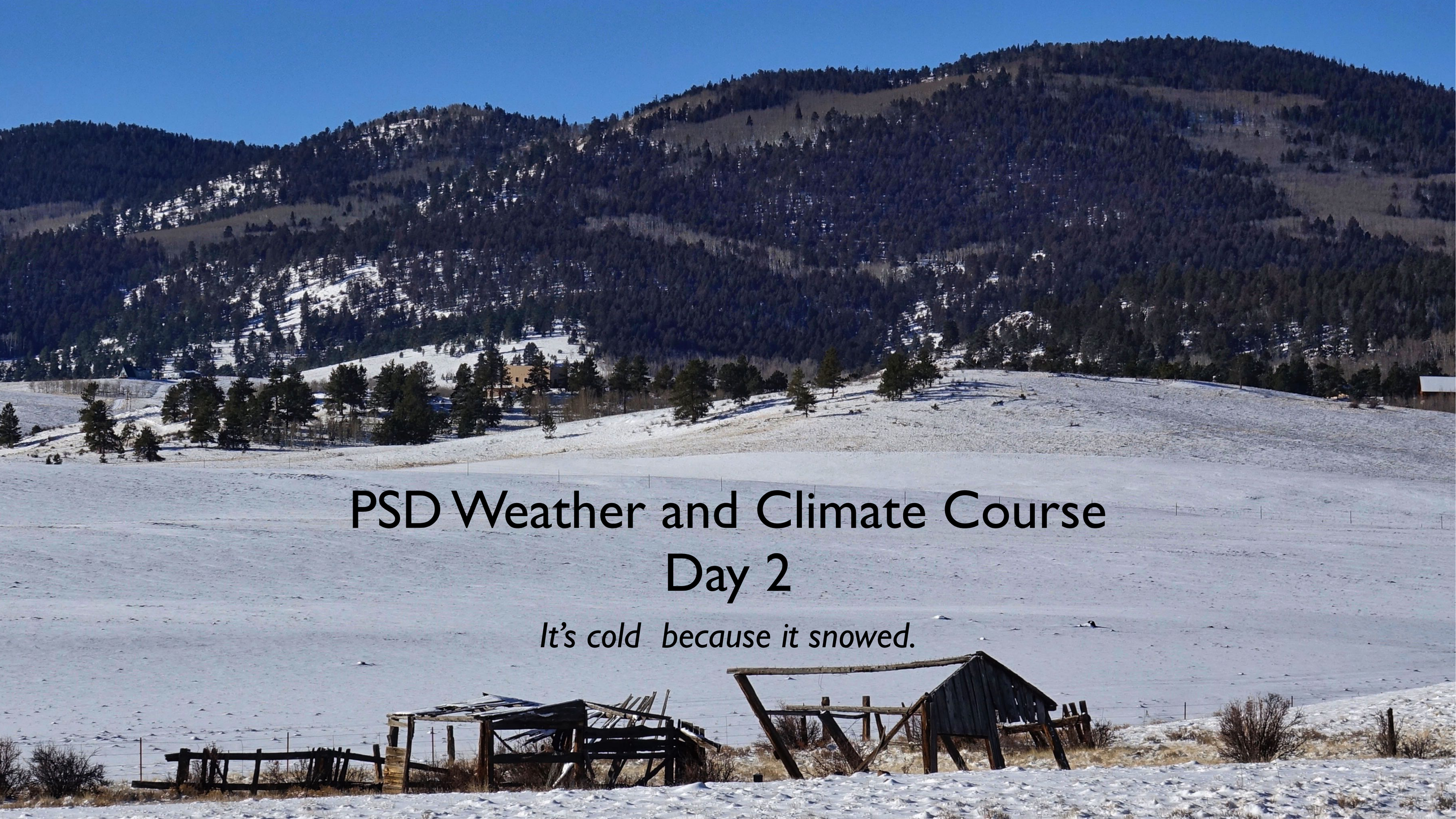


PSD Weather and Climate Course
Day 2

It's cold because it snowed.

DETAILS

The course will meet on 5 Thursday evenings, for 3 hours per session:

- Thursday, February 4, 5:00 – 8:00 PM
- Thursday, February 18, 5:00 – 8:00 PM
- Thursday, March 4, 5:00 – 8:00 PM
- Thursday, March 25, 5:00 – 8:00 PM
- Thursday, April 1, 5:00 – 8:00 PM

Each class will be a mix of experimentation, discussion, and explanation.

SIGNING UP

You will need to sign up for CSU credit to take part in this course. Here is a link to the CSU registration page:

- CSU / PSD Science of Weather and Climate Course

PSD is covering the cost of your credit, so you won't be charged.

SCHEDULE

Links will be live shortly before the course begins

Day 1: Energy & the EM spectrum

- Zoom link: https://zoom.us/j/92574585808
- Outline of day's activities with links to documents
- Link to upload daily writing assignment

Day 2: Energy in the Earth System

- Zoom link: https://zoom.us/j/92574585808
- Outline of day's activities with links to documents (link available soon)
- Link to upload daily writing assignment

Day 3: Air, Water & Clouds

- Zoom link: https://zoom.us/j/92574585808
- Outline of day's activities with links to documents (link available soon)
- Link to upload daily writing assignment

Day 4: Weather: Local and Global

- Zoom link: https://zoom.us/j/92574585808
- Outline of day's activities with links to documents (link available soon)
- Link to upload daily writing assignment

Day 5: Climate and Climate Change

- Zoom link: https://zoom.us/j/92574585808
- Outline of day's activities with links to documents (link available soon)
- Final project
- Final course survey

THE SCIENCE OF WEATHER AND CLIMATE: DAY 1

Introductions & Zoom Details

Course & Content Overview

- Details
- Overview of course structure / assignment / credit / instructional approach / mixing / questions and suggestions

Engage / Explore / Explain: Energy & Radiation

- Day 1 slides: *Energy, light & matter*
- Energy concepts: *What is energy?*
- The basic energy model
- Numbers & efficiency: *How much energy does it take to perform a task?*
- Electrical appliances: *Measuring energy and power*

Engage / Explore

- Energy and light: *Writing with light*

Explain: EM Spectrum

- Question: *How big is light?*
- Scales of energy and wavelength
- Interaction of electromagnetic waves with matter

Engage / Explore / Explain: EM Radiation

- The visible spectrum: *Using the rainbow glasses*
- Photon energy: *What is the difference between red light and blue light?*
- Beyond the rainbow, part I (Infrared filter): *What's beyond the rainbow?*
- Beyond the rainbow, part II (UV laser pointer + stuff that fluoresces)
- Astronomy connection: *Would you get a sunburn on Mars?*
- Thermal sensor: *What does it measure?*

Extend

- Things to try for next week

Evaluate: Today's Writing Assignment

- Write and upload answers to the following questions:
  - What are the main lessons from this session's activities and discussions?
  - What questions or uncertainties about this material do you still have?
  - What did this session make you wonder about—what questions did it raise?

https://www.lsop.colostate.edu/the-science-of-weather-and-climate/

Energy comes in many different forms.

Mechanical energy:

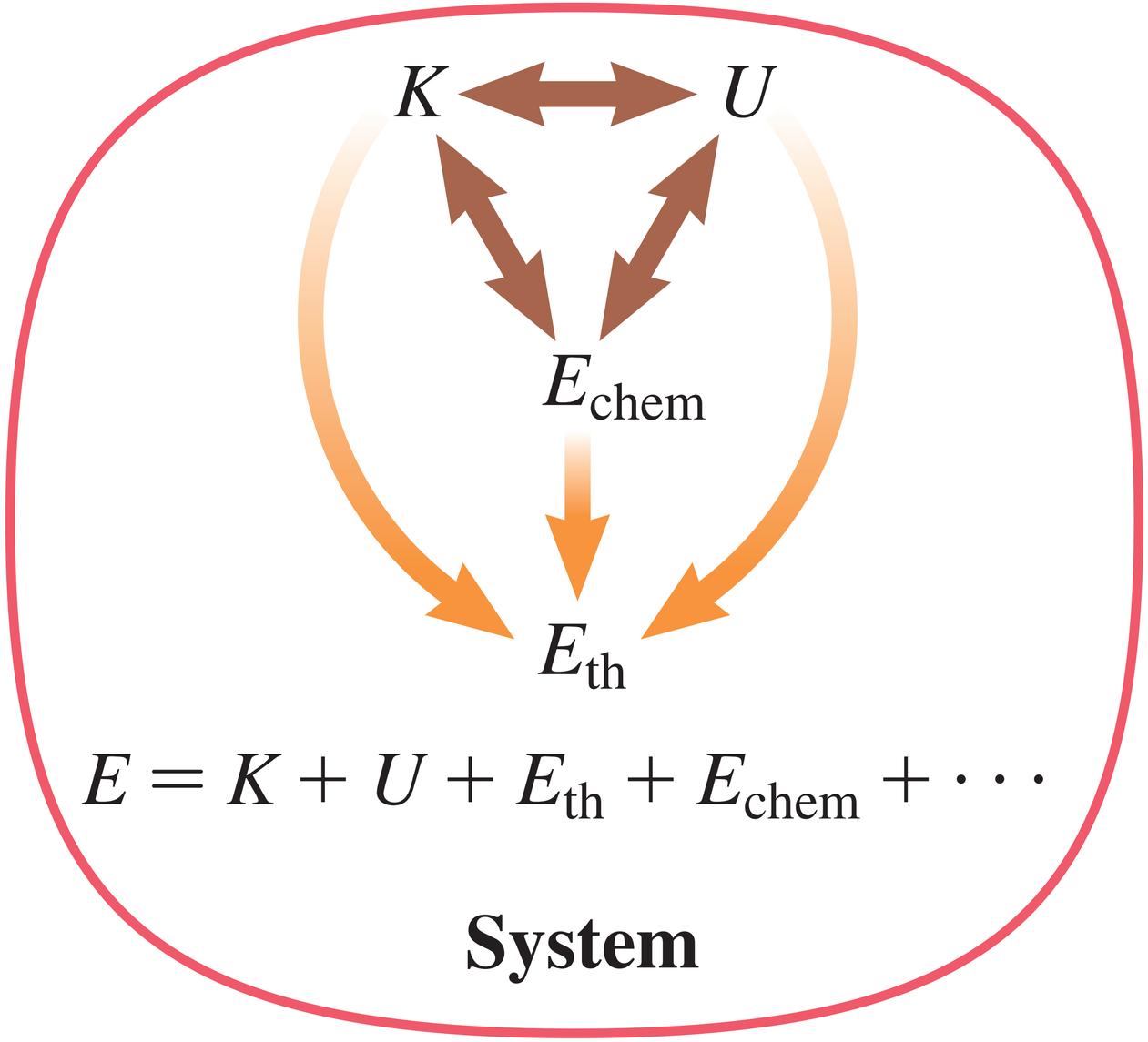
Thermal energy:

Other forms include:

E_{chem}

$E_{nuclear}$

The Basic Energy Model



$$E = K + U + E_{\text{th}} + E_{\text{chem}} + \cdots$$

Modes of Heat Transfer

Conduction

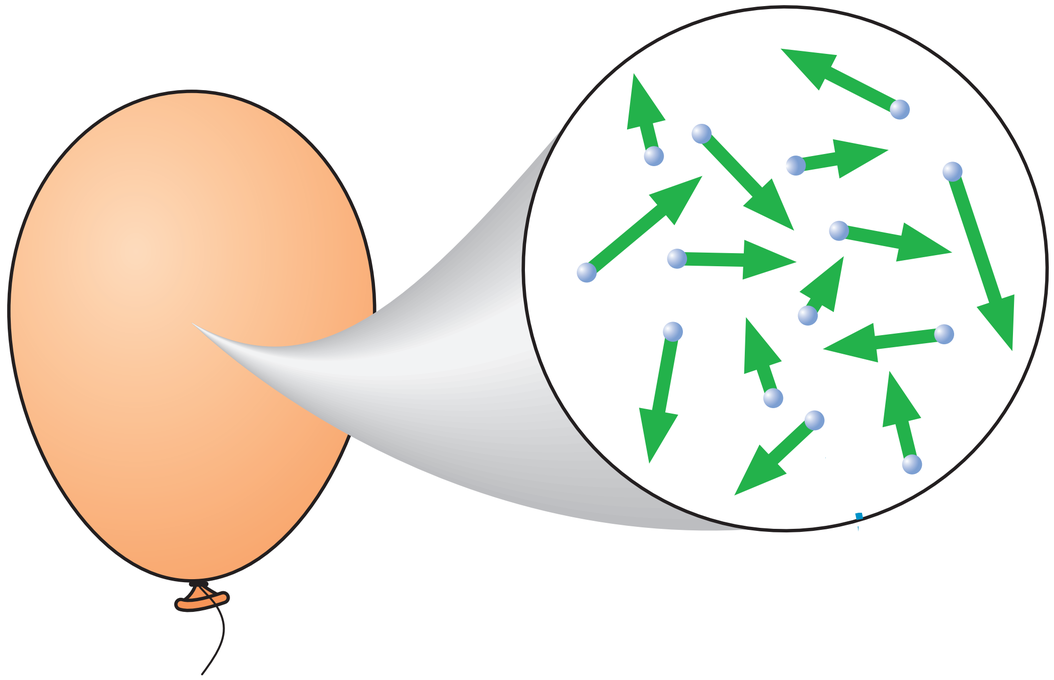
Convection

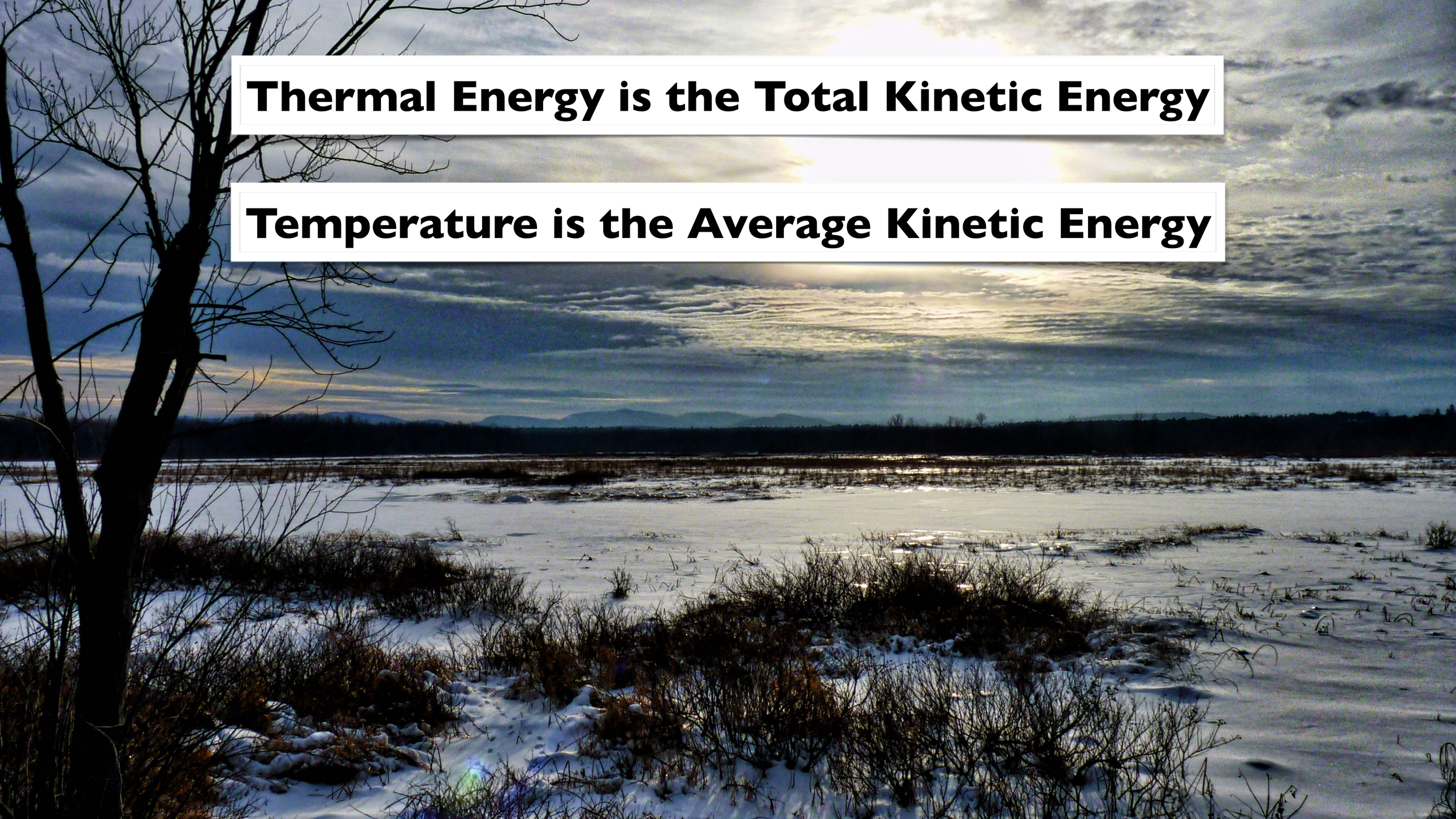
Radiation

Evaporation

Thermal Energy

Thermal Energy
is
Kinetic Energy of Atoms and Molecules





Thermal Energy is the Total Kinetic Energy

Temperature is the Average Kinetic Energy

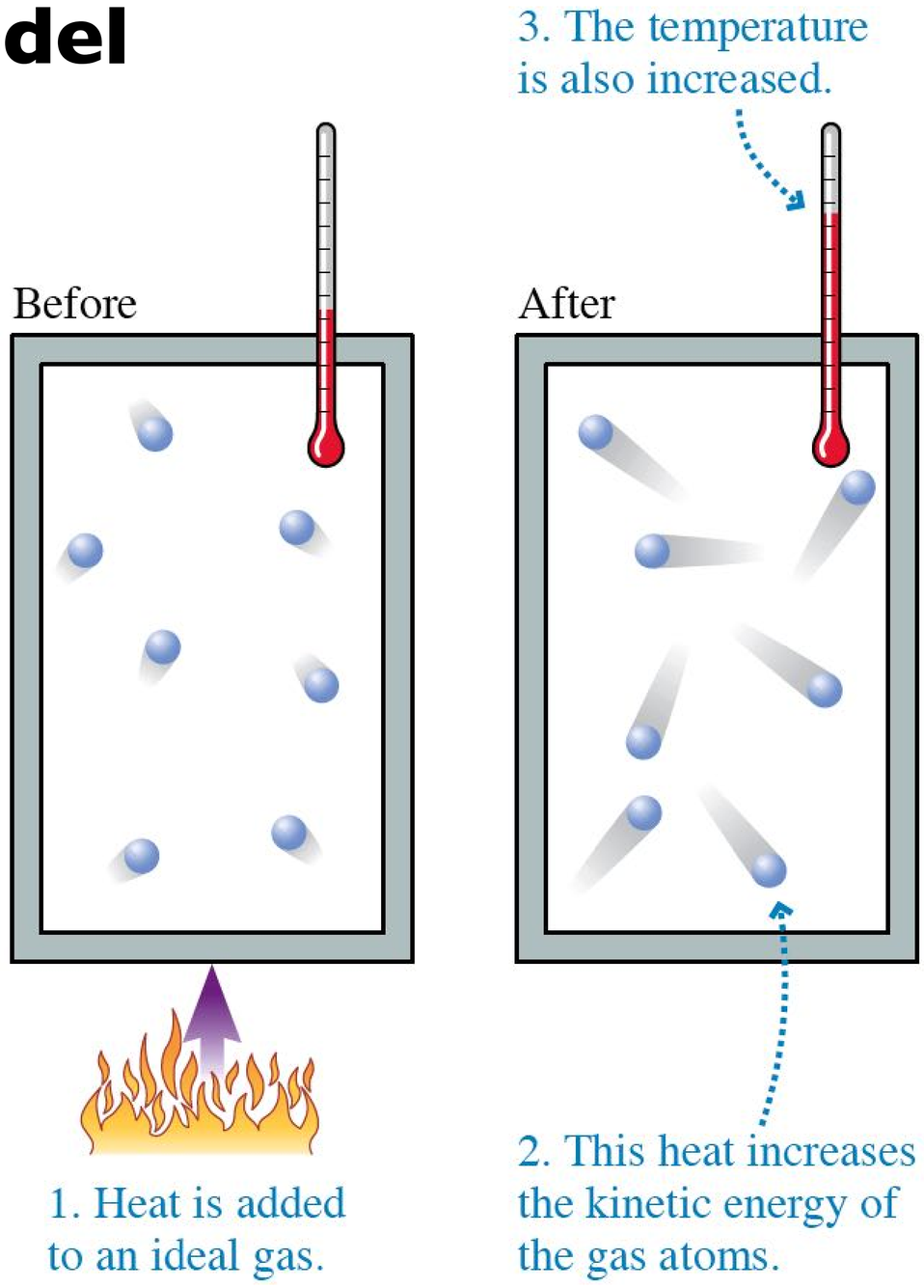
The Ideal Gas Model

$$T = \frac{2}{3}\frac{K_{\text{avg}}}{k_{\text{B}}}$$

$$E_{\text{th}} = \frac{3}{2} N k_{\text{B}} T$$

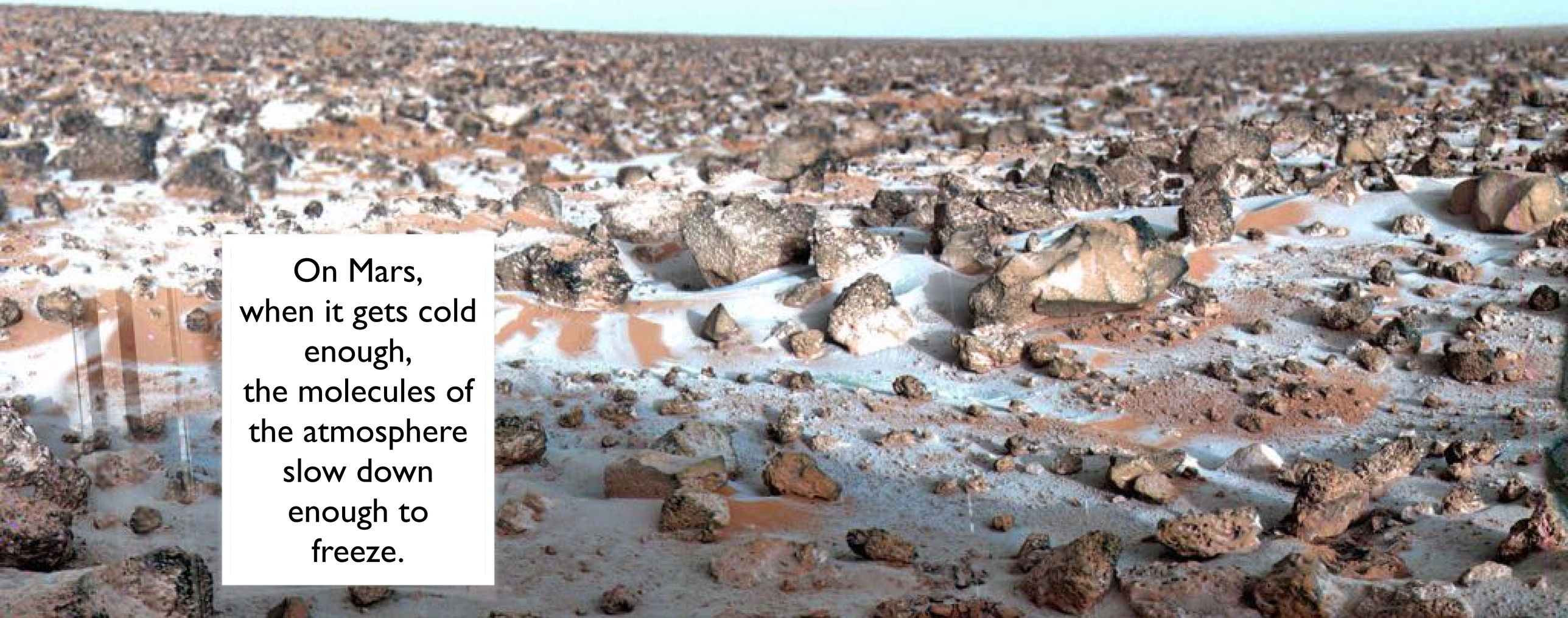
Boltzmann's constant:

$$k_{\text{B}} = 1.38 \times 10^{-23}\ \text{J/K}$$



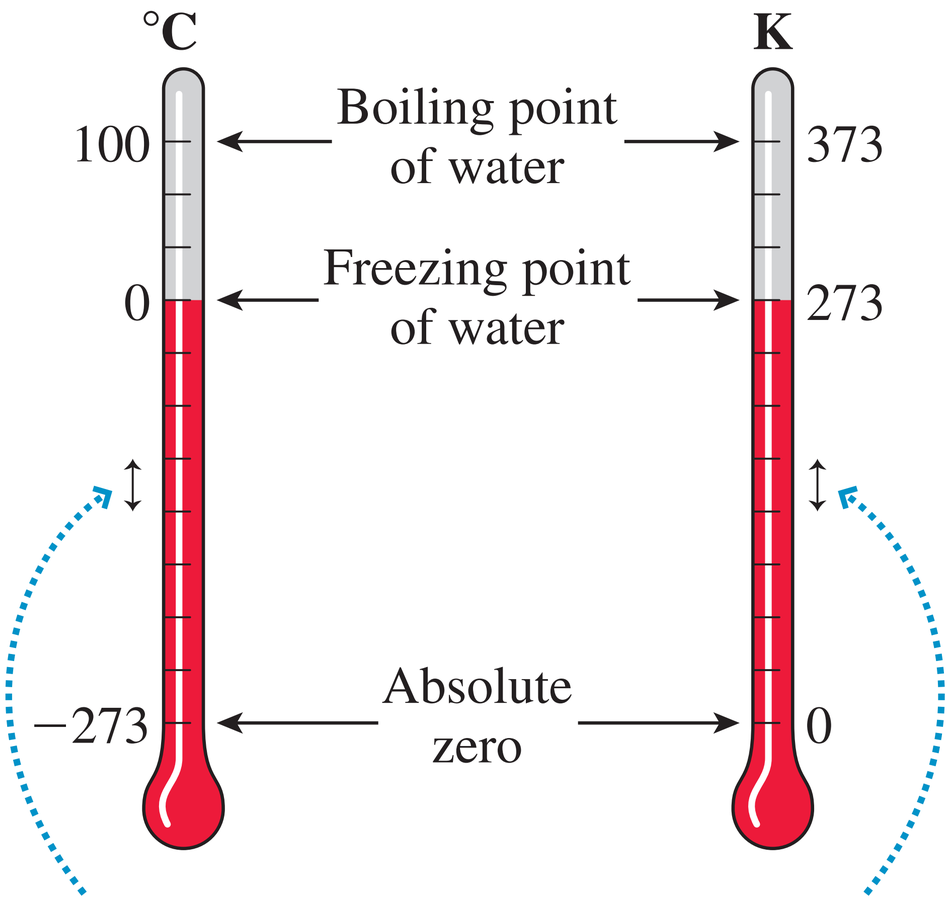
Absolute Zero.

$$T = 0 \Rightarrow K_{\text{avg}} = 0$$



On Mars,
when it gets cold
enough,
the molecules of
the atmosphere
slow down
enough to
freeze.

Temperature Scales



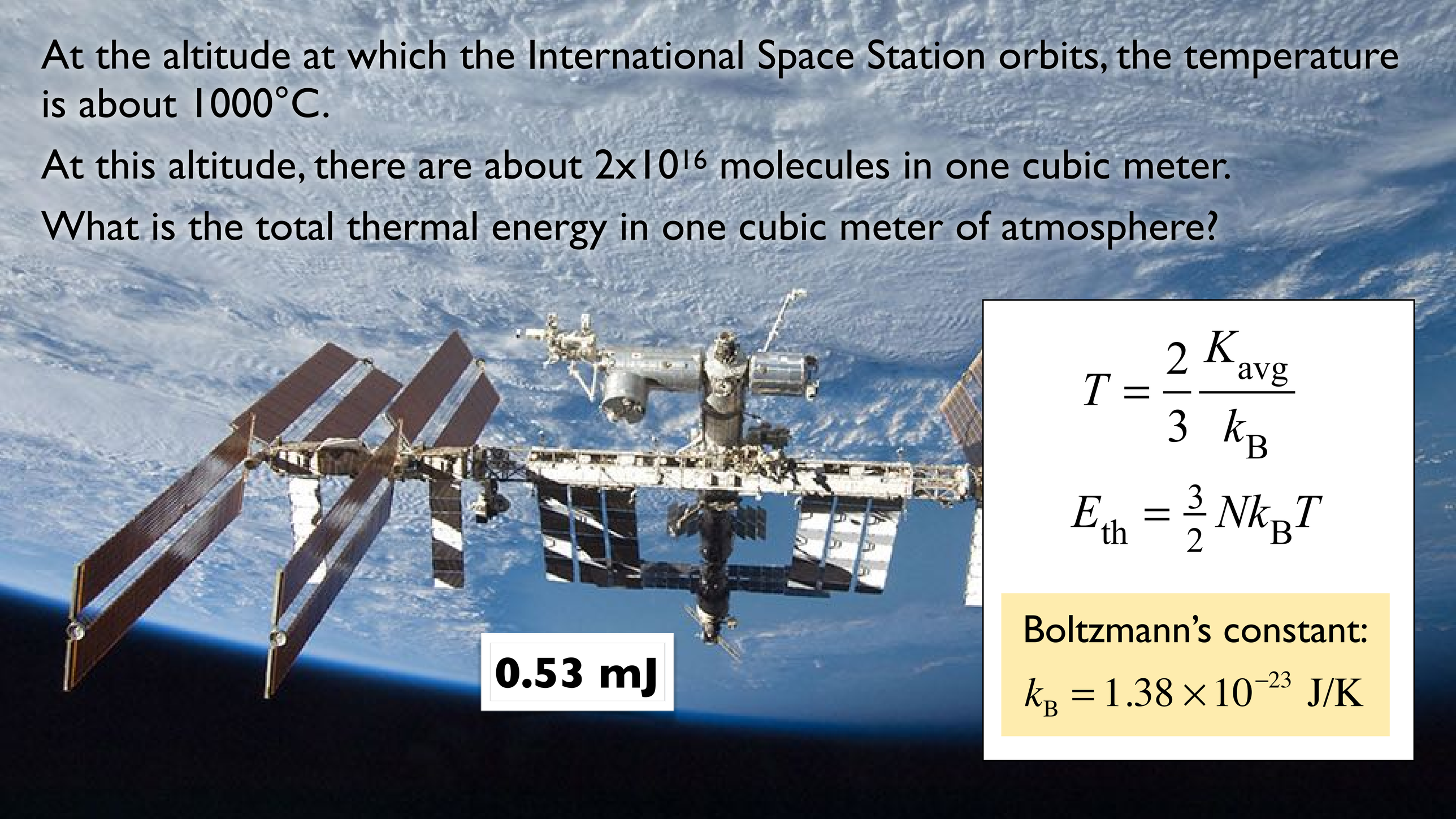
Temperature *differences* are the same on the Celsius and Kelvin scales. The temperature difference between the freezing point and boiling point of water is 100°C or 100 K.

In physics, "*T*" means a temperature in kelvin.

At the altitude at which the International Space Station orbits, the temperature is about 1000°C.

At this altitude, there are about 2×10^{16} molecules in one cubic meter.

What is the total thermal energy in one cubic meter of atmosphere?



0.53 mJ

$$T = \frac{2}{3}\frac{K_{\text{avg}}}{k_{\text{B}}}$$

$$E_{\text{th}} = \frac{3}{2} N k_{\text{B}} T$$

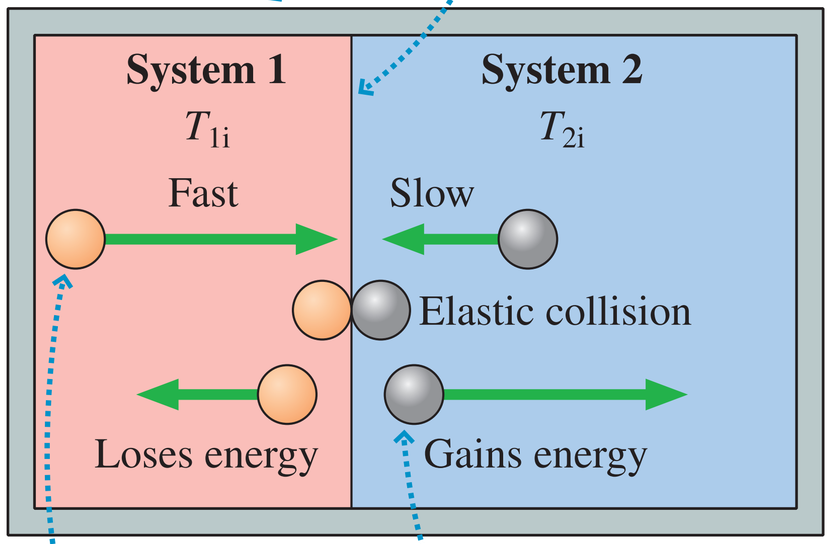
Boltzmann's constant:

$$k_{\text{B}} = 1.38 \times 10^{-23} \text{ J/K}$$

Collisions transfer energy, until the temperatures are the same.

Insulation prevents heat from entering or leaving the container.

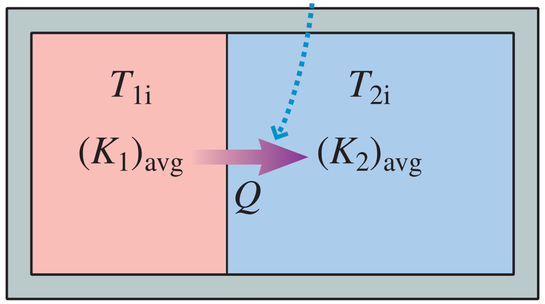
A thin barrier prevents atoms from moving from system 1 to 2 but still allows them to collide.



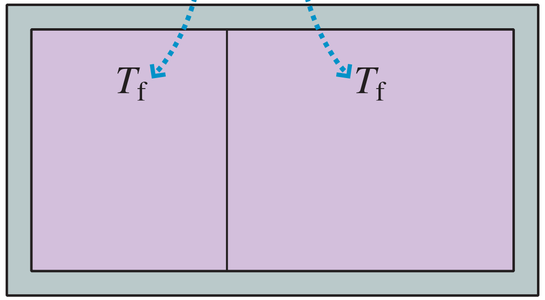
System 1 is initially at a higher temperature, and so has atoms with a higher average speed.

Collisions transfer energy to the atoms in system 2.

Collisions transfer energy from the warmer system to the cooler system. This energy transfer is heat.



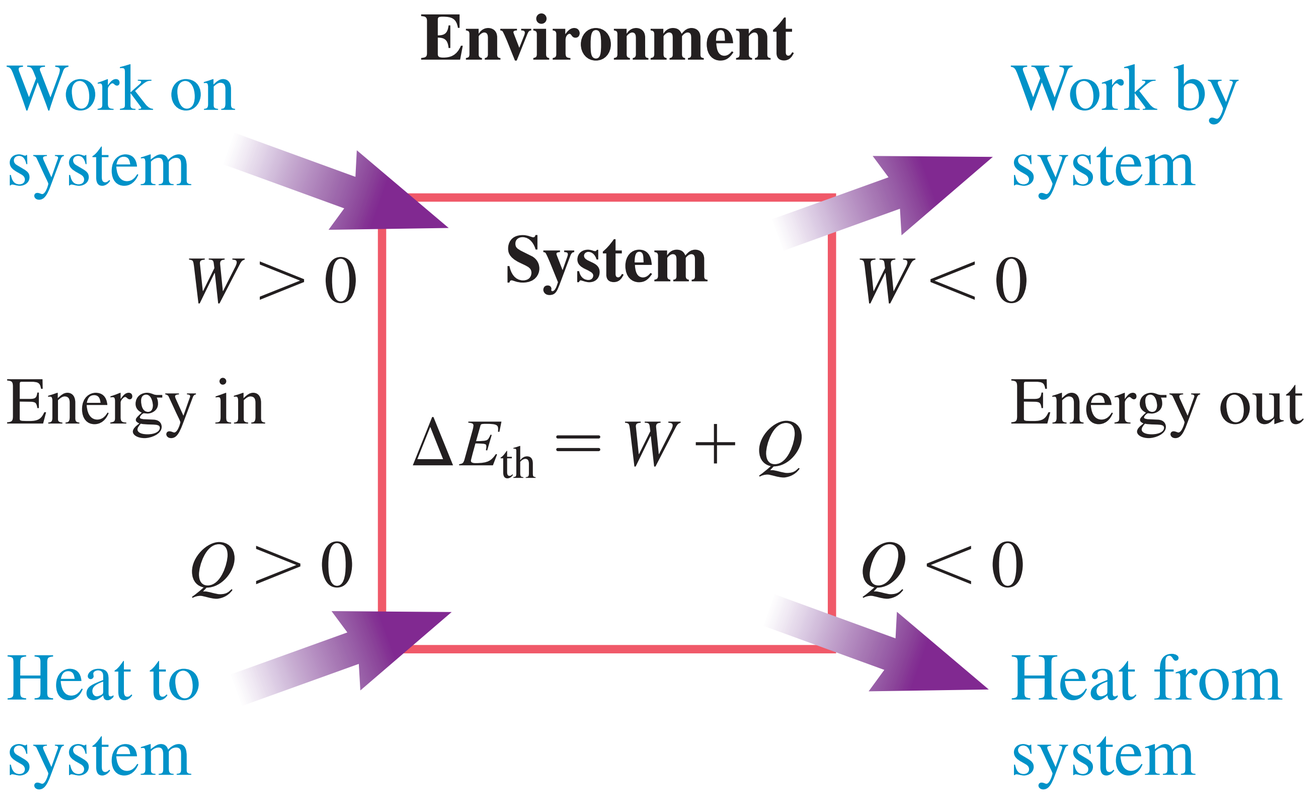
Thermal equilibrium occurs when the systems have the same average kinetic energy and thus the same temperature.

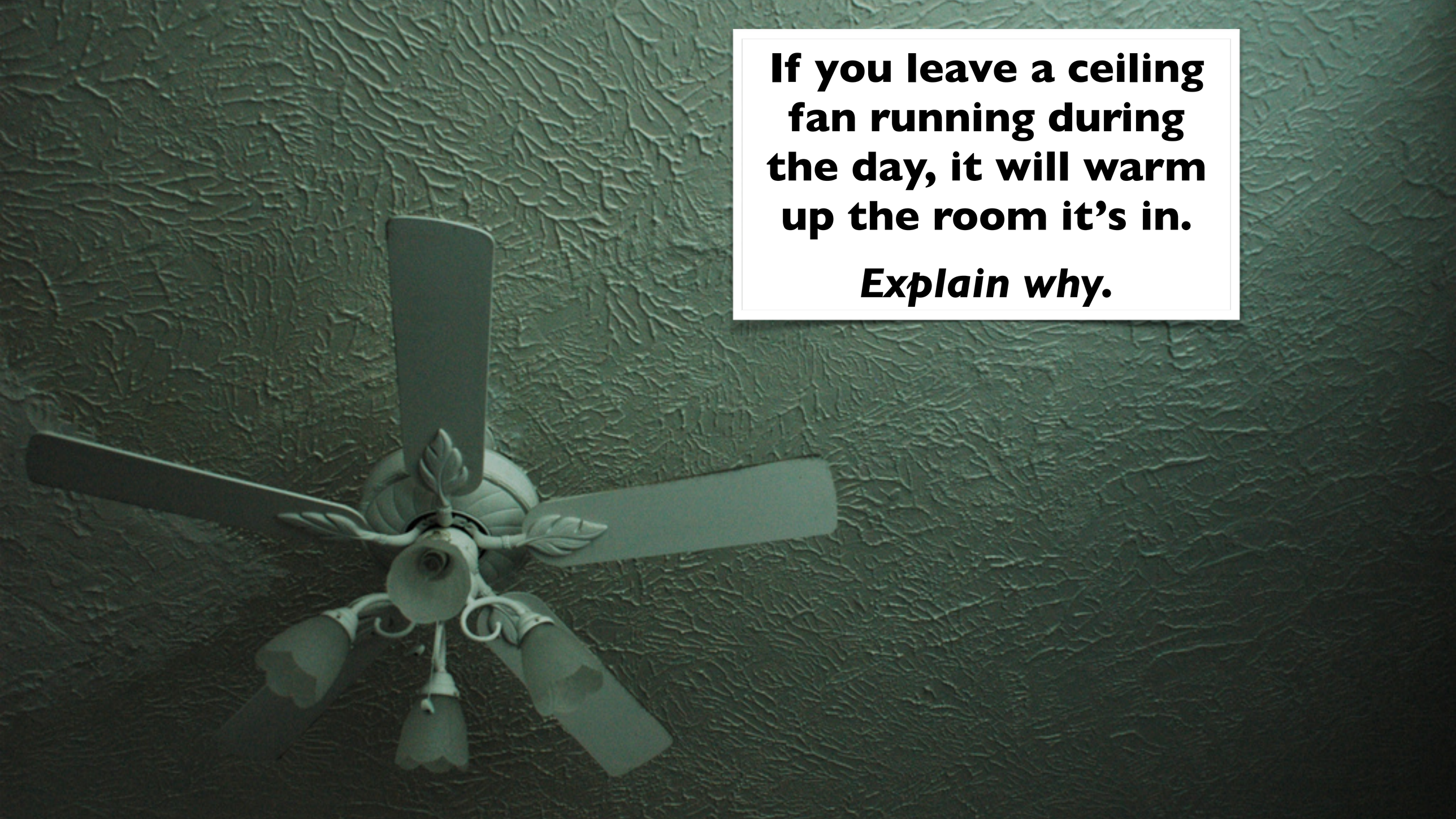


First law of thermodynamics For systems in which only the thermal energy changes, the change in thermal energy is equal to the energy transferred into or out of the system as work W, heat Q, or both:

$$\Delta E_{\text{th}} = W + Q \tag{11.8}$$

Not a new law of physics.





If you leave a ceiling fan running during the day, it will warm up the room it's in.

Explain why.

The blender is faster than the microwave.