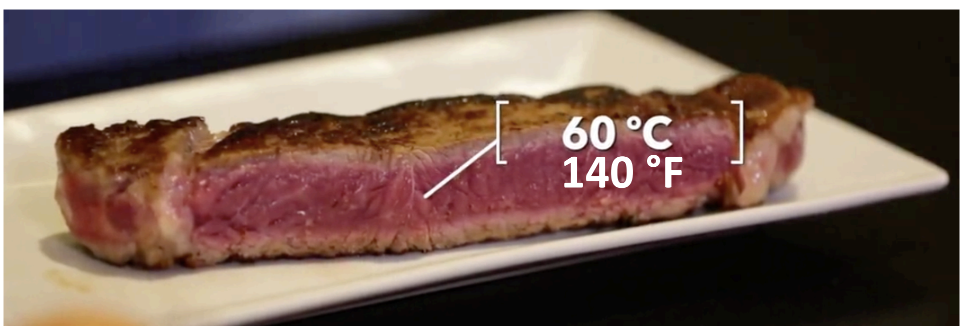
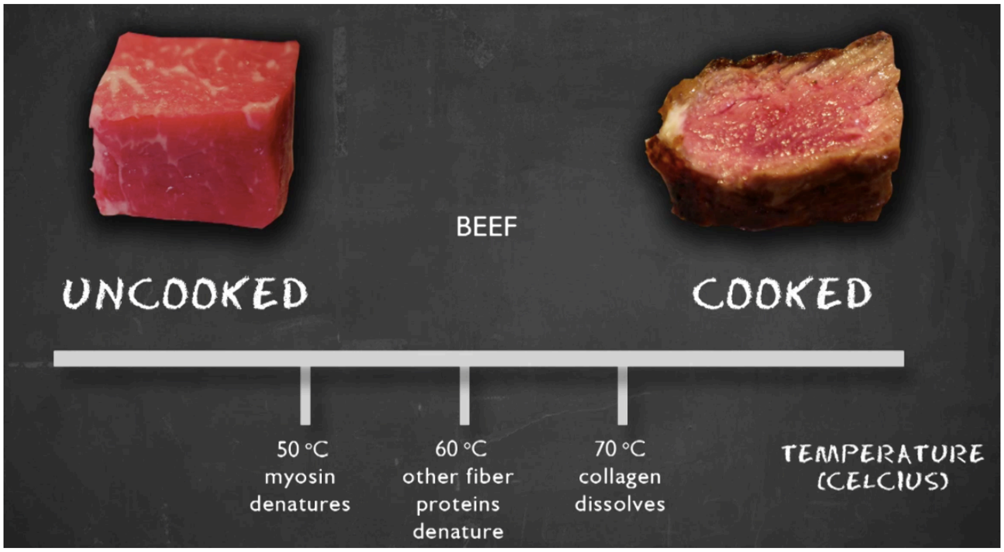
Heat Transfer

Heat Transfer and the Maillard Reaction



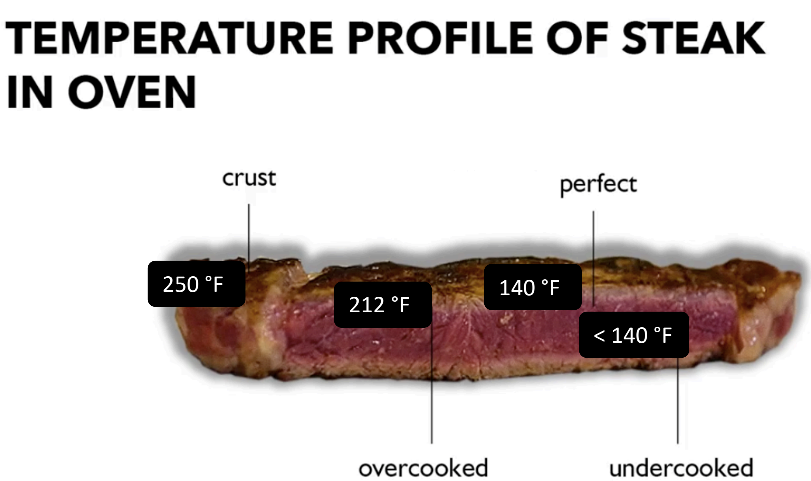
- Challenge:
  - In the center of the steak, you want this perfect texture, ~ 140 °F
  - Very thin crust where the browning reactions occur.

60 °C / 140 °F is common critical temperature



Common temperature where the proteins in the food unfold and interact with each other to cause the food to become cooked.

Recipes call for much higher temperatures.

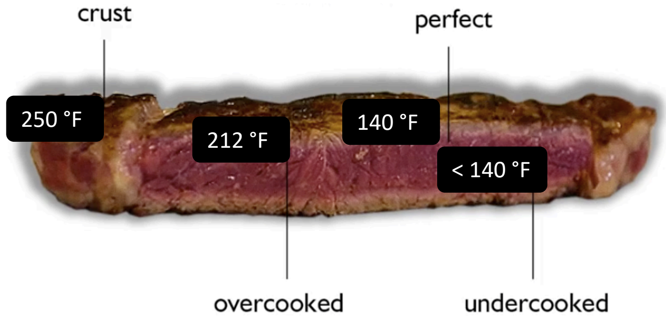


Why?

Two chemical reactions that need to occur

1. The texture on the inside has to change. (140 °F)
2. Browning reactions on the outside. (250 °F)

Why is hard to cook steak, tofu, fish, potato…



First -- want outside to be 250 °F

- Major component of steak is water and that boils at 212 °F
- Can't reach 250 °F right away
  - Get to 212 °F then water changes phases
  - Boil off some of the water
- Once dry on outside, can heat to 250 °F.

Another challenge.

When you cook (add heat) to a steak—it absorbs energy. $Q = mC_P \Delta T$

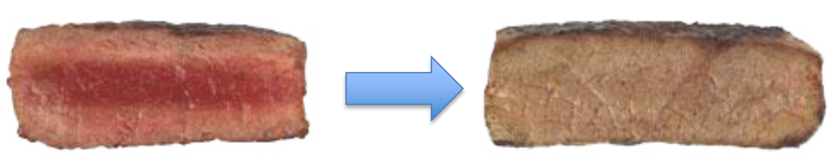
Don't want to eat a 250 °F steak!

- Must release that energy to cool back to room temperature.

How can it release energy/heat: to air or spread throughout meat.

- Problem: Air is a horrible thermal conductor therefore steak retains its heat.

Heat redistributes throughout steak.



Heat continues to diffuse even after you've taken the meat off of the heat source.– HEAT TRANSFER

How can your prevent overcooking?

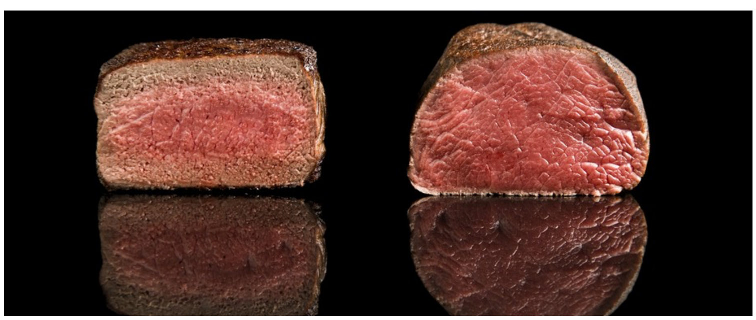
Preventing Over-Cooking

Sous-Vide Cooking

Cooking food at a constant temperature under vacuum in a sealed plastic bag

- by submerging in a temperature controlled water bath.
- it would taste quite bland although it has the perfect texture.
    - Why?   Don't produce flavor molecules!

Sous-Vide Cooking



- If you sear it immediately following you will produce the flavor molecules in a very thin layer.
- Sear
    - Put on a grill or on a very hot stove and cook at a very high temperature for a short time
    - Searing won't mess up the perfect texture in the middle.

Heat Transfer

How does the heat actually propagate from the outside to the inside?

- heat diffuses into food.
  - Moves from where there is more to where there is less until evenly distributed

How far does the heat diffuse in an amount of time?

$$L = \sqrt{4Dt}$$

L = distance the heat diffuses through the food

D = diffusion constant (unique for each food)

t = time

Food	Diffusion Constant (x 10^{-3} cm^2/sec)
Beef	1.35
Chicken	1.36 (white meat)
Chicken	1.28 (dark meat)
Fish	1.09
Apple	1.12
Strawberry	1.27
Peas	1.82
Potato	1.23
Water	**1.4**

Heat Diffusion over time.

Imagine that we're cooking the steak on the stove. The bottom is hot, and heat is defusing into the steak.

How far does the heat diffuse in a minute?

So what do we do?

$$L = \sqrt{4Dt}$$

4 minutes?

D = diffusion constant = 1.3 x 10^{-3} cm^2/sec

t = time = 60 sec

Determining Cooking Time

How long will it take for the heat to diffuse through (to cook) a 3 cm salmon fillet on the grill?

$L = \sqrt{4Dt}$ Solve for t. → $t = \frac{L^2}{4D}$

$$t = \frac{(3\ cm)^2}{4\left(1.09 \times 10^{-3}\ \frac{cm^2}{sec}\right)} = 2064\ \text{sec} = 34.4\ min$$

How is heat transferred?

Types of Heat Transfers in Cooking

– three ways that heat is transferred to foods.

Conduction is the direct transfer of heat between adjacent molecules.

– An example: cooking on a flattop range.

- The pan must be in direct contact with the range for conduction to occur.