Heat Capacity and Specific Heat

- *Heat Capacity:* ratio of the amount of energy absorbed to the associated temperature rise.
- Example: if it takes 10 calories to raise the temperature of a glass of water by 2 °C, then the heat capacity of the glass of water is 10 calories/2°C = 5 calories per °C.

- *Specific Heat:* the heat capacity of a substance per unit mass
- Example: for water, it takes 1 calorie to raise the temperature of 1 gram of water by 1°C. So the specific heat for water is 1cal/gram °C

Specific Heats of Various Substances

Substance	Specific Heat (cal/gram °C)	Specific Heat (J/kg °C)
water (pure)	1.00	4186
wet mud	0.60	2512
Ice (0 °C)	0.50	2093
sandy clay	0.33	1381
dry air (sea level)	0.24	1005
quartz sand	0.19	795
granite	0.19	794

Note: 1 calorie = 4.186 joules (both are units of heat (energy))

Q: Which has the highest heat capacity:
2 grams of pure water
4 grams of ice at 0 °C
10 grams of quartz sand
Answer: Water and ice both require 2 calories per degree C

Q: Which will become warmer:
adding 10 calories to 1 gram of water
adding 10 calories to 1 gram of quartz sand
Answer: The sand will become warmer.

The difference in specific heats between land and water creates the sea breeze circulation

Latent Heats

When a substance changes from one state to another, latent heat is added or released in the process.
Latent heat: the energy required to change from one state to another at constant temperature
Consider the water substance: all three phases of water (vapor, ice, and liquid) can be present at the same time
in a thunderstorm, for example, water is changing phases on a continual basis, therefore, latent heat is added or released on a continual basis

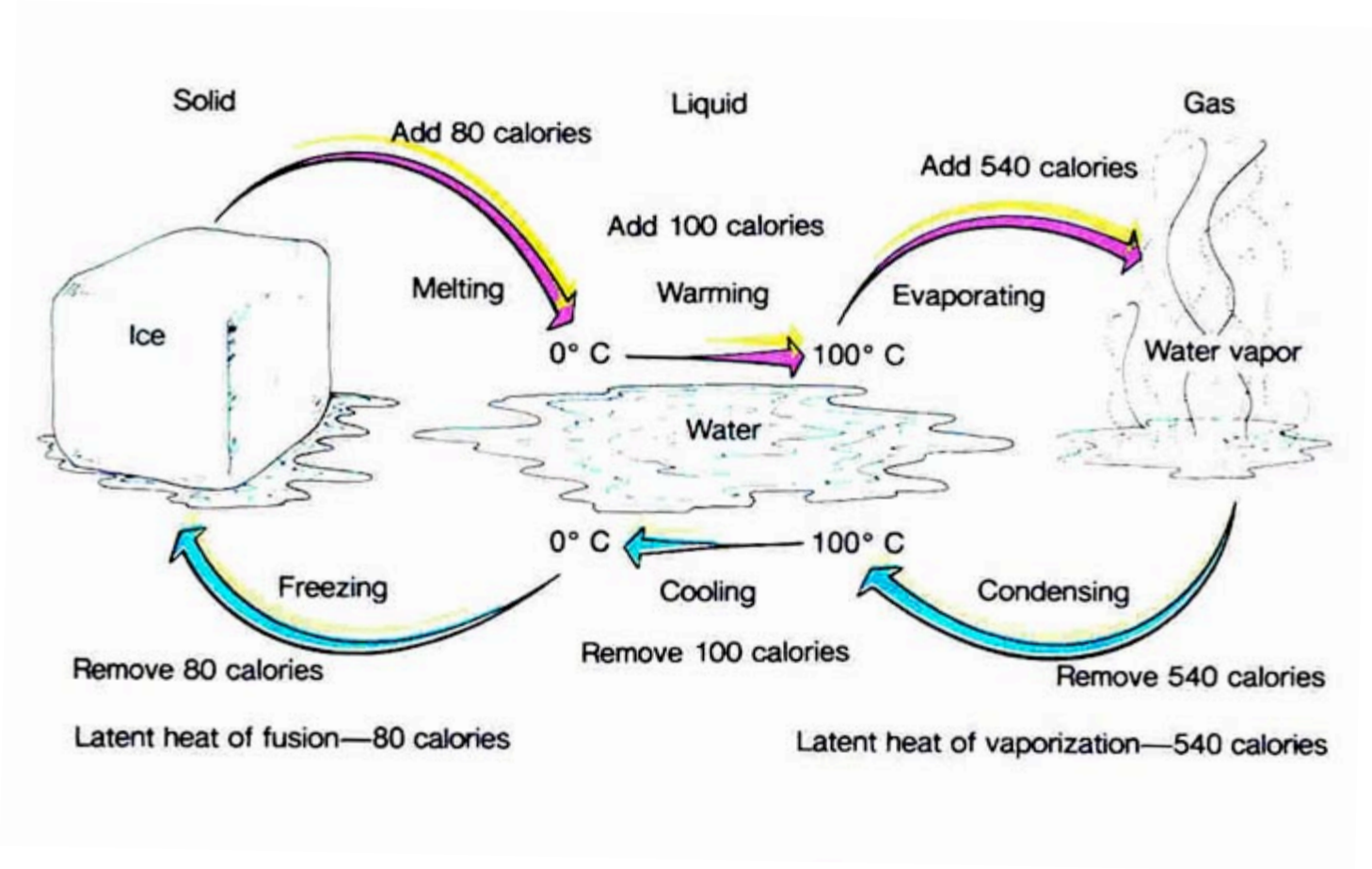
Change of state for water:

liquid --> vapor, latent heat of *evaporation* is added (about 600 cal per gram)
Q: What are some real-world examples of this process?
Answer: Sweating, water evaporating from lakes, ponds, ocean, boiling water….

vapor --> liquid, latent heat of *condensation* is released (about 600 cal per gram)

liquid --> ice, latent heat of freezing is released (about 80 cal per gram)

ice --> liquid, latent heat of fusion (melting) is added (about 80 cal per gram)



In a hurricane, if 100 grams of water vapor condense into water every second, how many calories of heat are released into the atmosphere in one day?

Answer: 100g x 540 calories/g x 3600 sec/hour x 24 hours = 4.7×10^9 calories

How much additional heat per day would be released if the water then froze into ice particles?

$4.7 \times 10^9 \times 80$ calories/gram = 3.8×10^{11} calories