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## Quick Guides

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# Food Chemistry: Phase changes

## Phase Changes are Isothermal Events - Joseph Black 1761

Under different conditions, matter takes different forms. Most commonly, we interact with water in its different phases, we know it as ice, water and steam. In each phase, the chemical nature of the substance has not changed, but its physical properties are radically altered. Physics tells us that although these changes require input of energy, there is an interesting phenomenon that occurs. Throughout the entirety of the phase transition, temperature remains constant. When heated, Ice water will not rise to a temperature above 0 C or 32 F until all the ice has completely melted. Similarly, a boiling pot of water can never exceed 100 C or 212F.

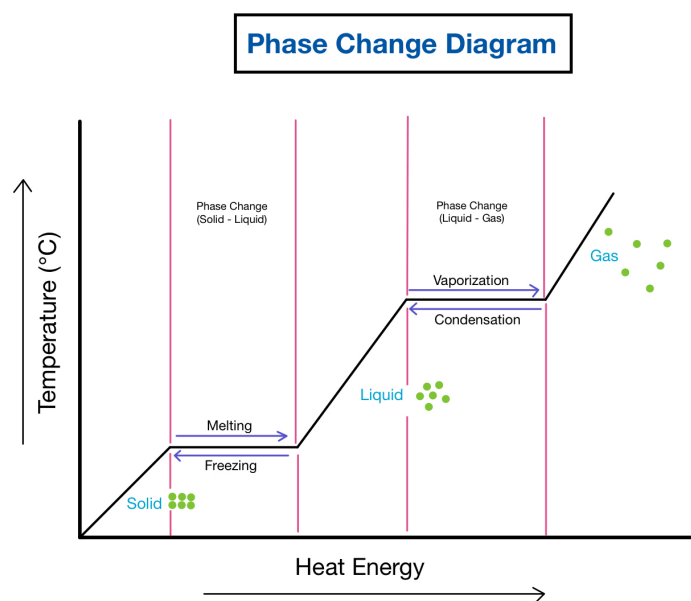


Figure 1 Temperature as a function of heat input

<https://www.expri.com/t/phase-change-diagrams-overview-examples-8057>

Since this process also depends heavily on pressure, we have another variety of diagrams available, which is unique to each substance.

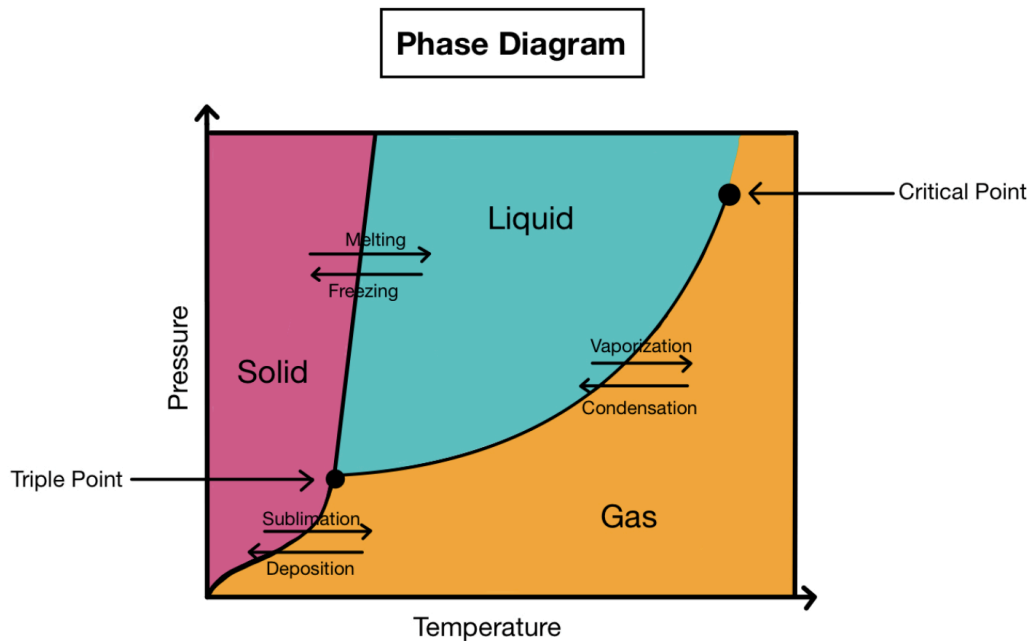
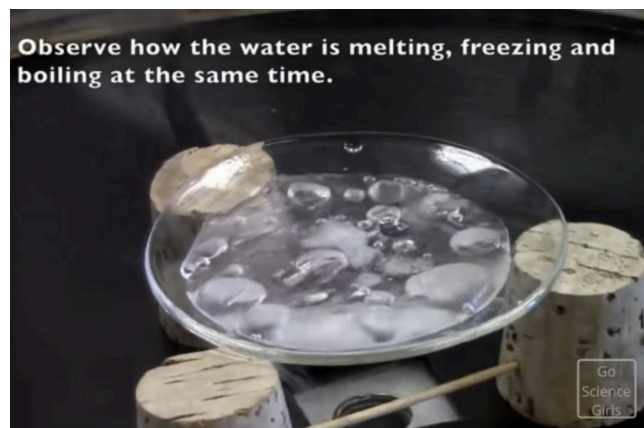


Figure 2: Gives regions of phase transition based on temperature and pressure

<https://www.expjii.com/t/phase-change-diagrams-overview-examples-8057>

The Triple point, is a set of temperature and pressure, where a substance exists in equilibrium with each of its phases at the same time,



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Figure 3 <https://gosciencegirls.com/triple-point-of-water/>

### Implications in cooking

Most foods have some implicit water content. Mushrooms for example are up to 90% water by weight when fresh. Vegetables like onions, leafy greens, and squash also contain a significant water content. When we begin cooking, our food begins to heat up, the proteins in its structure at a certain temperature contract and water is released. Even in a dry pan with no additional liquid or oil we will achieve a simmer when many food items are cooked. Adding salt helps to draw out this moisture.

Now we know that since phase changes are isothermal, our pan will not exceed the boiling point of water until all of this moisture is driven out, regardless of how much flame we apply.

We also know from our study of umami flavor, that the maillard reaction takes place above 140 C or 284 F

This means that as long as there is water around, we can never generate enough heat to drive the maillard reaction forward, and we are not reaching the flavor potential of our food.

Similarly on the cold side, food laws require cold held foods not to exceed a certain temperature, when we hold over ice, we guarantee that the temperature will not rise above 0 C or 32 F so long as there is ice remaining. The food safety of raw seafood depends on this phenomenon.

### Technique

Many recipes benefit from this technique. The principle is to simmer or steam foods of all types in water first then fry in oil. By first simmering in water we take advantage of the cooking power of steam. Mushrooms are a perfect candidate for this technique and I've often had comments on mushrooms prepared this way ranging from "Best mushroom I've ever had" to "I thought I hated mushrooms until now." Once the steam has achieved cooking the food above its protein coagulation temperature, and it releases its moisture, we can cook this until most of the moisture has been driven out. Once dry add cooking oil. **There is a moment, when the sound of cooking transitions from the bubbling wet simmer to a dry sizzle of oil.** This transition is utilized by the best cooks to produce new and unique flavors from the protein, and carbohydrates from the food via the maillard reaction. My philosophy is that good cooking is more about the flavors produced through the alchemy of cooking than it is about the flavors of added ingredients. When this technique is used, there is simply no need for cheap thrill flavor add ingredients, the natural flavor is much more layered and nuanced.

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Recipe:

### Egg scramble with tomato

I always wanted to get this right and the technique above is the key to a good veg scramble.

Add your tomato, onion, herbs of choice to a pan and crack eggs directly in.

Simmer out all of the water (the eggs can take this prolonged cooking)

Add oil, and fry this until vegetables are cooked through season at the end with salt



Figure 4: Simmering vegetables and eggs before scrambling in oil to fry