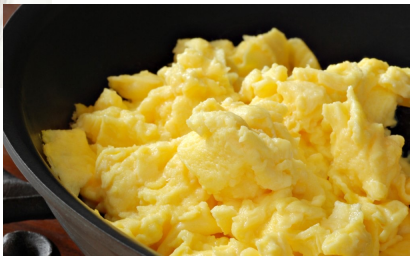
Variations on denaturation and coagulation

Cooking Eggs

Cooking with eggs

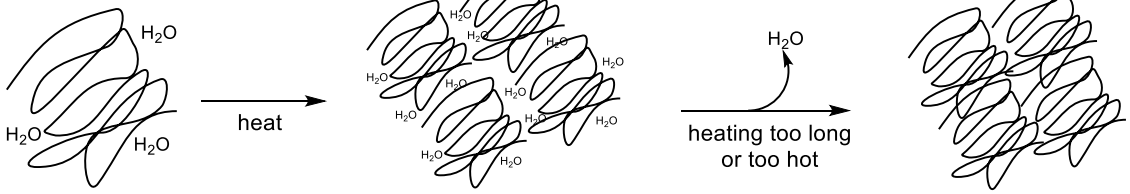


Denaturation and Coagulation of Egg Protein

Denaturation is always followed by coagulation

Clear, transparent, raw egg white is full of happy, folded proteins

Opaque, white, cooked egg white is made of heat denatured, coagulated and solidified protein

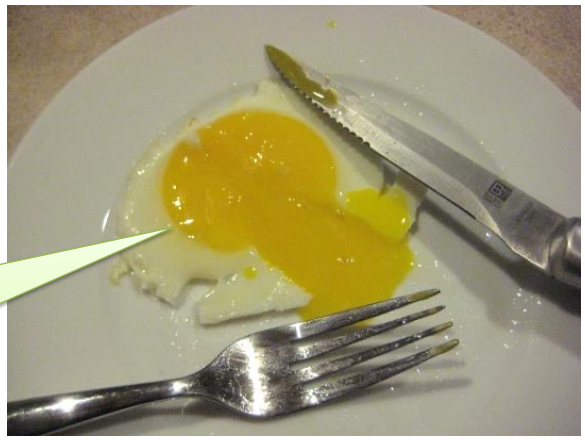


Denatured egg white protein (egg white already contains water)

Many egg white protein molecules that have *coagulated* trapping water molecules = tender solid

Coagulated egg white proteins that have lost water due to overheating = rubbery solid

Different rates of denaturation and coagulation



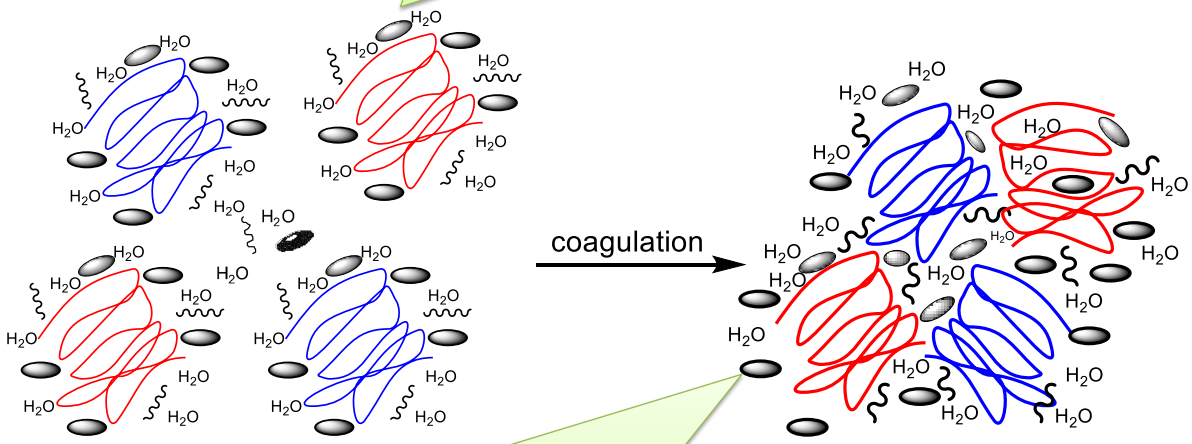
Why does the egg white "set" (i.e. denature and coagulate) before the yolk?

Table 9-1 The Composition of a U.S. Large Egg [1]

	Whole Egg	Egg White	Egg Yolk
Weight	55 grams (g)	38 g	17 g
Protein	9.9 g	3.9 g	2.7 g
Carbohydrate	0.9 g	0.3 g	0.3 g
Fat	9 g	0	9 g
Monounsaturated	2.5 g	0	2.5 g
Polyunsaturated	0.7 g	0	0.7 g
Saturated	2 g	0	2 g
Cholesterol	213 milligrams (mg)	0	213 mg
Sodium	71 mg	92 mg	9 mg
Calories	84	20	94

Interfering with Coagulation

Egg protein denatured in the presence of extra molecules (proteins are diluted)



Diluted egg proteins have coagulated (sticking hydrophobic regions together), while trapping extra molecules in the matrix - the extra molecules interfere with the protein-protein interactions so higher temperatures are needed to coagulate. .

Denaturation and Coagulation in custard making

Ingredients for Crème Brulee
1 quart heavy cream
1 vanilla bean, split and scraped
1 cup vanilla sugar, divided
6 large egg yolks

The diluted egg yolk protein denatures and coagulates into softer, more delicate solid…called a *custard*

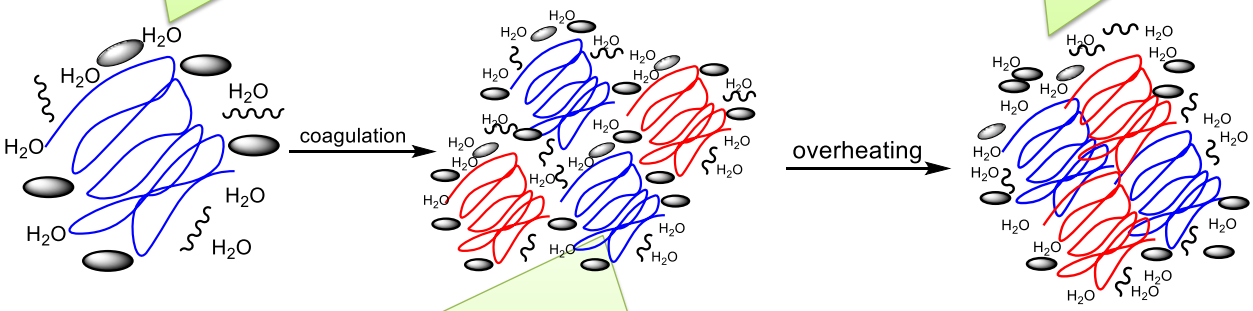
In a medium bowl, whisk together ½ cup sugar and the egg yolks until well blended and it just starts to lighten in color. Add the cream a little at a time, stirring continually. Pour the liquid into 6 (7 to 8-ounce) ramekins. Place the ramekins into a large cake pan or roasting pan. Pour enough hot water into the pan to come halfway up the sides of the ramekins. Bake just until the crème brulee is **set,** but still trembling in the center, approximately 40 to 45 minutes.

"Setting" is the process of a liquidy mixture becoming solid. What is causing the "setting" here?

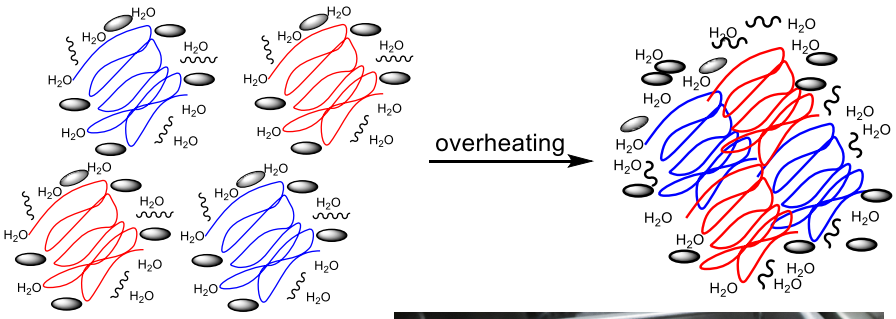
Interfering with Coagulation

Egg protein denatured in the presence of extra water with sugar and fat molecules (proteins are diluted)

Dilute mixtures of protein that get heated too hot or too fast will curdle. The protein clumps together in tight lumps, excluding the other molecules.



Diluted egg proteins have coagulated, trapping water, sugar and fat molecules in the matrix - the extra molecules interfere with the protein-protein interactions. **The network of protein is weaker and more fragile.**



- If you heat a custard too much or too fast, the proteins will *curdle* instead of *thicken.* In curdling, proteins denature and form hard, tight lumps of coagulated protein that exclude the water, sugar and/or fat molecules (in custard making, the effect is called *syneresis*).
- Because custards are so sensitive to overheating, they are often cooked in an oven, while sitting in a ***water bath***. The water bath keeps the temperature constant during cooking.

The boiling point of water is 212˚F/100˚C, while a typical oven temperature is 325-350˚F. No matter how hot you make the oven, the water will only ever reach 212˚F/100˚C, upon which it will boil and eventually evaporate away.

A chef was preparing a custard and wanted to test how different ingredients might affect the time it takes the custard to set

The chef made a batch of crème anglaise (egg yolks, vanilla, milk, cream, sugar and salt) and split it into thirds. To one third he added another whole egg (yolk and white), to another third he added additional sugar, and the remaining third he left alone – then he cooked all three in the same 180˚F water bath.

Which batch of custard will *set* first, second and third? Explain the chemical reasoning behind your prediction.

Custard mix: Egg yolks, vanilla, milk, cream, sugar and salt		
Batch 1: added whole egg	Batch 2: added more sugar	Batch 3: nothing added