

Note on calorimetry experiment: We know carbs have ~ 4 food cal/gram
 fats have ~ 9 food cal/gram

We measured $\sim 3-6$ food cal/gram - pretty close!

(lower because of heat loss to surroundings)

History of Energy Usage

prehistoric man: ~ 100 W food
 ~ 100 W fire

ancient Egypt: + building, glass blowing,

China 100 BC: + transportation

Europe 1300: + more heating (Europe is cold!)

England 1880: Industrial Rev \rightarrow + production

N. America 1990: + transportation

Industrial Revolution: "We have all these machines and no good way to power them!"

Rotational Machines:

grinding
 pump
 lathe
 spinning wheel
 potter's wheel
 winch (lifting)

Linear Machines:

hammer mills
 bellows
 pump
 saw
 loom
 sails

} reciprocating
 (back and forth)

\hookrightarrow All this stuff used wind, water, animal, or human power

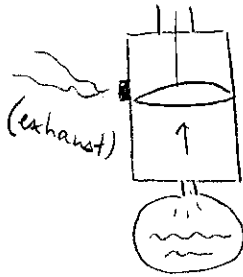
Breakthrough: 1. heat \rightarrow work barrier } talk about
2. work \rightarrow electricity \rightarrow work } these later

Heat Engines:

Step 1: "pull" machine

Step 2: Watt's engine: add second cylinder to cool steam
"push" machine

Step 3: eliminate cooling step



- light
- fast
- powerful

- open system (requires input water)
- wasteful of energy

Step 4: "double action steam engine" (see slide)

\hookrightarrow used for transportation: trains!