

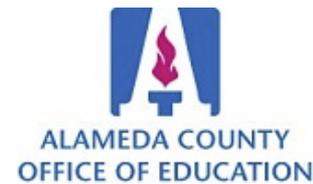
Why Does Hot Air Rise?



(1) Wikimedia User: DarlArthurS



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Why does a hot air balloon rise?

The common answer is that heat rises – but this is not really correct.

In order to understand why this answer is not correct, we need to consider what is meant by heat and temperature.

Temperature is the quantity that tells us how hot or cold an object is - relative to some other object or standard.

Heat is energy in the process of being transferred from one object to another because of a temperature difference.

Heat moves from a hot object to a colder object (with no regard to direction).



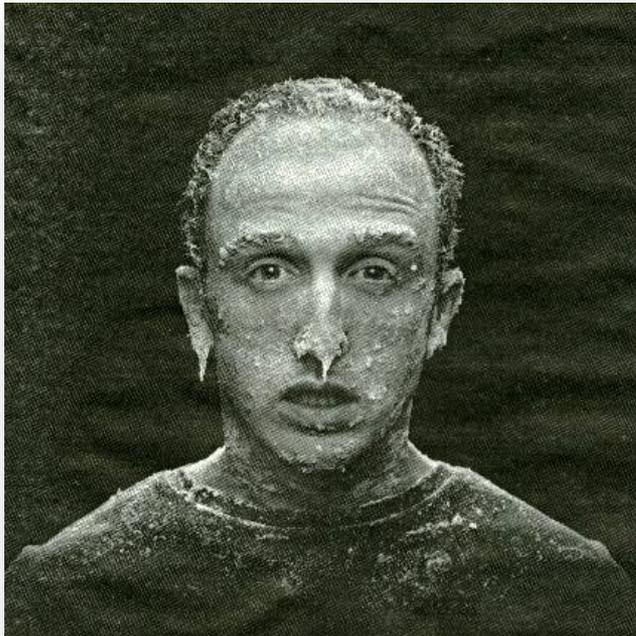
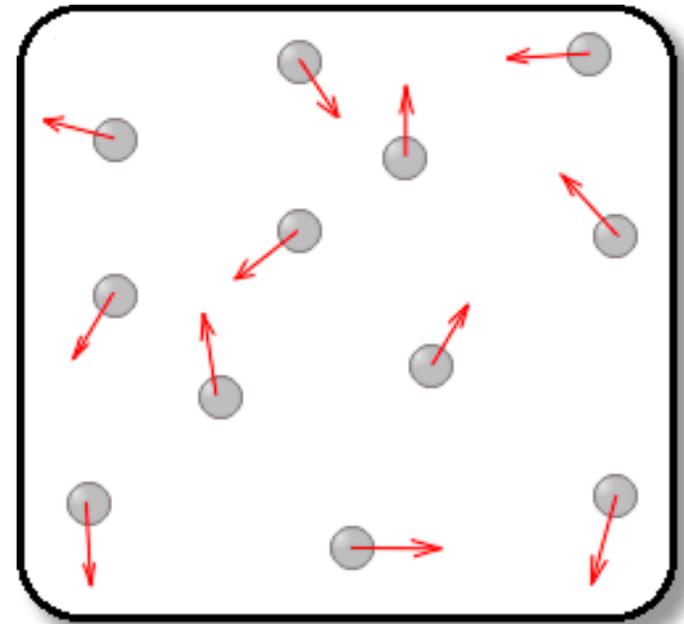
Thus, the simple interpretation that “heat rises” is not correct

. . . . but considering the nature of heat and temperature can lead us to understand the observation that hot air rises.



A more precise way to look at temperature (as a measurable quantity) is as a measure of the average *kinetic energy* of atoms and molecules.

Kinetic energy is the energy that an object possesses because of motion.

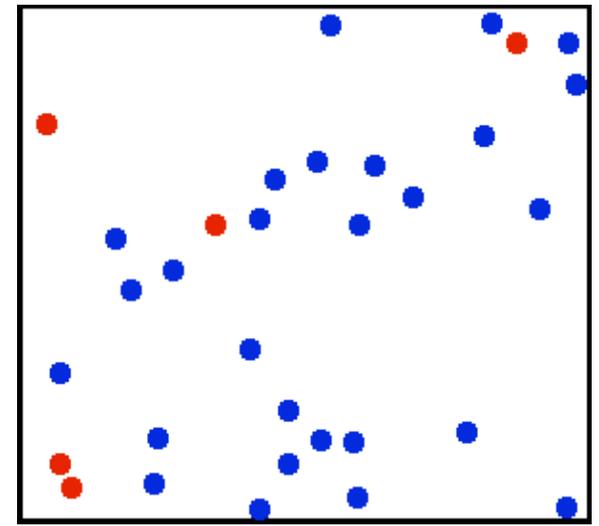


Molecular motion increases with an increase in energy (heat) — the molecules have a higher *kinetic energy*. Thus, higher temperatures correspond to higher *kinetic energy* or faster molecular motion.

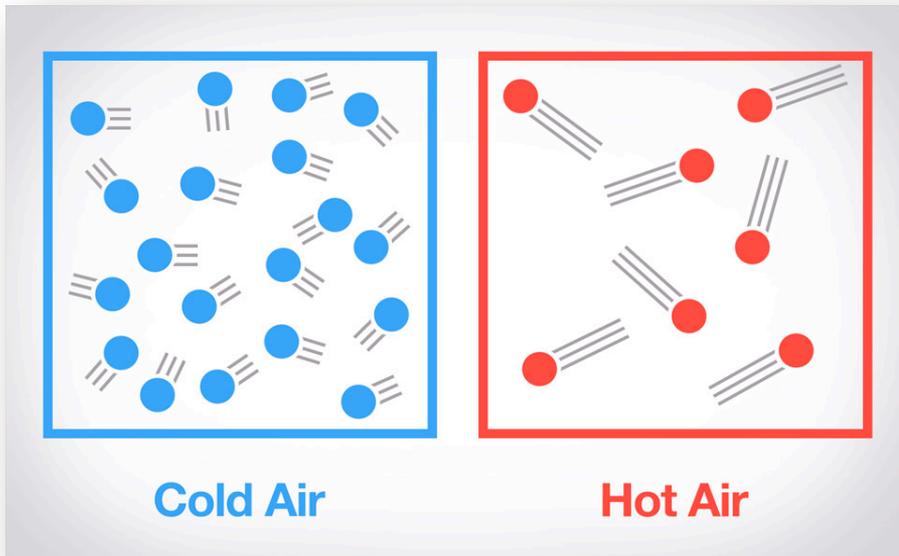
It is an important concept to understand the relationship between heat (temperature) and molecular motion.

If the molecules in air have higher *kinetic energy* at higher temperature, what happens when they collide?

As the temperature of a gas or liquid increases, the average kinetic energy increases. Thus, the energy of the collisions increases causing the distance between the molecules/atoms to increase that result in an expansion of the gas or liquid.



Wikipedia: User:Greg L



Which box of air has the lower density?

Buoyancy is the ability or tendency for an object with a lower density to float or rise within a fluid (liquid or gas) of greater density.

Solid ice has a lower density than liquid water and therefore floats in a glass of water.



[Photo courtesy photos-public-domain.com](https://www.courtesy-photos-public-domain.com)



The air inside a hot air balloon is less dense and *buoyantly* rises through the colder air outside the balloon.

[Wikimedia User: TakeAway](#)

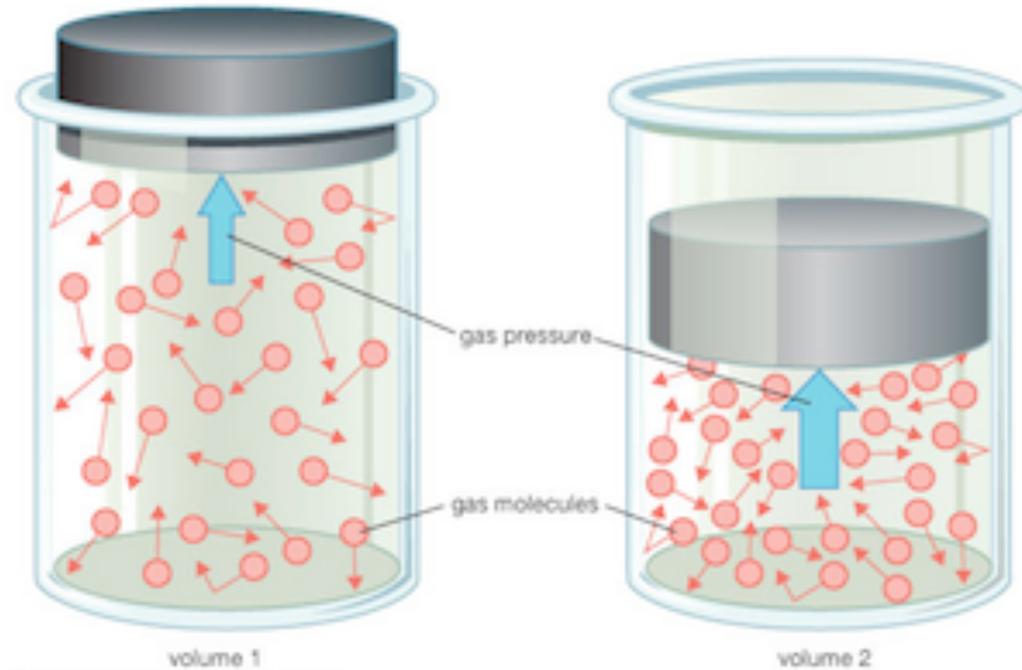
Another way of looking at this is through the ideal gas law. The *ideal gas law* describes the relationships between volume (V), pressure (P) and temperature (T) in an ideal gas.

$$PV=nRT$$

n is the number of gas molecules

R is the *ideal gas constant* that accounts for the units by relating the energy scale in physics to the temperature scale.

Ideal gas law



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Rearranging the *ideal gas law*:

$$\text{density} = n/V = P/RT$$

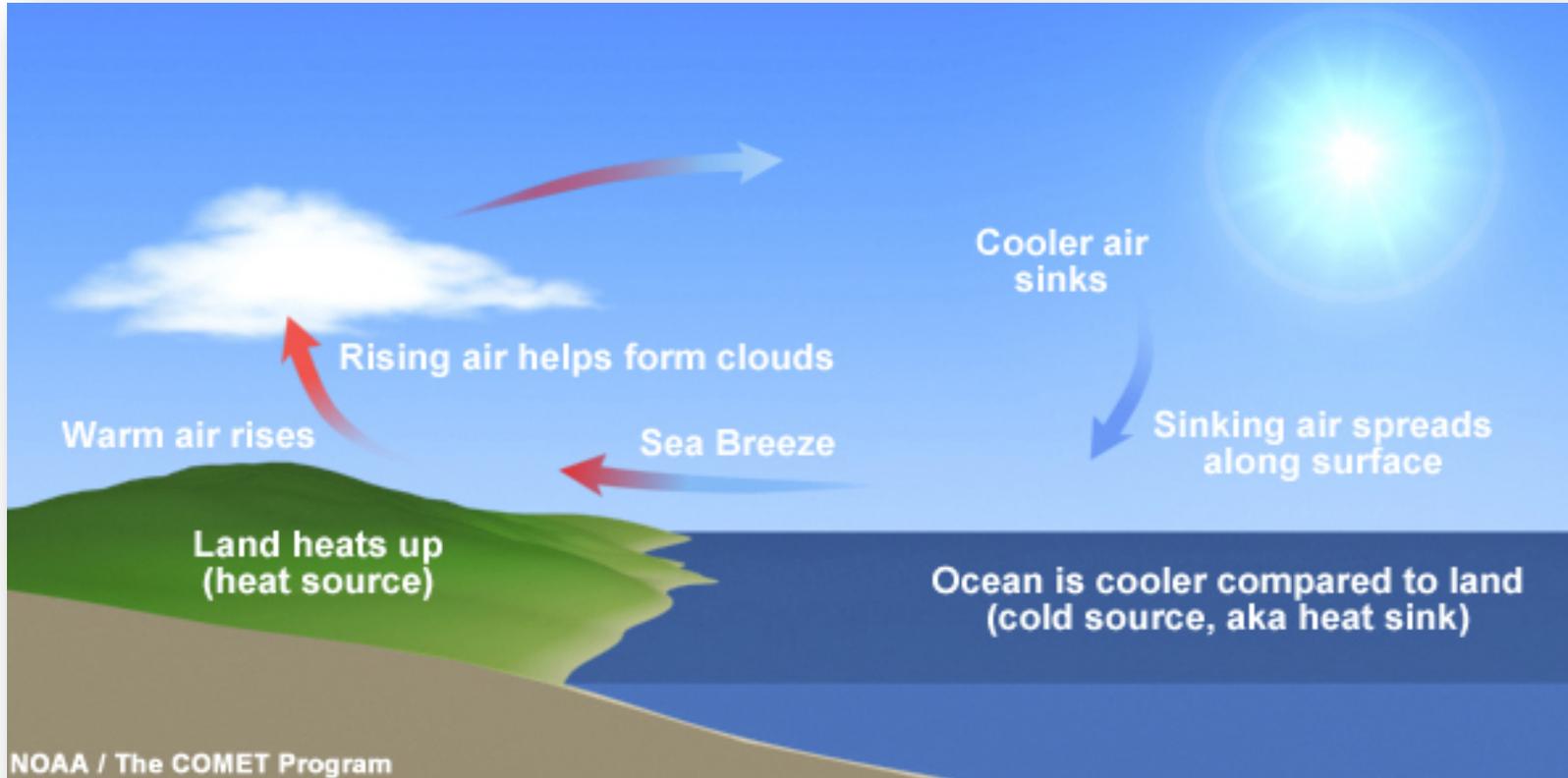
If the temperature of a r gas increases and it expands, the density (mass/volume) decreases.

Thus warm air (or water) rises buoyantly because it is less dense.

Conversely, if air or water is cooled, the density increases and it will sink.



Why is this important?



Temperature-driven density differences in the Earth's atmosphere are responsible for important meteorological *phenomena* such as atmospheric convection, cloud formation, and the development of sea breezes.