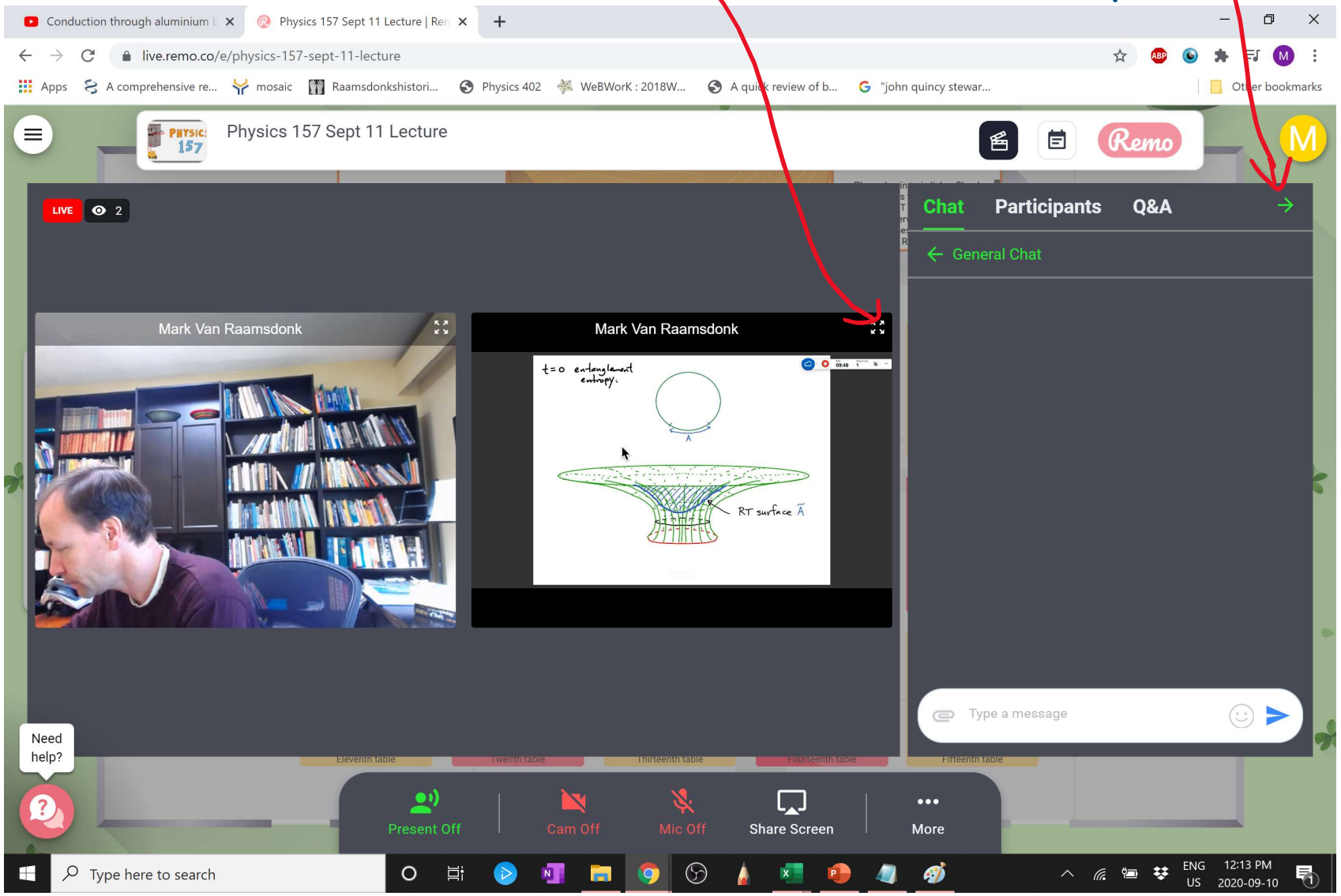
Class will begin soon!

- If you have technical problems, try reloading the page, or closing your browser and coming back

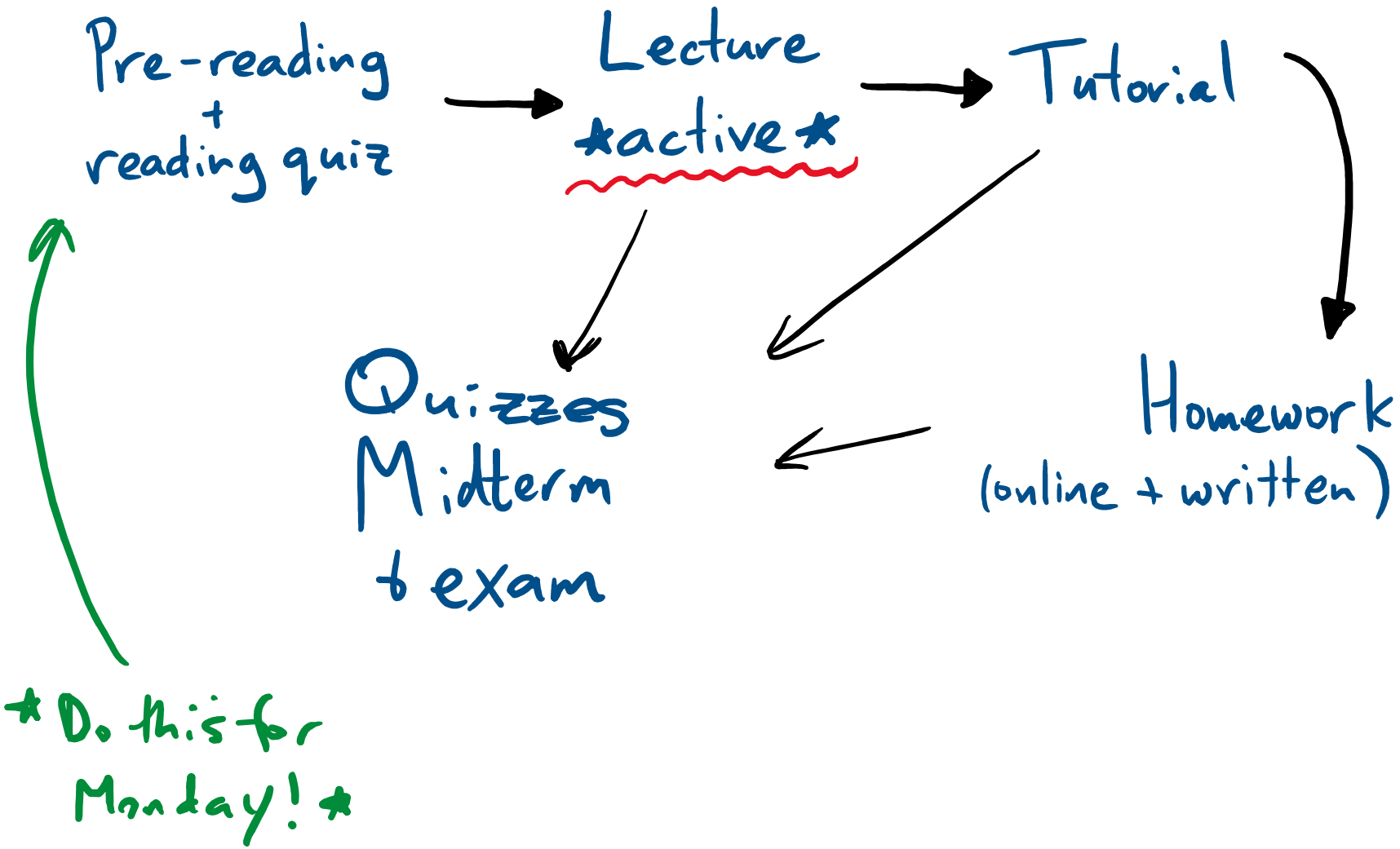
- Log in to i-clicker – use Canvas link or search “i-clicker login” (you may want to do this on another device, e.g. you phone)

- Office hours today: 3:30-4:30pm (Zoom link on Canvas page)

You might want to: maximize slides OR hide right panel



How the course works:



Ways to ask questions in class:

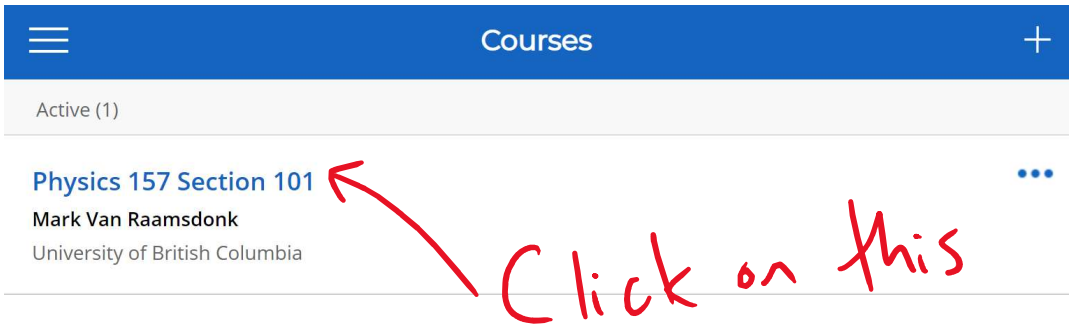
General Chat: these will be answered by the TA in real time (or moved to the Q&A)
Reserve this for questions only

Q&A: I will answer these when I notice or pause for questions

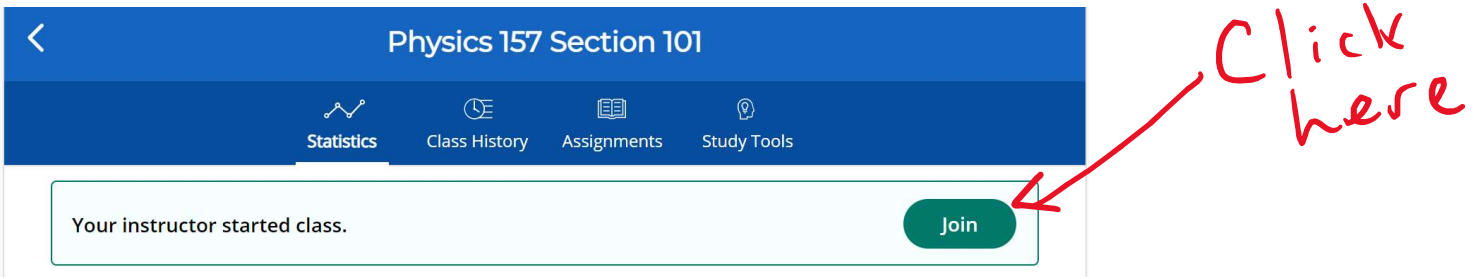
Raise hand: will answer these when I notice or pause for questions

1) Follow the i-Clicker link in Canvas or Google "i-clicker login" and choose "Reef – Login".

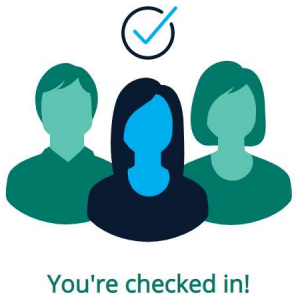
2)



3)



4) You should see this:



A mercury thermometer sits in a glass of water. If the thermometer reads 20ºC, we can conclude that

A) The temperature of the water is 20ºC.
B) The temperature of the mercury in the thermometer is 20ºC.
C) Both A and B
D) Neither A nor B

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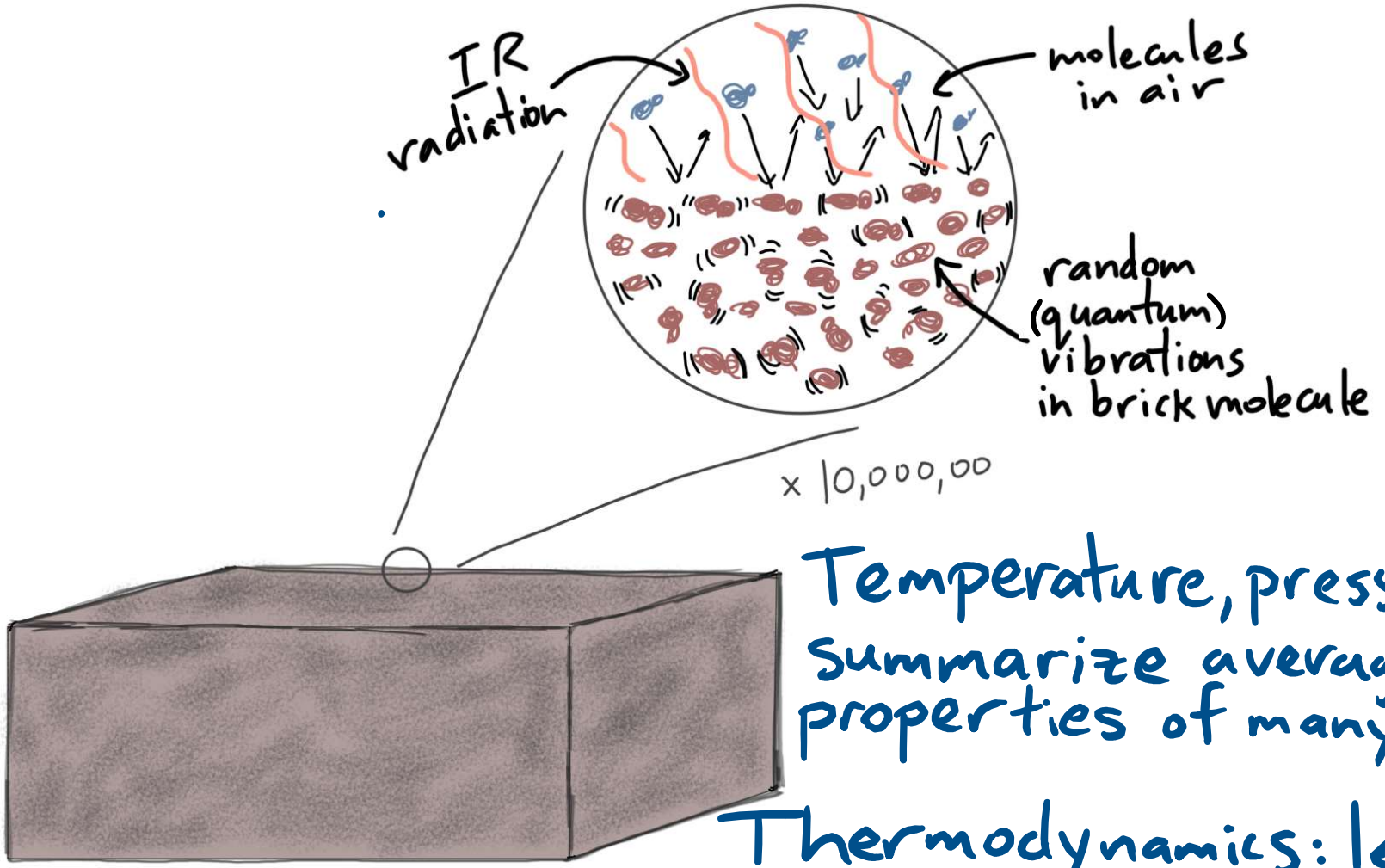
Last time in physics 157...

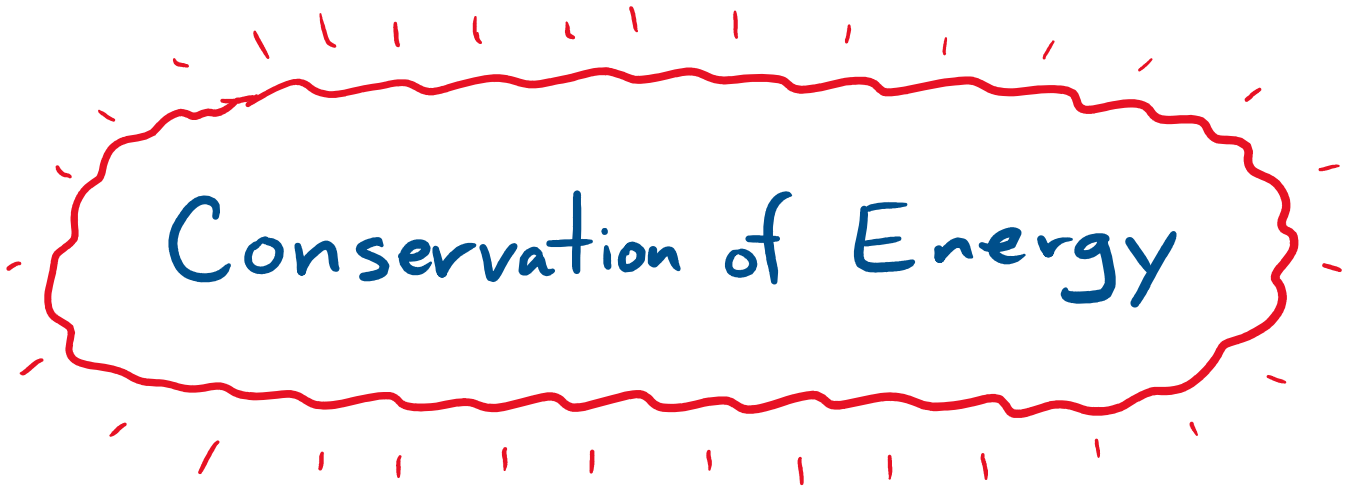
Thermodynamics: how to summarize microscopic physics of 10^{23}+ things.



Temperature, pressure, ...: summarize average properties of many atoms

Thermodynamics: lets us understand behavior of these

Our starting point:



Conservation of Energy

- each part of a physical system has a certain amount of energy
- the total energy of an isolated system doesn't change with time

BUT: energy can move between different parts and take different forms

In thermodynamics we care about the microscopic kinetic & potential energy of atoms & molecules

ASIDE:

First understood fully by one of the greatest physicists of all time...

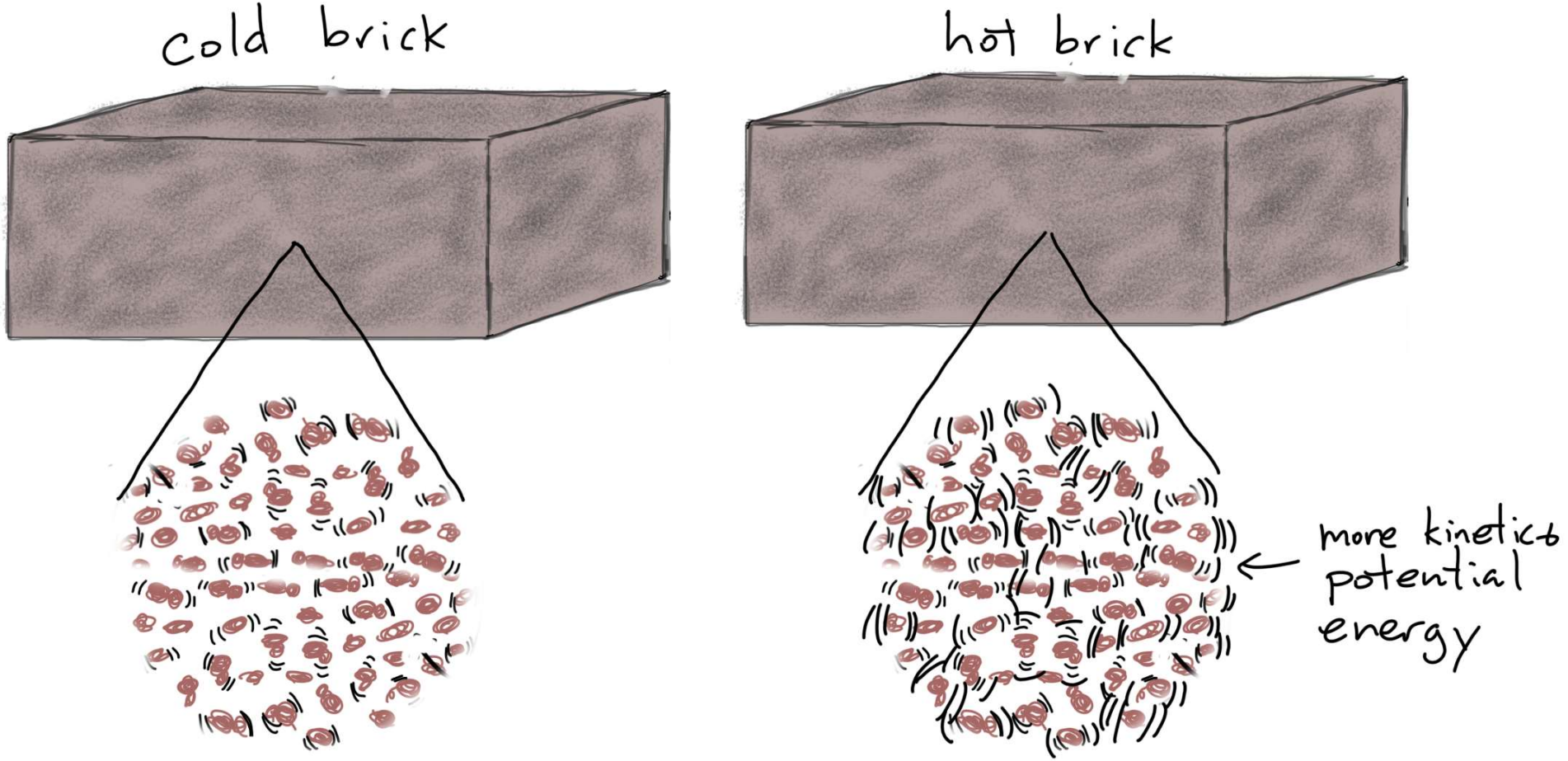
guess who with i-Clicker

Emmy Noether 1882-1935

Proved "Noether's Theorem" that explains how conserved quantities are related to "symmetries" in nature

(ask me later!)

When we heat/cool an object, we are adding/removing energy at the molecular level:



But, heating/cooling also affects macroscopic/observable properties

Which macroscopic properties of objects change when they are heated/cooled?

(discuss!)

Which macroscopic properties of objects change when they are heated/cooled?

* Most of them (but often only slightly)

size/volume/density

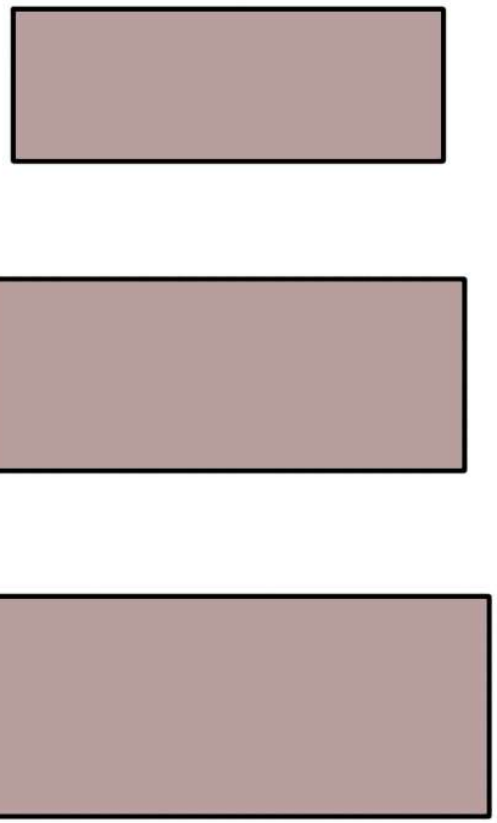
amount of light/IR radiation emitted at different frequencies

(and many others e.g. electrical conductivity)

Examples:

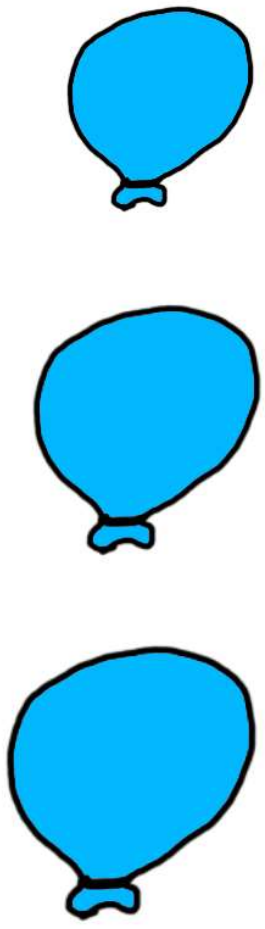
solid:

hotter



(size changes greatly exaggerated)

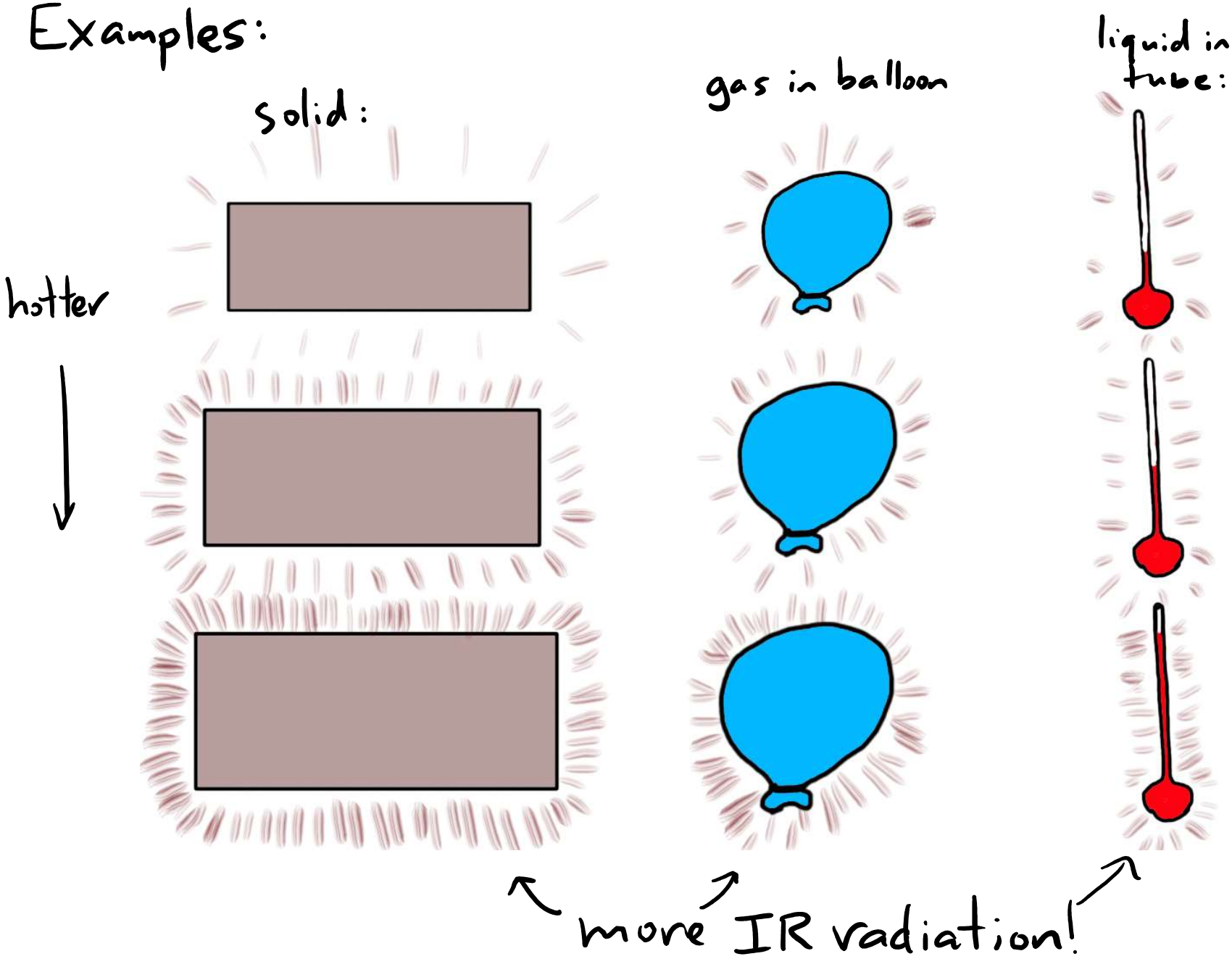
gas in balloon



liquid in tube:

★there are exceptions!★

Examples:


solid:
gas in balloon
liquid in tube:
hotter
more IR radiation!

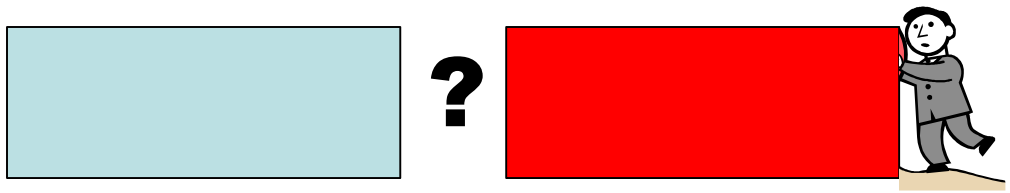
Demo: https://www.youtube.com/watch?v=kfCVtnayKk4

Bonus demo: https://youtu.be/iqPS_JiKSHo

Hot block + room temperature block

What happens if we put a hot block in contact with a room temperature block?

A. Nothing
B. Heat flows until they are the same temperature
C. The hot block will cool down to room temperature
D. The room temperature block will heat up to the temperature of the hot block
E. None of the above



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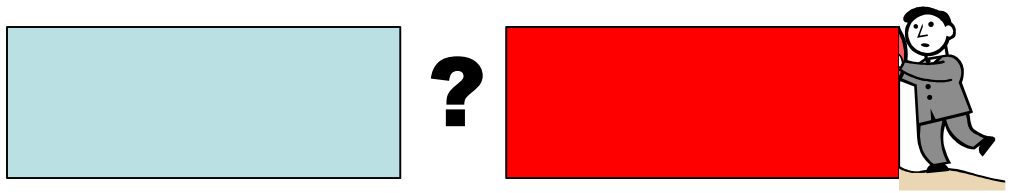
final temperature depends on how hot the hot block was



Demo: IR camera

Make a prediction:

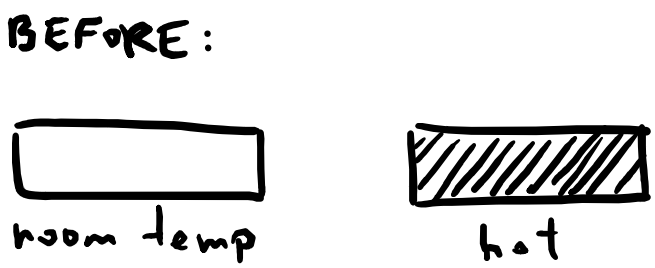
We put together two blocks of aluminum, one heated on the hot plate and the other left in the room for a long time. We observe this on an infrared (IR) camera. It shows hotter objects as brighter.

Make a sketch of what you think we will see

a) just as we bring the blocks together

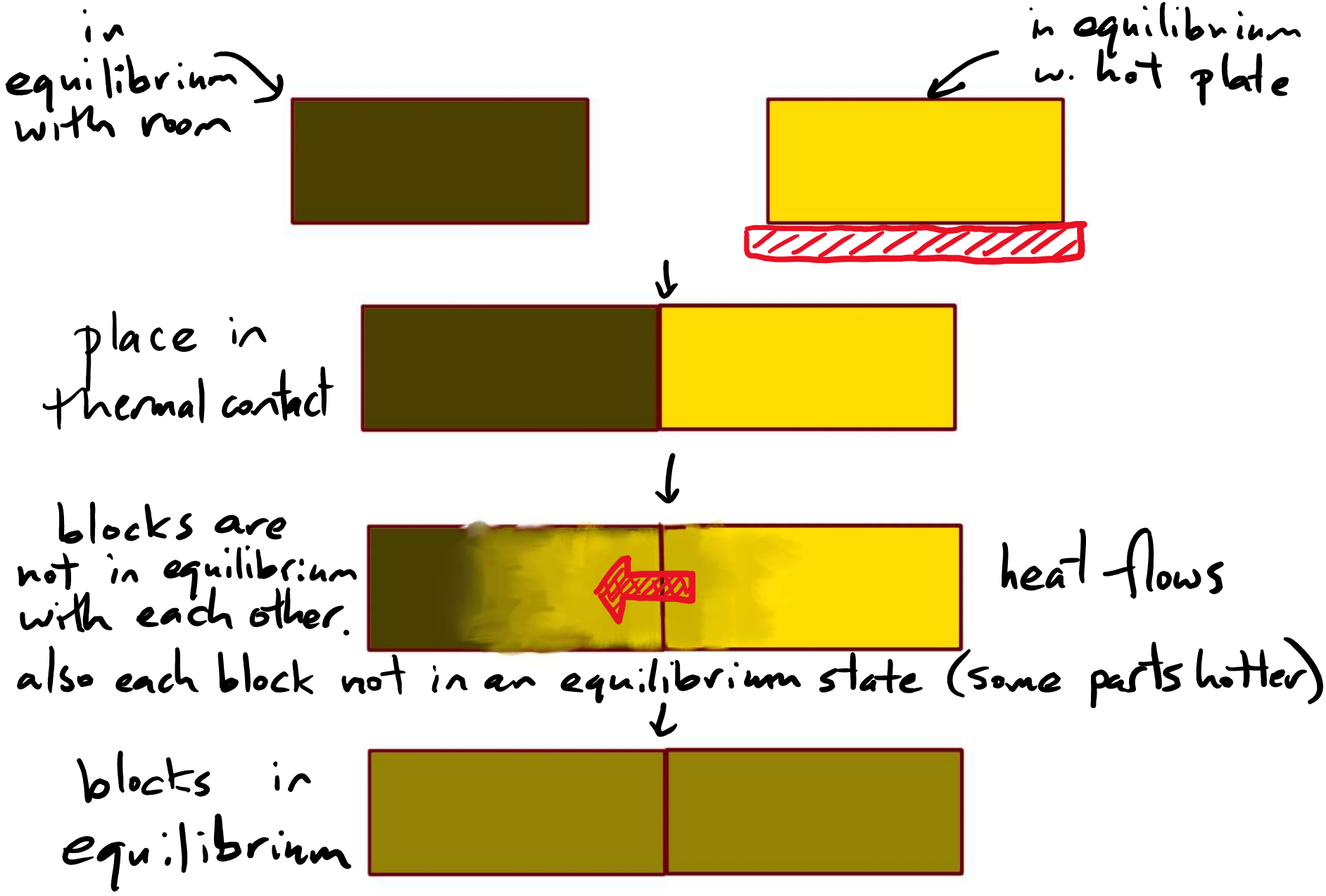
b) after a short amount of time

c) after a long amount of time



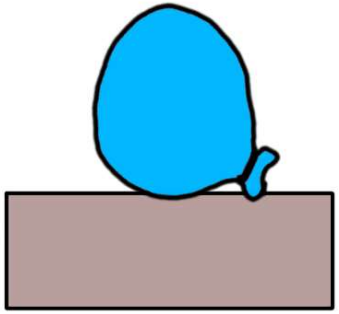
(shade in regions that are brighter on the IR camera)

https://youtu.be/xe_oCx5IyF4


in equilibrium with room
in equilibrium w. hot plate
place in thermal contact
blocks are not in equilibrium with each other.
heat flows
also each block not in an equilibrium state (some parts hotter)
blocks in equilibrium

If we bring two objects in contact:

3 options:

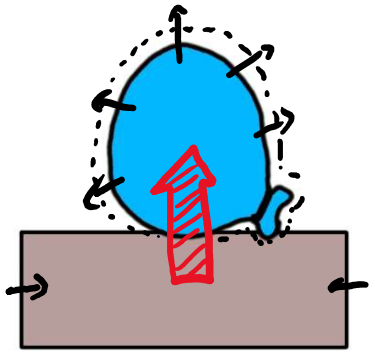


nothing changes

we say the systems are

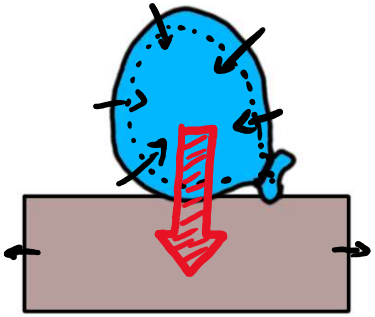
EQUILIBRIUM

same TEMPERATURE



energy from brick→balloon = flow of HEAT

brick has higher temperature

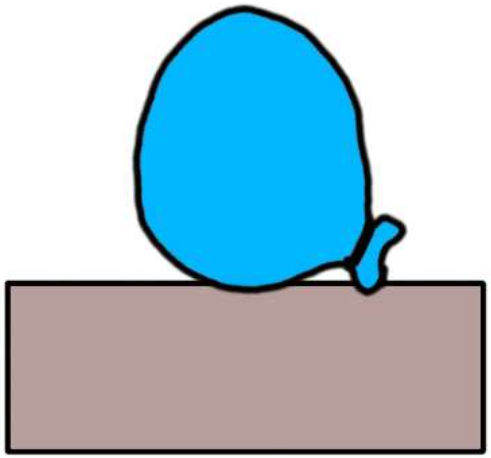


energy from balloon to brick

balloon has higher temperature

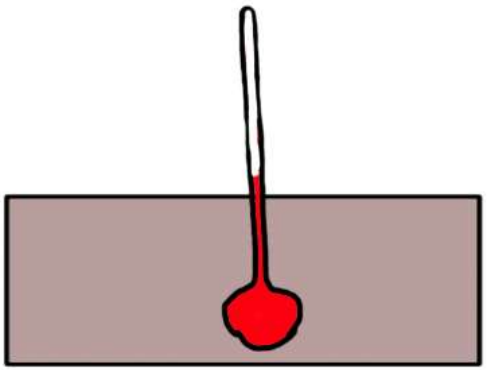
Zeroth Law of Thermodynamics:

If



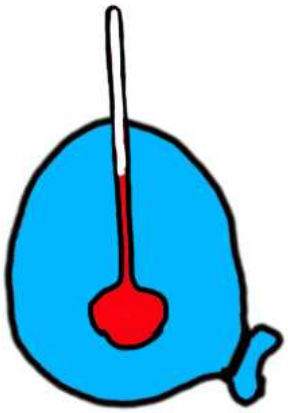
in equilibrium

and



in equilibrium

then:



in equilibrium

otherwise, temperature wouldn't make sense!

We can assign a numerical value for different temperatures by using some temperature-dependent macroscopic property of a standard object (e.g. volume of liquid in a tube)