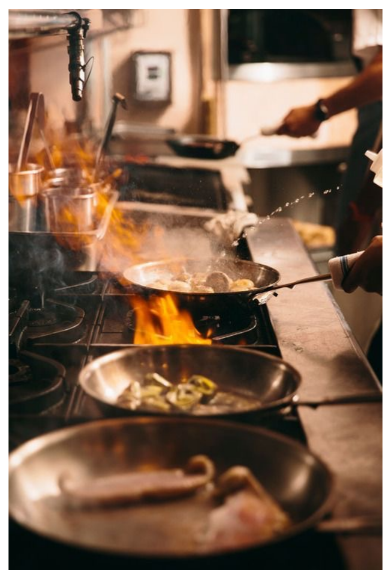
Cooking with Heat

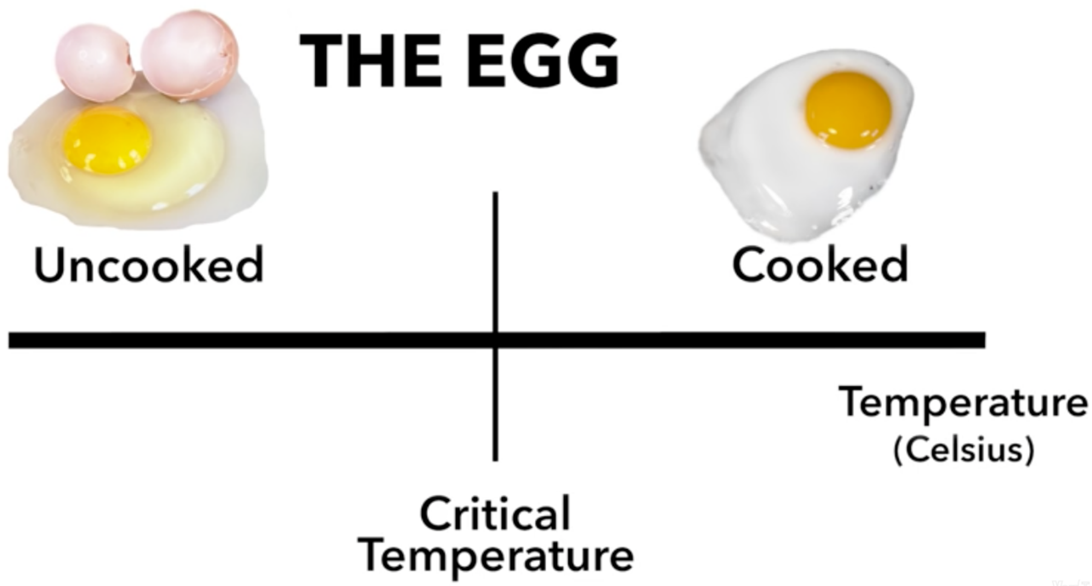
What is cooking?

Oxford English Dictionary:

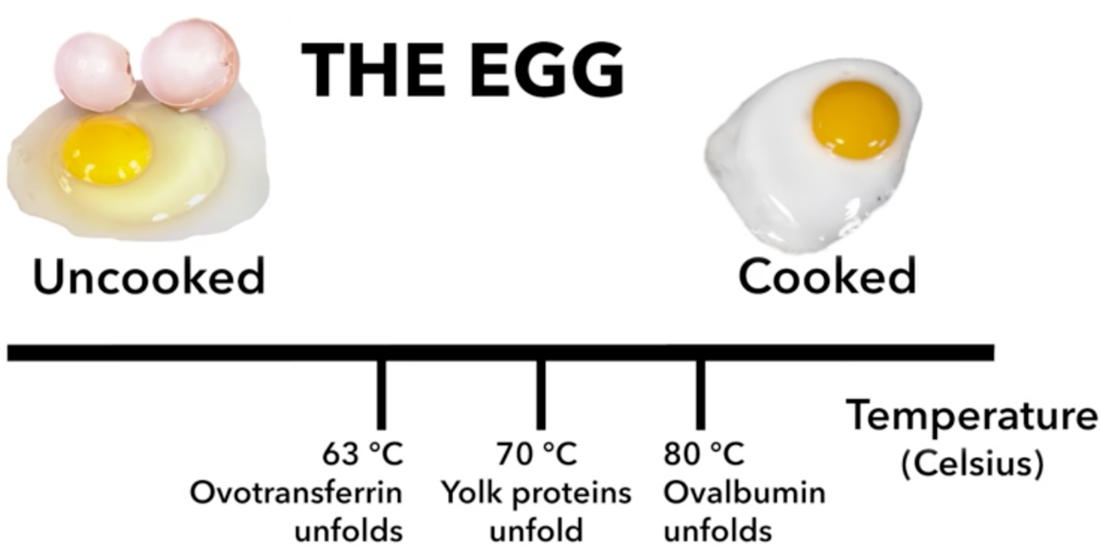
"To prepare or make ready (food); to make fit for eating by due application of heat, as by boiling, baking, roasting, broiling, etc."



What this implies…



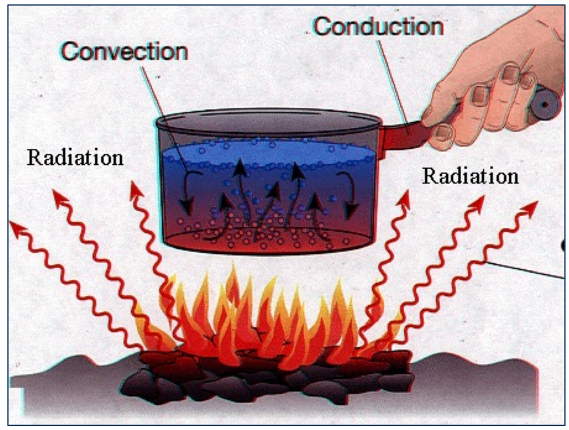
However, it is not that simple.



Different proteins in the egg denature at different temperatures.

How do we cook?

- Transfer heat from fuel to food.
  - gas, charcoal, wood
- Joule (J)
  - unit of energy



1 J	An apple falling from 1 meter.
230 J	Fastball @ 100 mi/hr
5000 J	220 lb tackle running 40 yd in 4 sec
	Burning of 1 kg (2.2 lbs) of wood

How much energy will your food absorb as it cooks?

- Depends on how much energy your cooking instrument puts out over an amount of time.

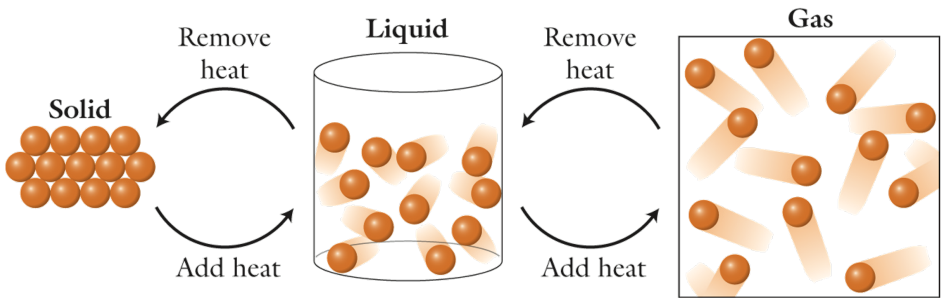
$$\frac{energy}{time} = \frac{joules}{\text{sec}} = watts$$

How much energy (J) does a 10,000 W stove produce in 20 min?

Where does the heat go?

Most food molecules do change from one phase to another when heated:

They also react to form different molecules.



What is heat?

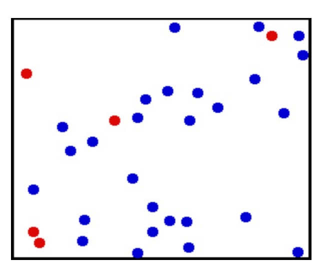
- Heat is the energy that flows between two samples of matter due to their difference in temperature.
  - Usually denoted by the letter Q or q.

What is temperature?

- A measure of the energy in the motion of the molecules in a material.

Jiggling and whizzing of molecules

Causes changes to happen



How much energy does it take to cook an object?

- For example: an egg
  - Depends on three things:
  1. The mass (m) of the egg
  2. The beginning and ending temperature

     $T_{final} - T_{initial}$ (°C) = ΔT
  3. How much the material heats up when a certain amount of energy is given to it – heat capacity (C_p)
     - Varies with the food item.

$$Q = mC_p \Delta T$$

Q = amount of heat dumped into a food.

Specific Heats

Food item	Specific Heat (J/g•K)
Water	4.18
Egg	3.18
Milk	3.85
Beef	2.5-2.1
Olive oil	1.97
Air	1

Most food are between water and oil

How much energy does it take to boil a cup water?

$$Q = mC_p \Delta T$$

Given/known values

C_p = 4.18 J/g•°C

Boiling water = 100 °C

Room temp water = 23 °C

1 cup = 237 mL= 237 g

$$Q = mC_p\Delta T$$

$$Q = (237\ g)(4.18\ \frac{J}{g \cdot K})(77\ °C)$$

$$Q = 76{,}281\ J$$

Look at units we encounter.

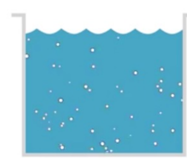
How can we relate joules to Calories?

Calorie

= the energy it takes to heat up 1 L (kg) of H_2O by 1 °C.

1 kg = 1000 g

$$Q = mC_p \Delta T$$



Food item	Specific Heat (J/g•K)
Water	4.18

= 1000 g (4.18 J/g•K)(1 °C)= 4180 J = 4.18 kJ = 1 Calorie

1000 J = 1 kJ

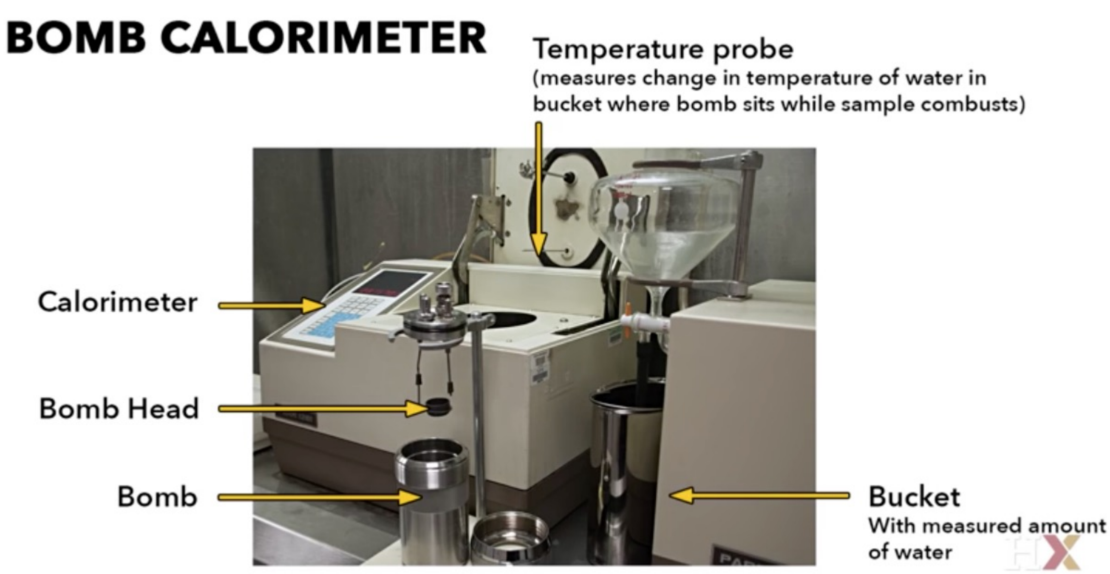
How much boiling water do you need to cook the perfect egg (35 g)?

$Q_{food} = Q_{water}$

Principe of Conservation of Heat:

- Energy cannot be created or destroyed but merely transferred from one location to another.

How do we measure calories in the real world?



Specific Heat, Calories and the 4:4:9 Ratio

CALCULATING THE CALORIE CONTENT

Carbohydrates

4 Cal/g

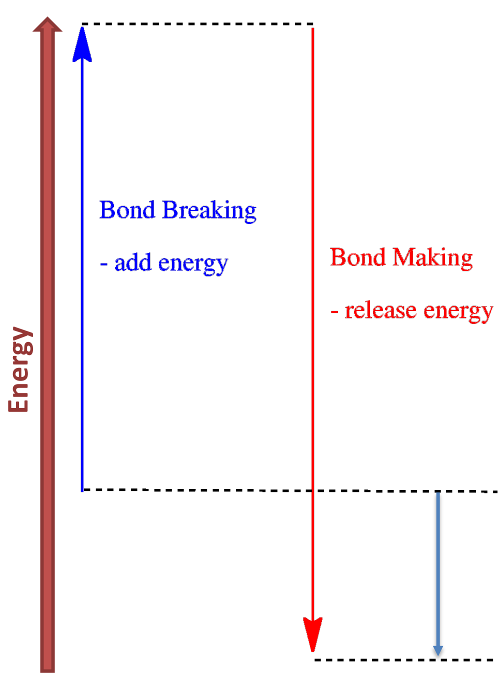
Proteins

4 Cal/g

Fats

9 Cal/g

Where does the 4:4:9 Ratio come from?



The amount of energy that is produced when a molecule is broken down to depends on **which bonds are broken and which bonds are formed**.

- Energy must be used to break bonds (costs energy).
- Energy is released when bonds form (releases energy).

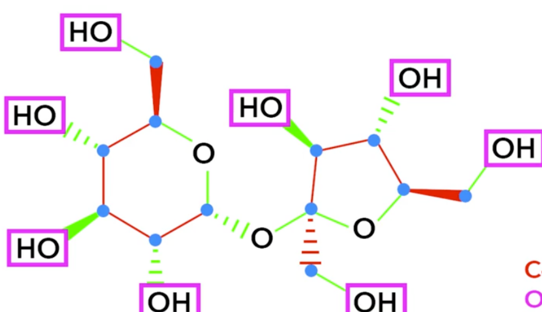
Calculate the calorie content.

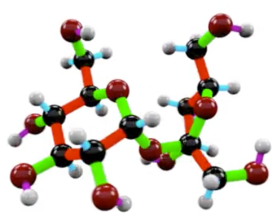
Nutrition Facts	
Serving Size 1 cookie (78.0 g)	
Amount Per Serving	
Calories 370	Calories from Fat 171
	% Daily Value*
Total Fat 19.0g	**29%**
Saturated Fat 9.0g	**45%**
Cholesterol 20mg	**7%**
Sodium 340mg	**14%**
Total Carbohydrates 49.0g	**16%**
Dietary Fiber 2.0g	**8%**
Sugars 28.0g	
Protein 4.0g	
* Based on a 2000 calorie diet	

4 g x 4 Cal/g = 16 Cal	Protein
47 g x 4 Cal/g = 188 Cal	Carbohydrates
<u>19 g x 9 Cal/g = 171 Cal</u>	Fat
375 Cal	

Origin of the 4:4:9 Rule

Let's look at sucrose.





C-C Bonds 10
O-H Bonds 8
C-H Bonds 14
C-O Bonds 14

is metabolized

$CO_2 + H_2O$

Balanced equation:

$$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$$

O_2 is needed to metabolize sucrose.