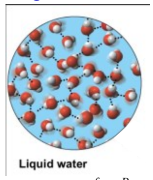
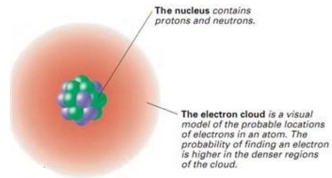
Summary of Classical Thermodynamics

- As developed in 1800’s (e.g., work of Joule and Clausius), “classical” thermodynamics
  - treats matter without regard to is microscopic nature (e.g., molecular/atomic/… structure)
  - based on empirical knowledge
  - broad/general applicability (to macroscopic systems)
  - provides relationships between TD properties, but cannot provide predictions of certain TD properties at given T, p
    - e.g., c_p, c_v, compressibility coefficients
- So how can we find these TD properties?



from Pearson Education

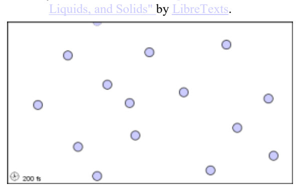


Stat Mech and Molec Modelsl-1

What Model to Use for Matter?

- What laws govern molecules?
- Could try to build model using Newtonian mechanics considering motions of each and every molecule
  - might be considered for a gas, where molecules spend most of their time a “long” distance from other molecules
  - but at normal conditions (T, p) there are O(10^{18}-10^{19}) molecules per cm^3 of a gas
    - even more for liquids and solids
  - would require updating ~3×10^{19} position and 3×10^{19} velocity components every ~10^{-10} seconds (time between collisions) **just to model something 1 cm^3 in size**
  - not possible in 1900’s, not practical even now

from " A Molecular Comparison of Gases, Liquids, and Solids" by LibreTexts.



Stat Mech and Molec Modelsl-2

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Statistical Mechanics

- Solution to this problem, developed around 1900, e.g., work of Boltzmann and Gibbs
  - **Statistical Mechanics**
    - uses statistical concepts/mathematics to average over large numbers of molecules to get macroscopic properties from microscopic/molecular information
- What kind of mechanics should be used to described molecules?
  - initially tried Newtonian Mechanics
    - some initial success, e.g., c_p of monatomic gases
    - but could not explain experimental observations for non-monotonic gases, metals, and blackbody radiation
  - success came with development of a more accurate representation of microscopic matter: **Quantum Mechanics**