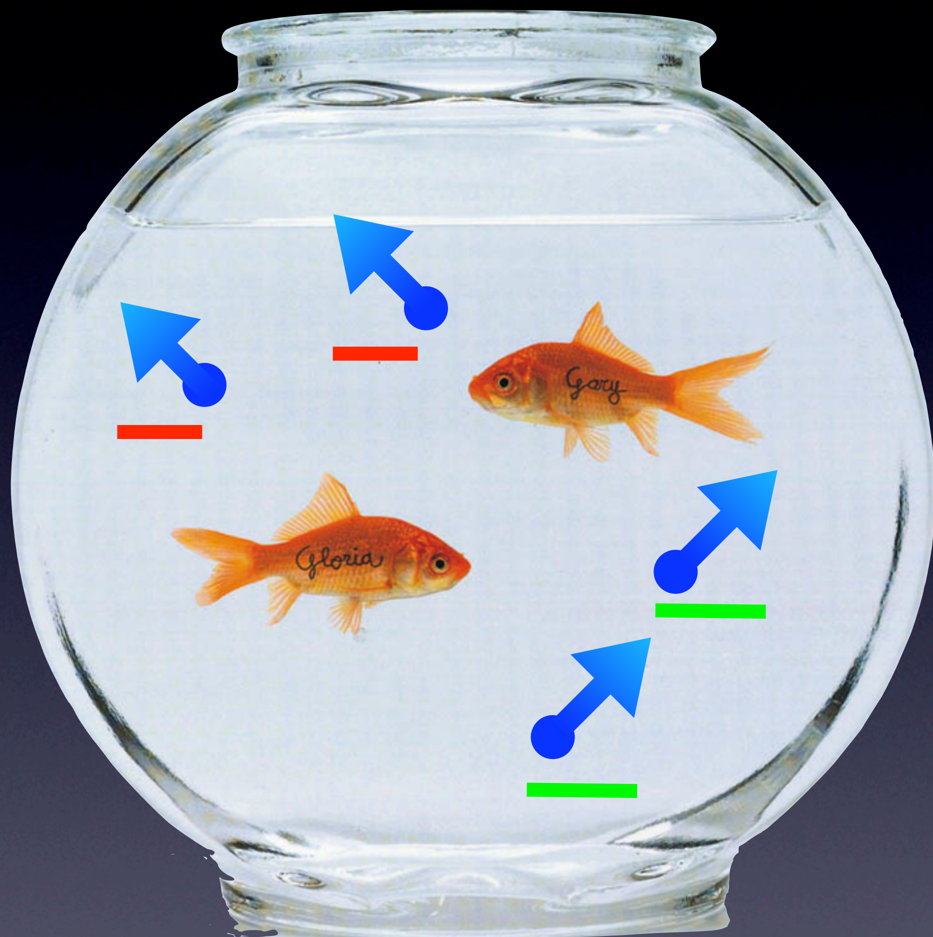
We expect a displacement of about 17 μm in 50 ms

Diffusion



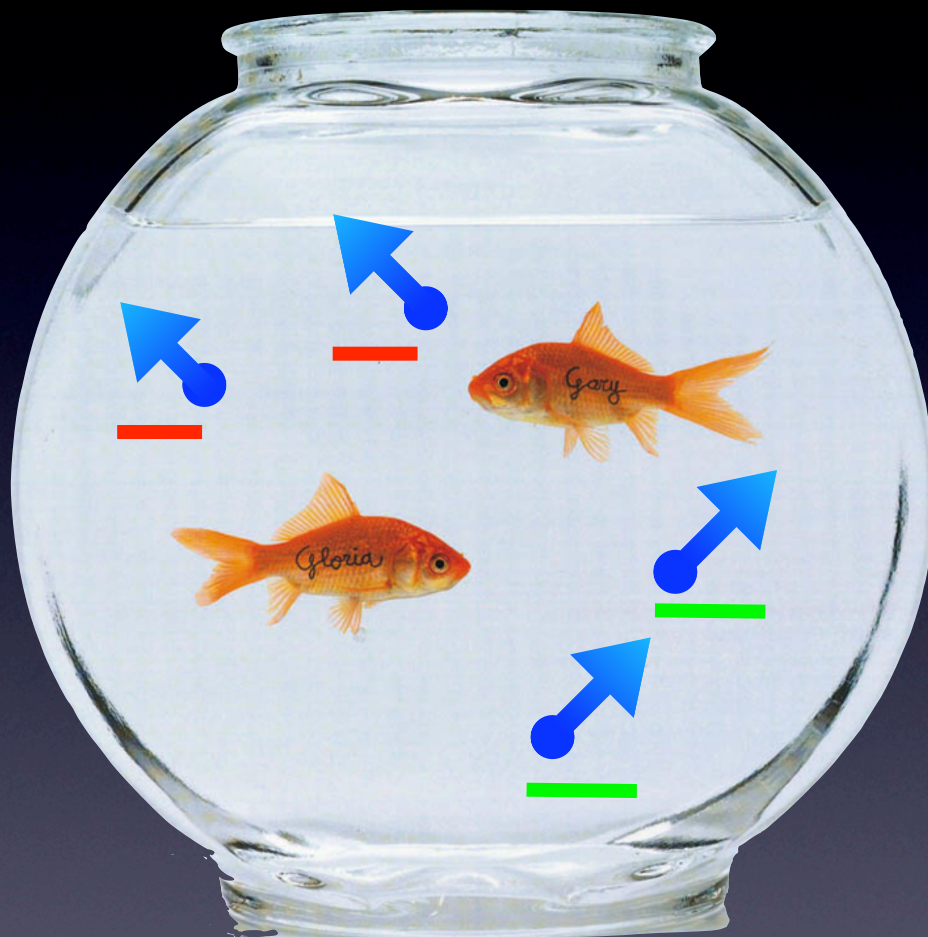
gradient

Diffusion



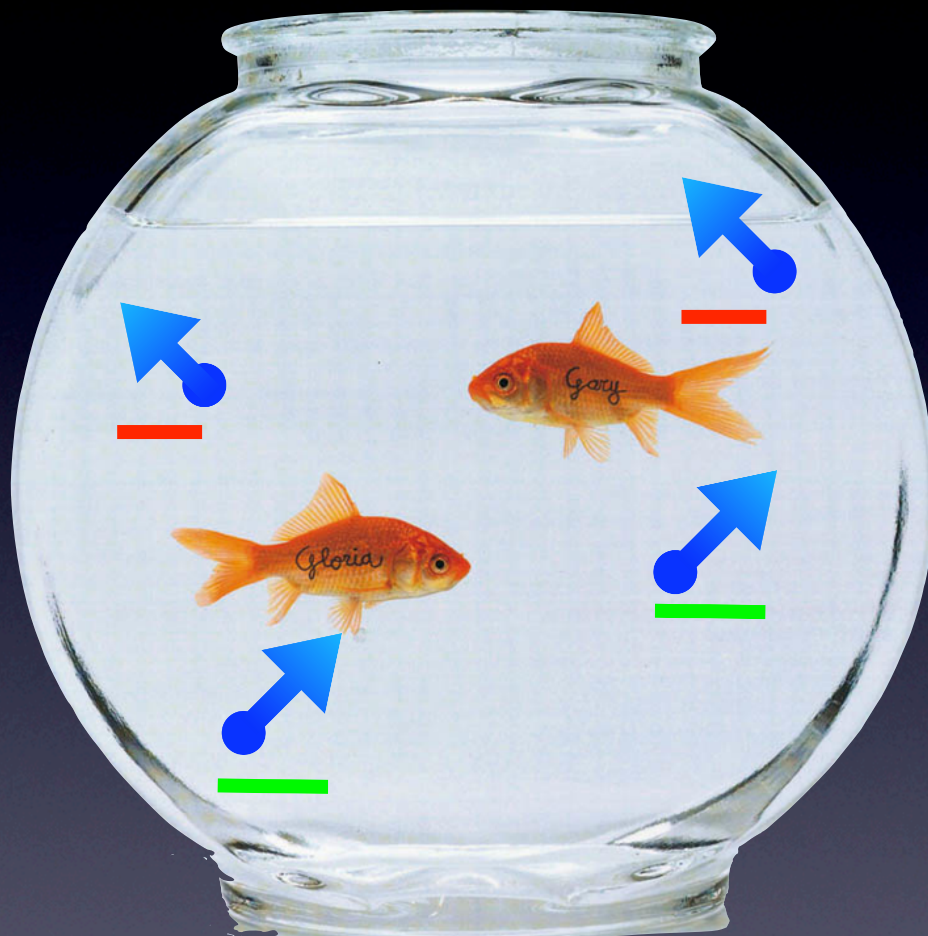
gradient

Diffusion



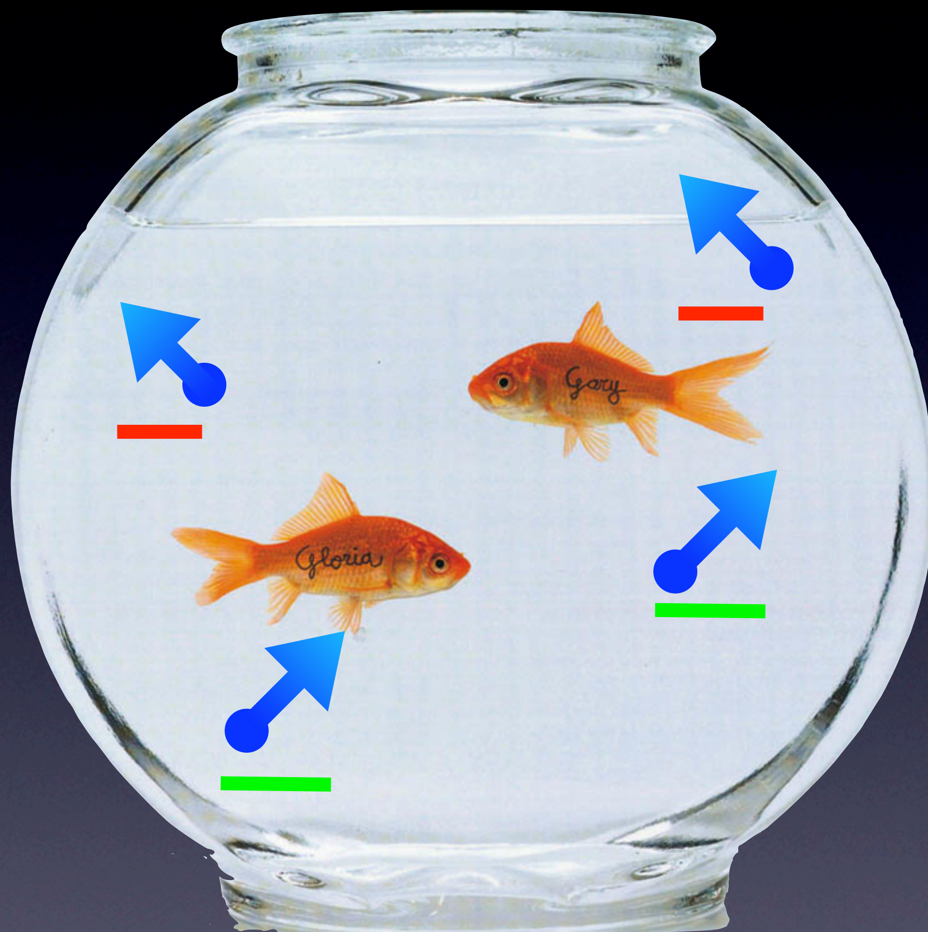
no gradient

Diffusion



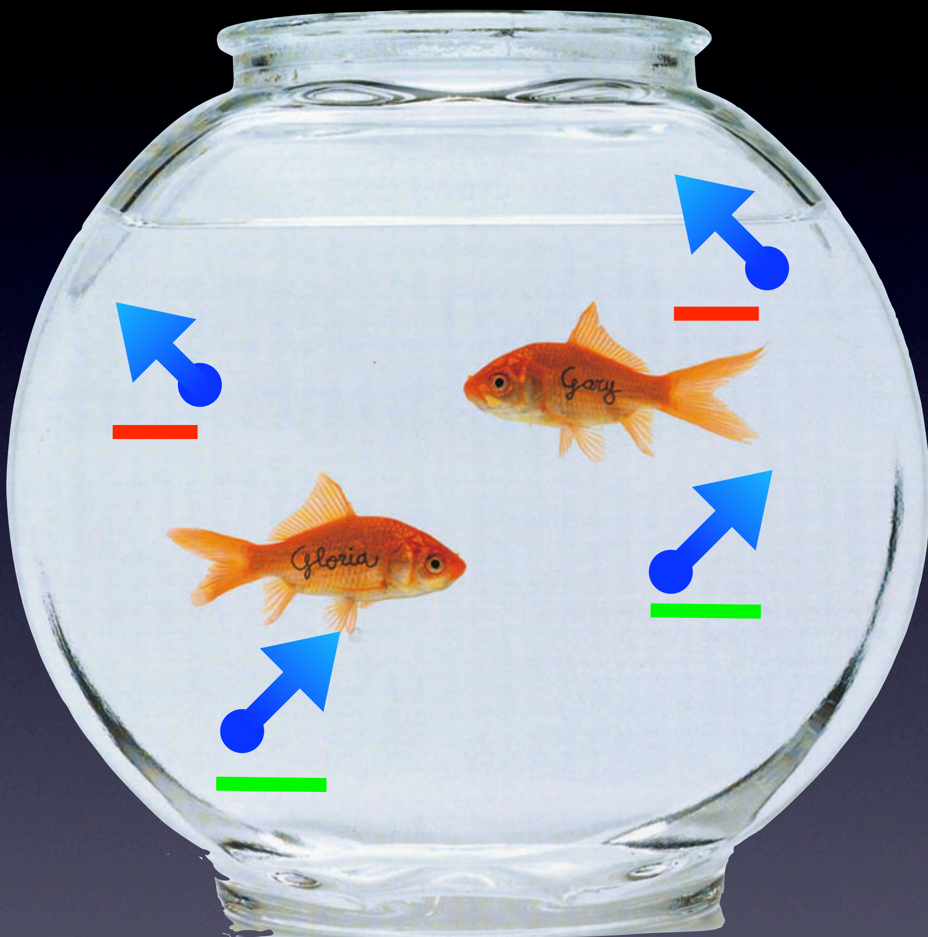
no gradient

Diffusion



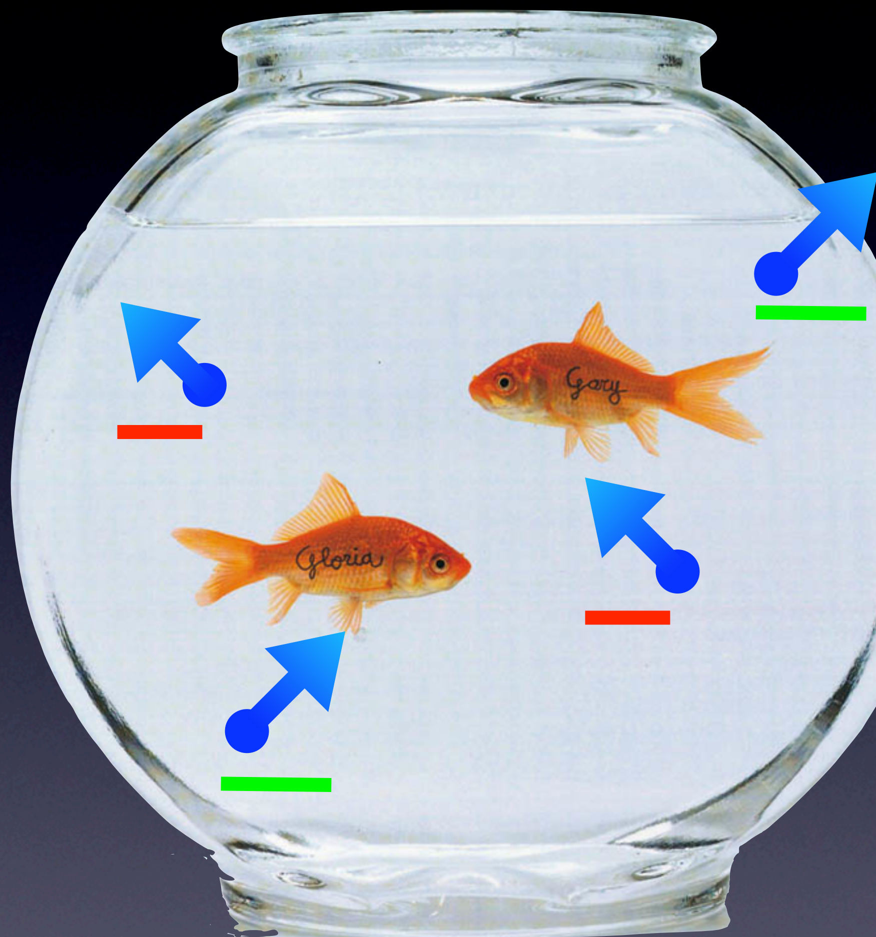
no gradient

Diffusion



opposite
gradient

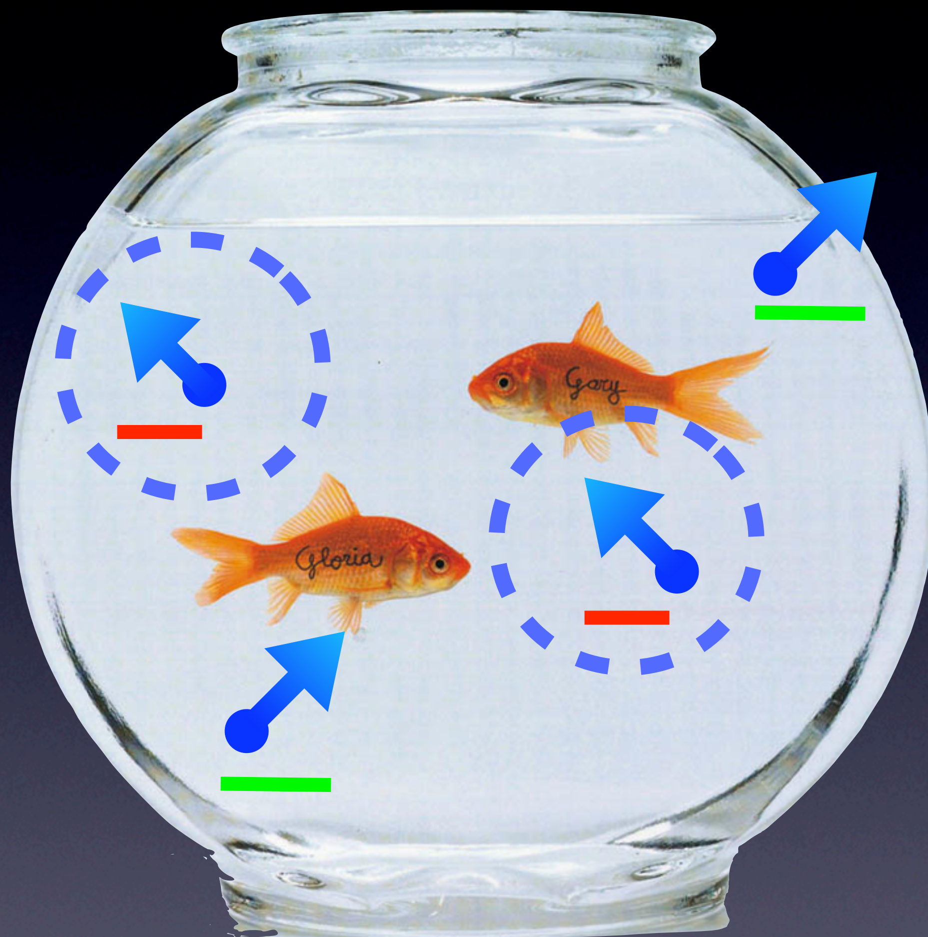
Diffusion



opposite
gradient

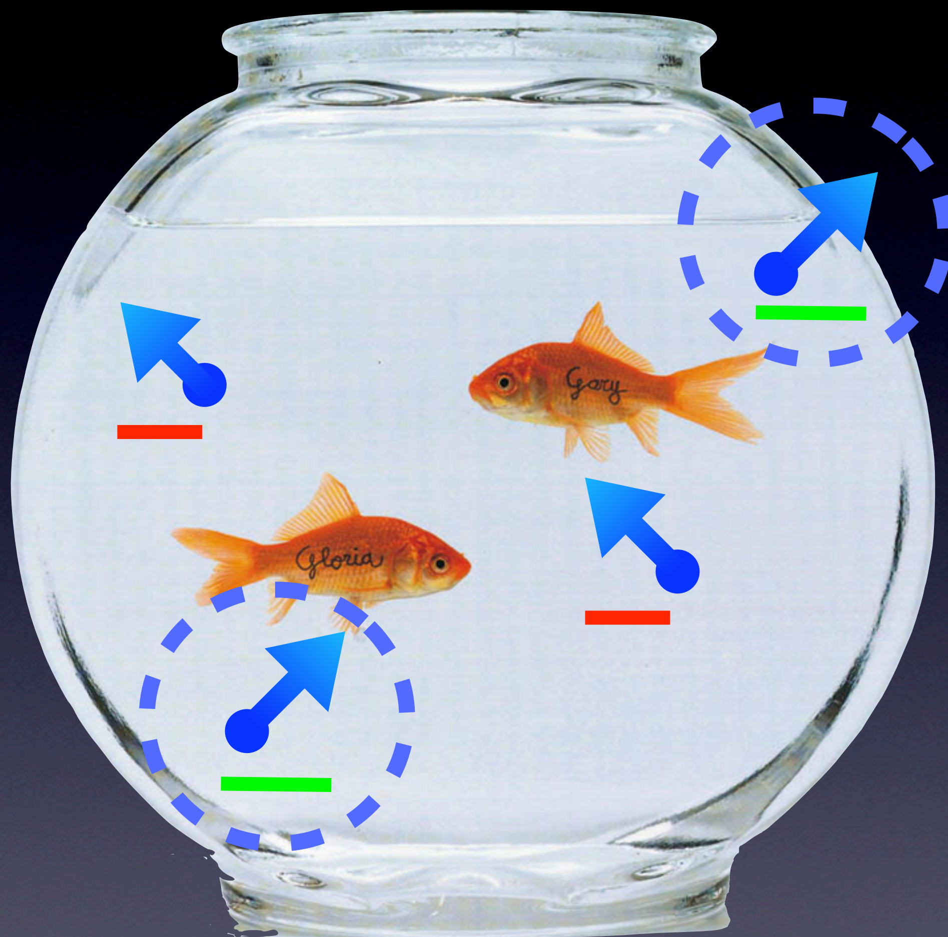
Diffusion

stationary =
re-focused



opposite
gradient

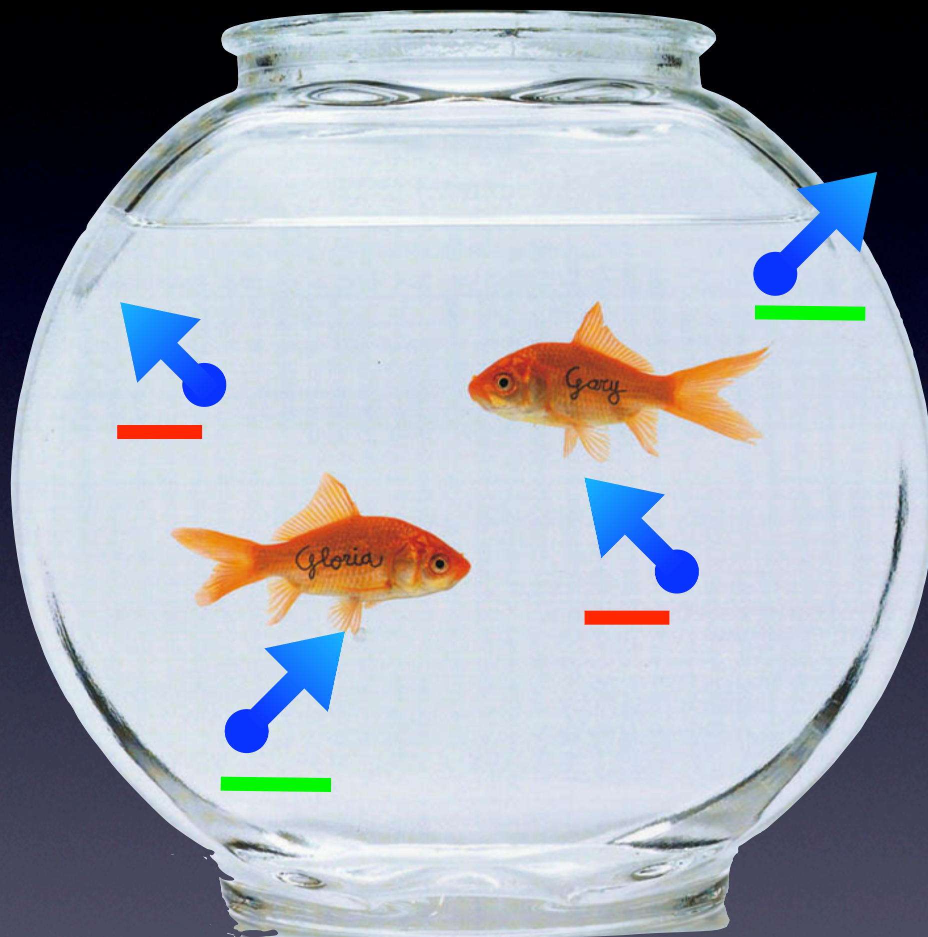
Diffusion



diffused = not re-focused

opposite gradient

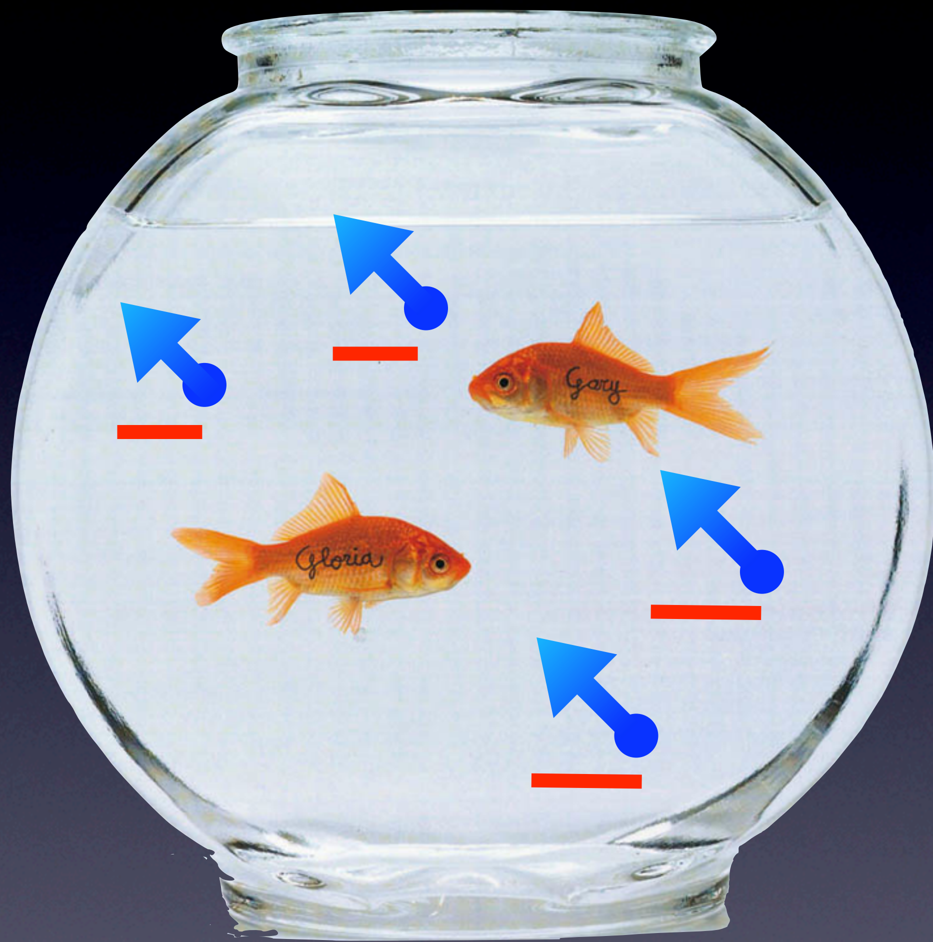
Diffusion



signal has cancelled out because of diffusion parallel to the gradients

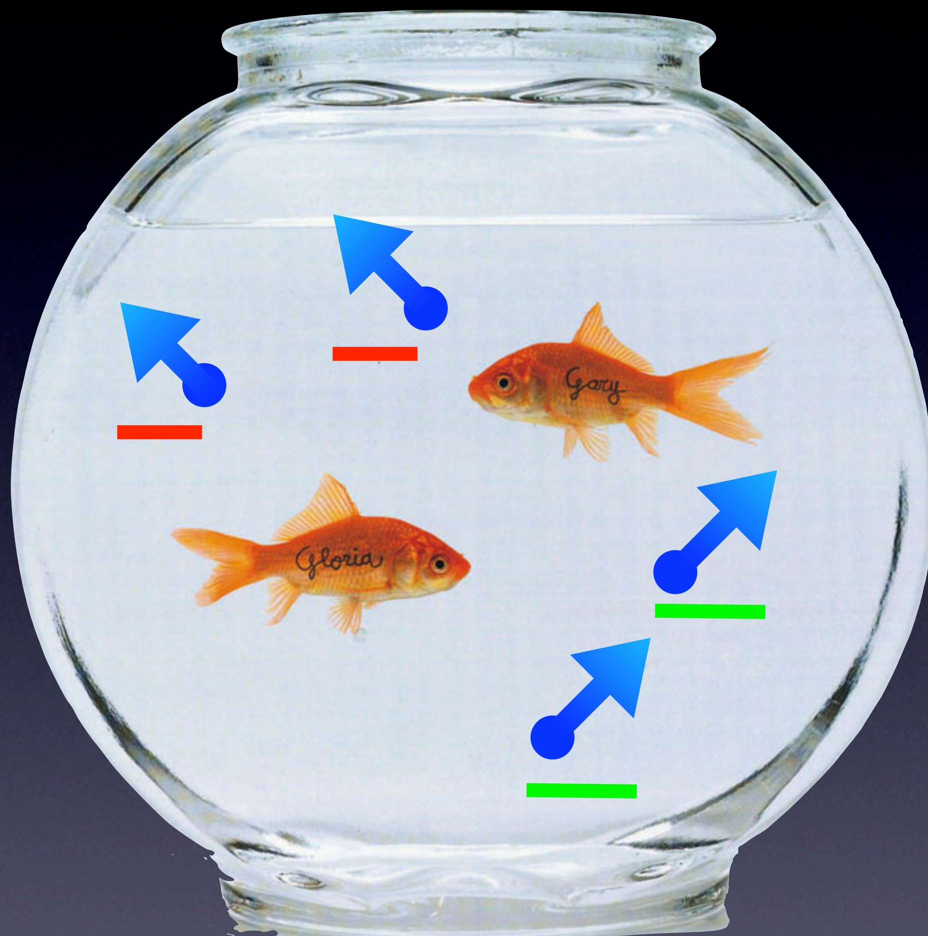
What happens with diffusion perpendicular to the gradients?

Diffusion



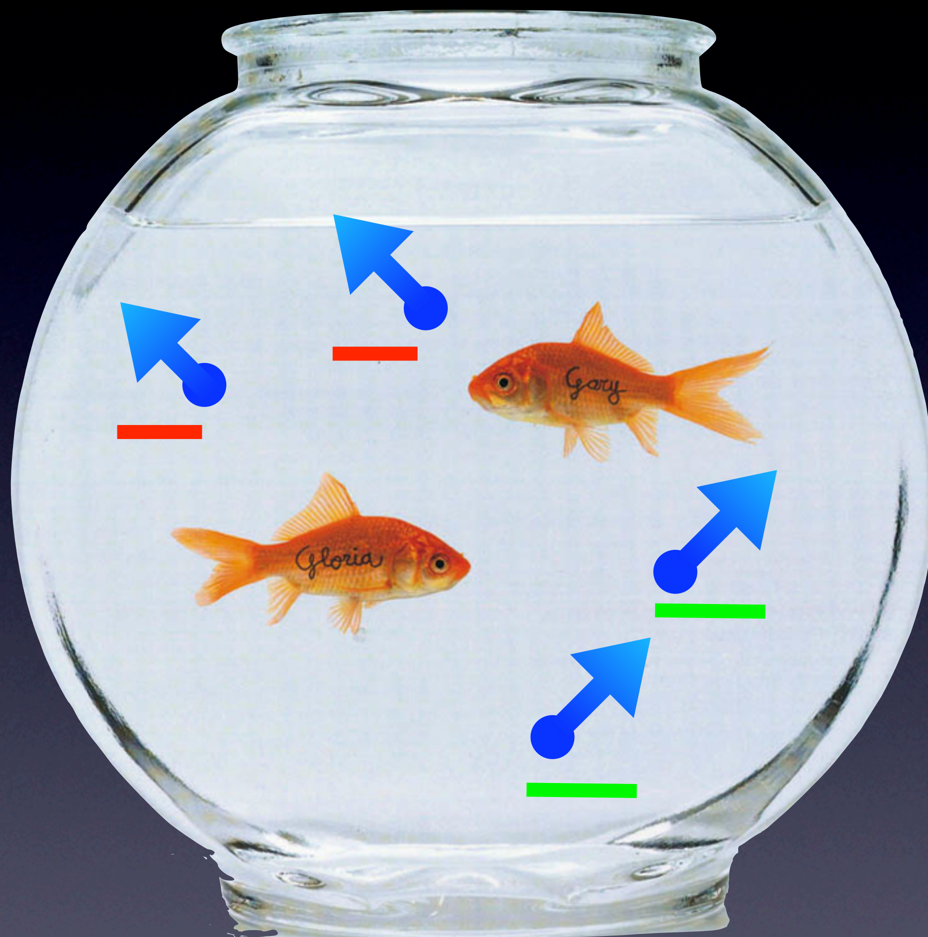
gradient

Diffusion



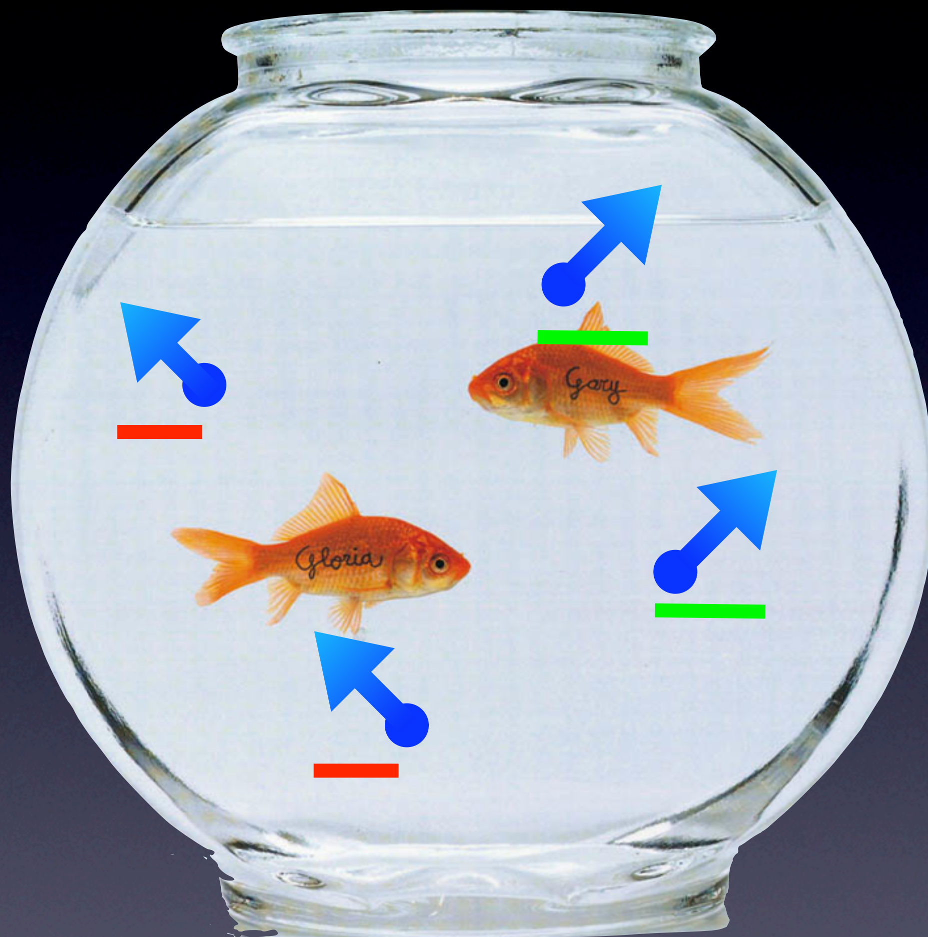
gradient

Diffusion



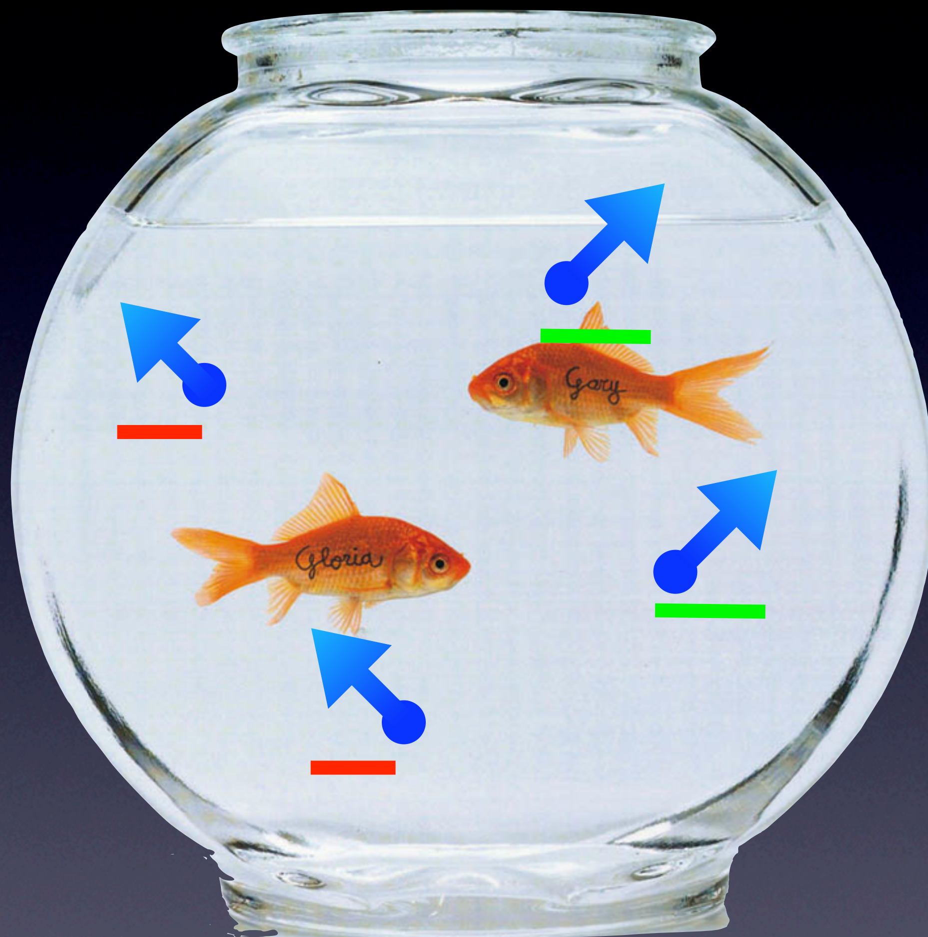
no gradient

Diffusion



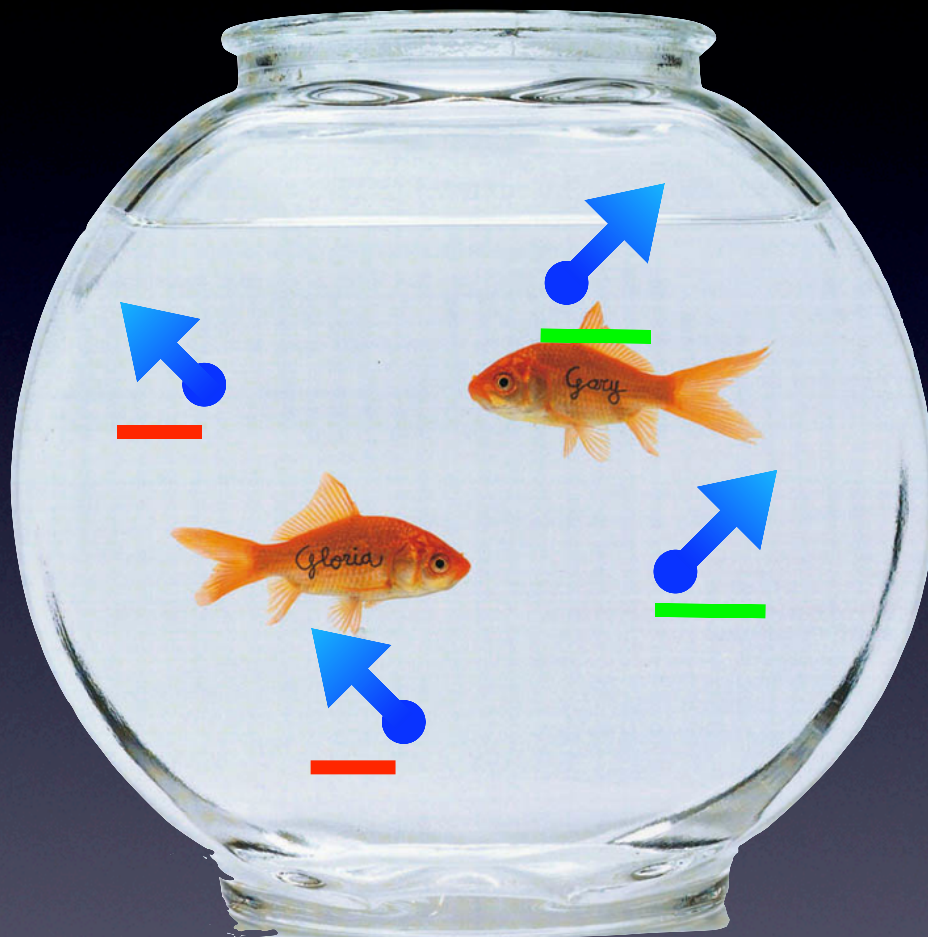
no gradient

Diffusion



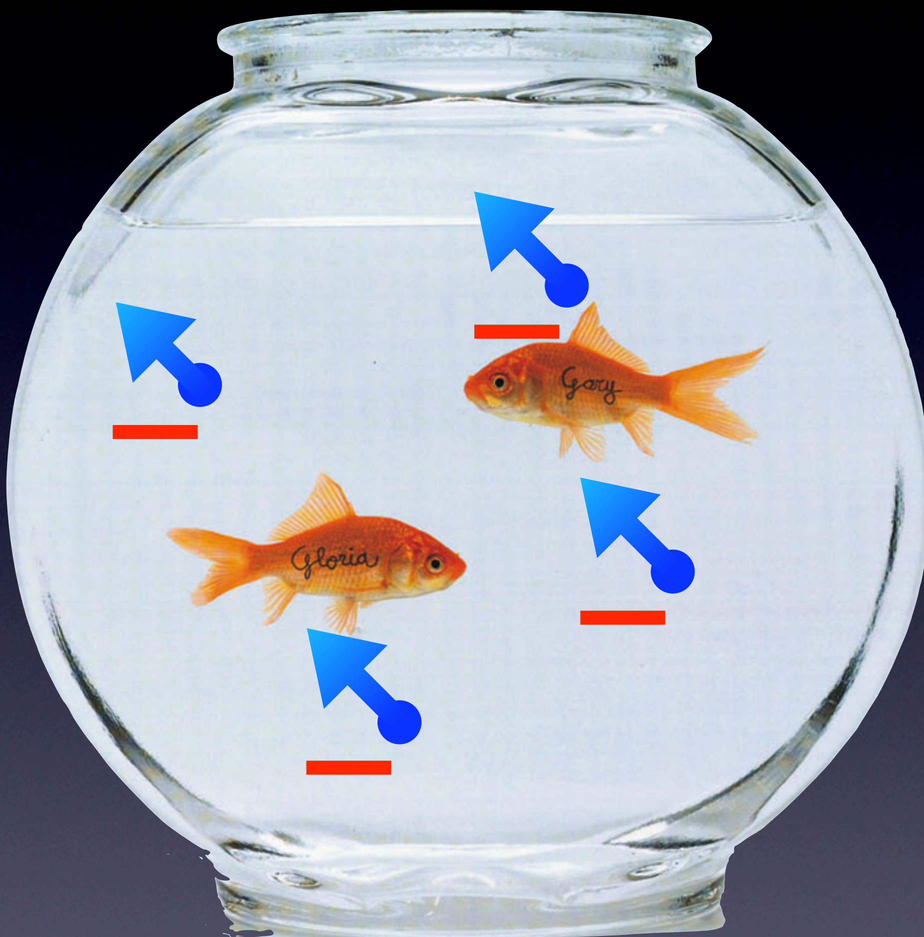
no gradient

Diffusion



opposite gradient

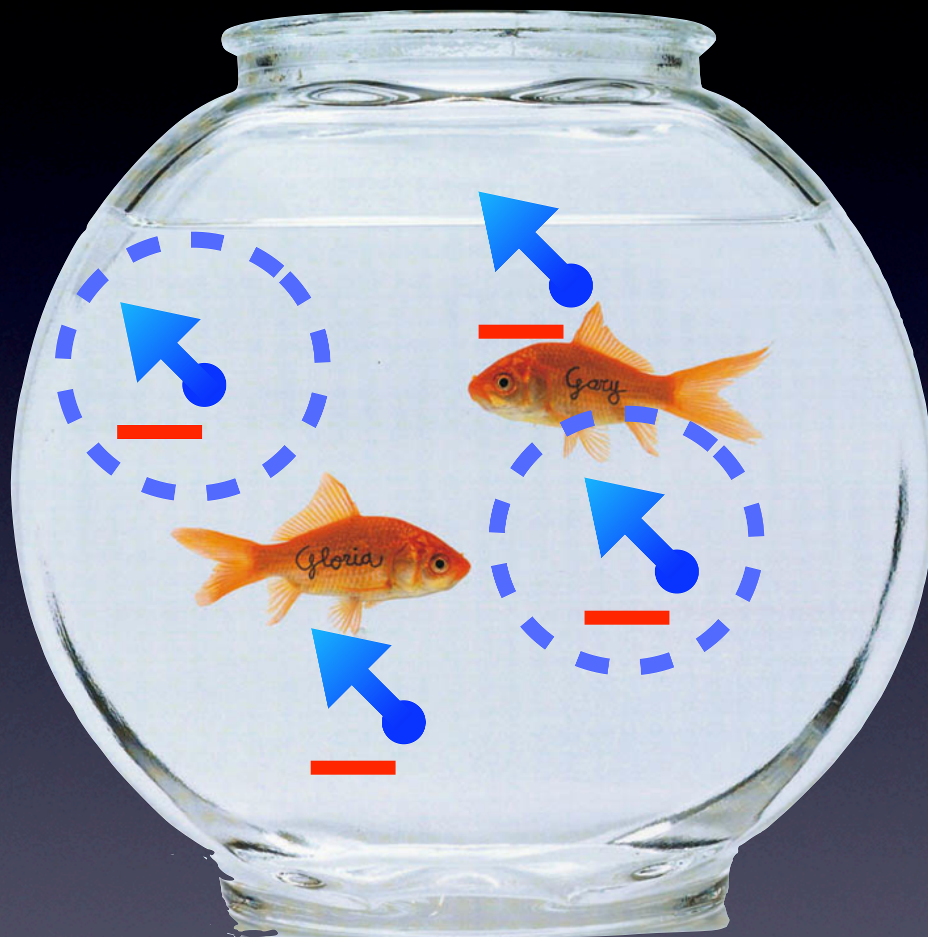
Diffusion




opposite
gradient

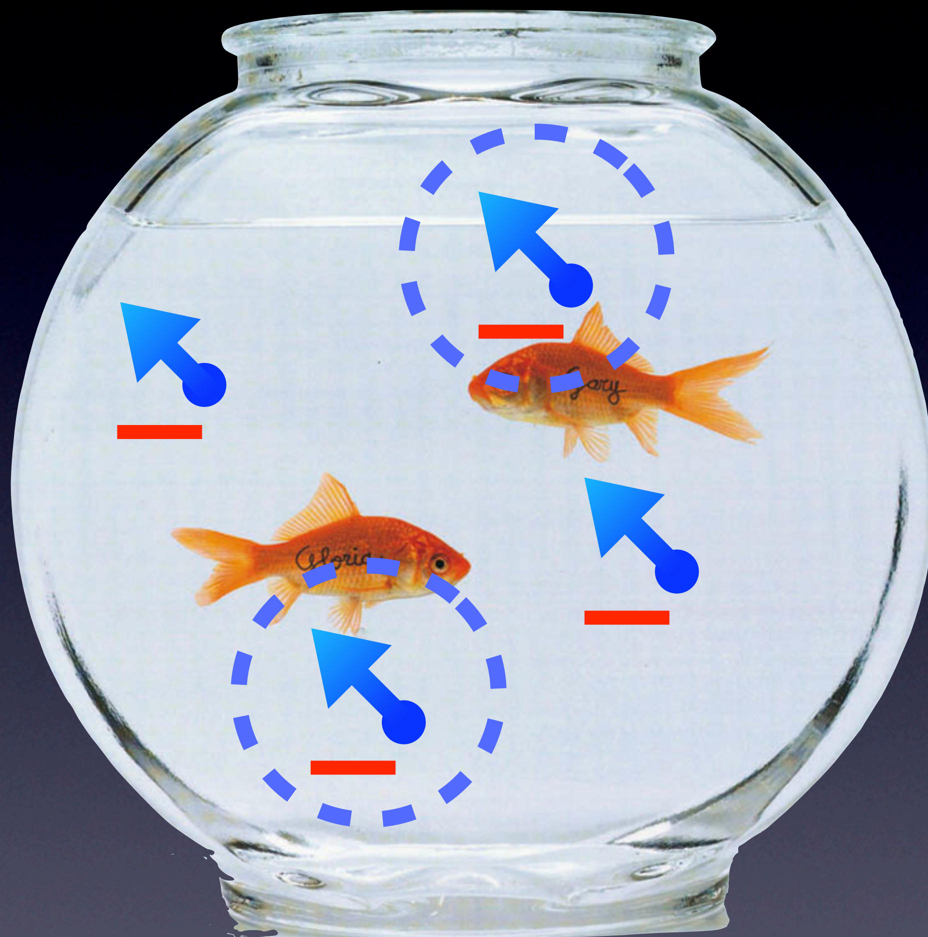

Diffusion

stationary =
re-focused



opposite
gradient

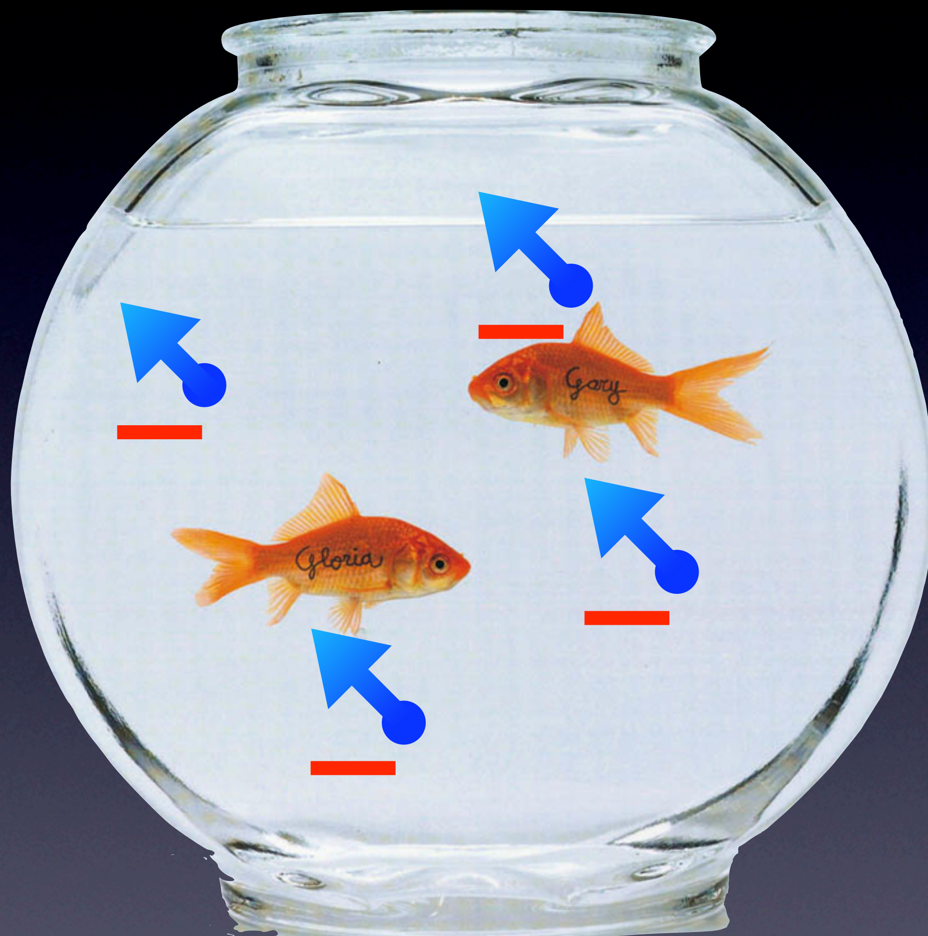
Diffusion



diffused =
re-focused

opposite
gradient

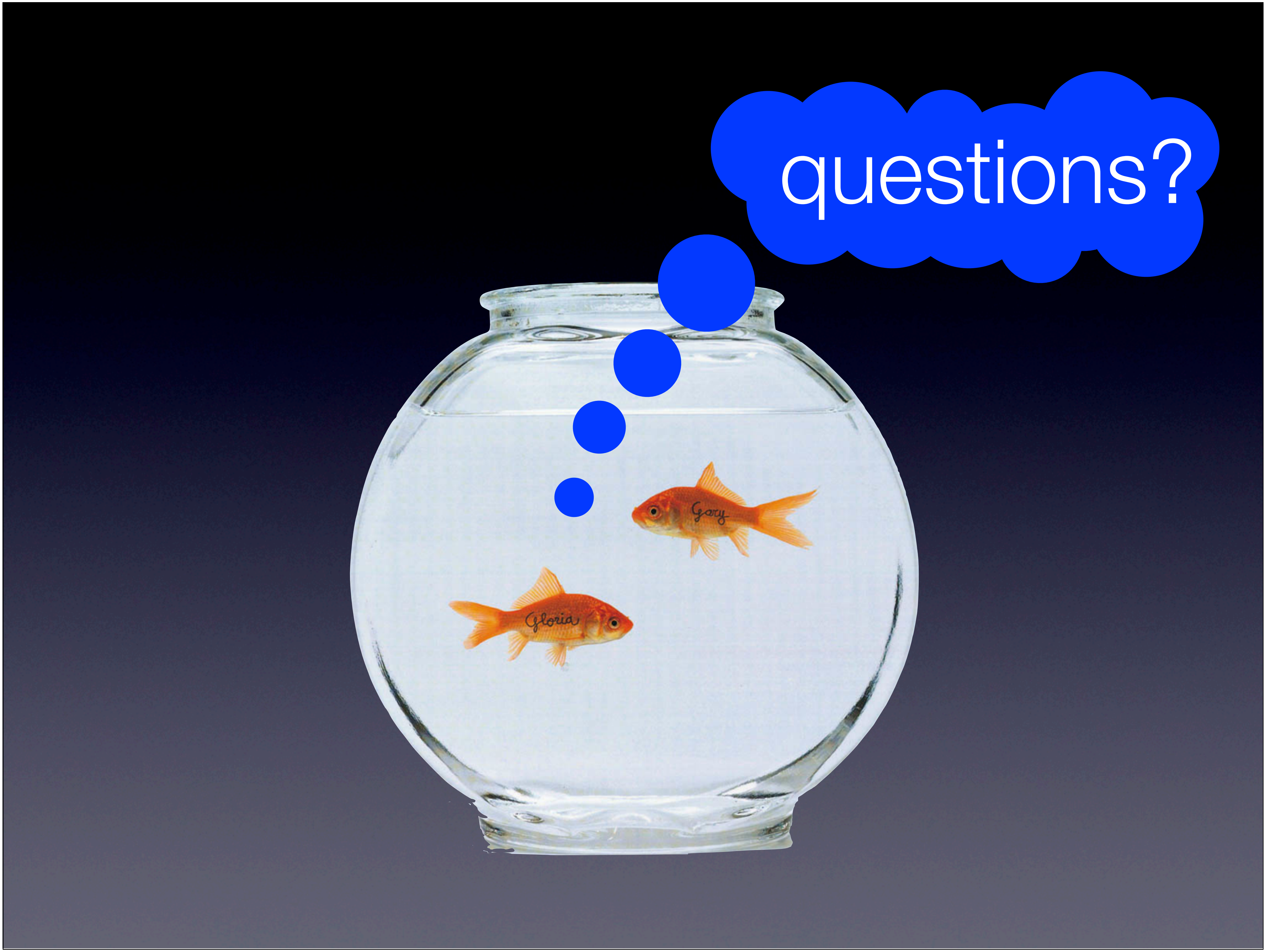
Diffusion



signal is unaffected by
diffusion perpendicular to the gradients

Diffusion imaging uses gradients to cancel out signal in water that moves in one direction.

Repeating the experiment, each time using gradient in a different direction, creates a map of how freely water diffuses in each voxel.


questions?
Gary
Gloria