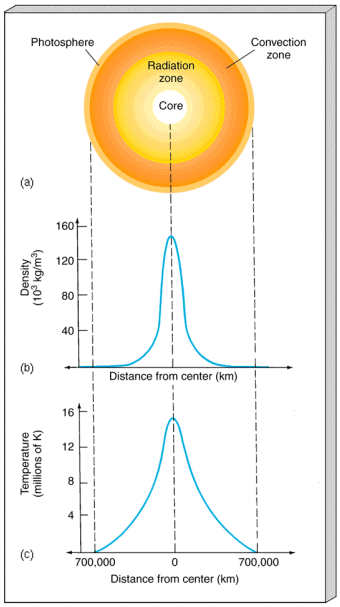
Laws of Stellar Structure

Think of star as layered shells… then the following laws must hold for each shell and for the transport of material and energy through shells.

1. Conservation of Mass
   Mass coming into shell equals mass going out of shell. Total mass equals sum of all shell masses.
2. Conservation of Energy
   Energy coming into shell equals energy going out of shell. Total energy equals sum of shells.
3. Hydrostatic Equilibrium
   Weight on a given shell balances with the pressure in that shell. Entire star in this balance.
4. Energy Transport
   Energy moves from hot to cool shells by either radiation, conduction, or convection.

i.e., 1. no clumps; 2. no hot spots; 3. no instabilities!



Hydrostatic Equilibrium

Each layer has its own weight (a force).

Each layers feels the summed weight of above layers.

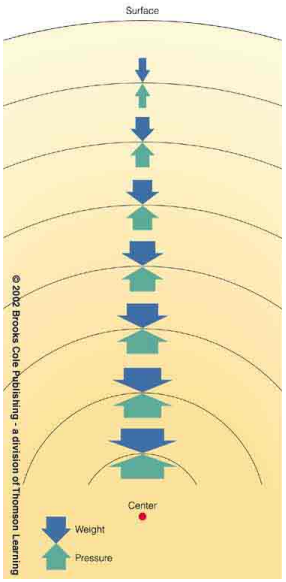
To balance gravity, something need to push upward on the layer (from below) and within the layer.

This is gas pressure (a force).

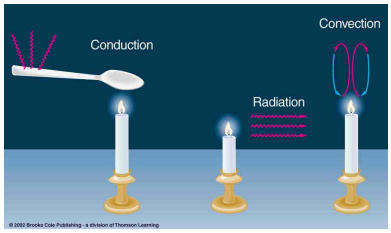
The gas pressure at each layer balances with the weight at each layer.

Gas pressure depends on temperature, or kinetic energy of gas.

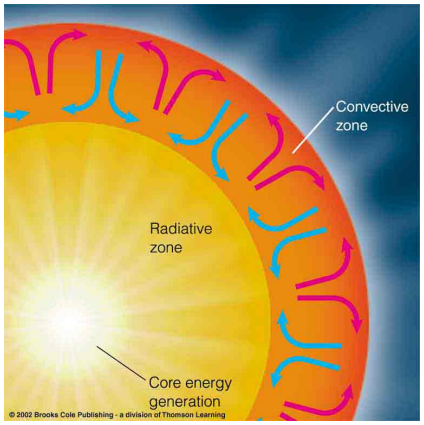
As you go down in the star, the weight increases, so you need greater balancing pressure, so you need greater kinetic energy. Thus, as you go down in the star the temperature increases.



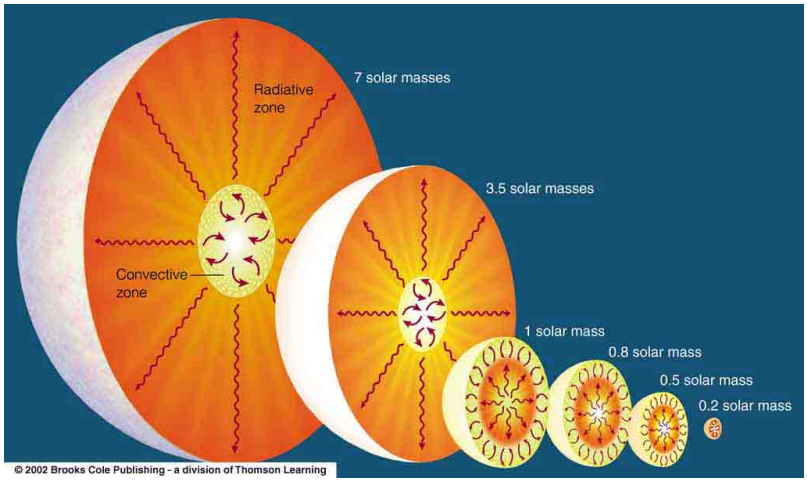
Energy Transport



Stars use only radiation and convection. The core gets so hot and dense (a high pressure area) that nuclear fusion reactions can happen, i.e. the PP chain.



Radiative and Convective Zones in Main Sequence Stars.



The more massive stars have small convective interiors and radiative envelopes. Sun-like stars have radiative interiors and thin convective envelopes. Very small stars have purely convective energy transport throughout.

Evolutionary Tracks

When Main Sequence Stars are newly born they are called Zero Age Main Sequence stars. (the red line on the graph)

As they convert hydrogen to helium in their cores, their *temperatures decrease* and their *luminosities increase* slightly. This is due to an increase in the stars' radii.

This moves the star to the upper right on the HR diagram as they age.

The "path of migration" on the HR diagram is called an evolutionary track.