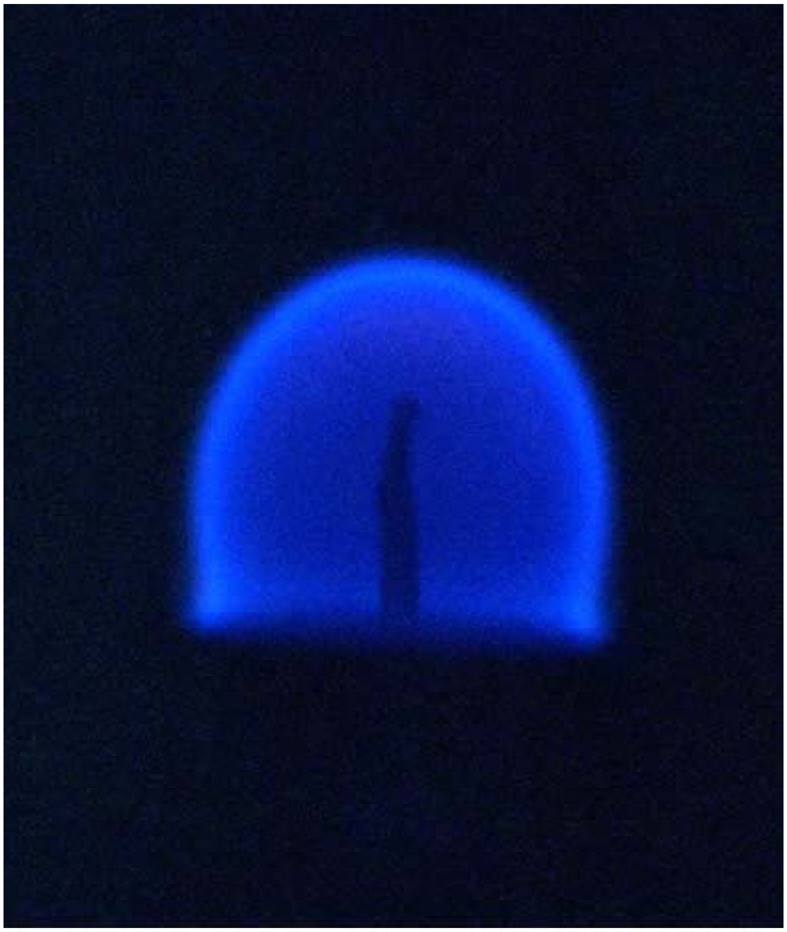
To see a world in a grain of sand... - William Blake

While enjoying a recent effect of Global Warming, a week-long blackout brought on by a freak ice-storm which devastated the central Massachusetts region, I had ample opportunity to contemplate how a candle's flame behaves.

It's often said that here on the earth's surface, air convection is the ruling heat-loss mechanism. And how. We're like fish living at the bottom of an ocean, yet are seldom aware of how our effort to generate heat is constantly thwarted by the very medium we're breathing. It's not that air is a good conductor, it's that once it does conduct it won't stand still. Due to gravity, heated air becomes lighter in weight and rises away, while cooler air is displaced downward and steals more heat from the source. This process shapes a candle's flame and even influences its color.

Hold a candle at any angle and the flame always points upward, away from the earth's center. The flame responds to gravity. It would otherwise look like a ball, not a teardrop, but the currents it generates push colder air into it, thus squeezing it into something more cylindrical. This air infiltrates the flame itself, so, although currents keep bringing in fresh oxygen to use, the cooling effect is profound. The net result is a vigorous flame that's too cool to burn efficiently. The black soot a candle emits is unburned carbon, a symptom of incomplete combustion. Due to air convection, then, a candle flame is never as hot as it *could* be although it's brighter than it *would* be. All because air moves so nimbly in a gravitational field.

The oddness of this being so familiar to us, the appearance of a candle in zero gravity is somewhat startling.



A candle flame in microgravity.

The flame is spherical because no convection occurs. Blue because of complete combustion. Dimmer because of a slower rate of oxygen replenishment in static air.

As I waited night after night for the electricity to return, candlelight kept teaching me about moving air's talent for removing heat, hampering any effort to keep warmth "down here" by constantly sending it up and away. Good thing for a heat-containing roof, then; it lessens the harm considerably. The earth itself lacks any such roof, however. And imagining that certain radiation-absorbing gases provide one is only to confuse radiation with convection.

A physical lid over a heat source decreases the zone of circulating air, thus reducing the cooling rate. But an open "lid" of gas that's capable of absorbing radiant energy will convect around like any other gas, stealing heat and doing nothing else except radiating the very energy it has received by radiation, having zero power to confine it. Rather than limiting the area in which heat-loss occurs, then, a radiant absorber constitutes no barrier to radiation at all — it's merely a second radiator that relays heat away. And, just as there’s no such thing as "back-convection" — where a flame makes itself hotter by the air currents it creates — or "back-conduction" — where a colder object raises the temperature of what it’s in contact with — there’s no such thing as "back-radiation." Redirecting radiant energy back to the source cannot increase its temperature.