Phase separation

Oil and vinegar will separate over time.

If you shake a vinaigrette, little droplets of vinegar will soon start to separate. **Over time the droplets will grow**.

Scientists call this **“phase separation”**. Preventing it from happening is important for many kinds of foods, medicines, chemicals, and metals.

Recently, biologists have discovered that proteins (molecules that have specific jobs in our cells) phase separate, also!

https://www.jessicagavin.com/what-is-an-emulsion/

Phase separation

The two liquids phase separate because of a force called **surface tension**.

Surface tension acts to **decrease the area that the two liquids have in contact.**

Higher surface tension produces rounder droplets. (Why?)

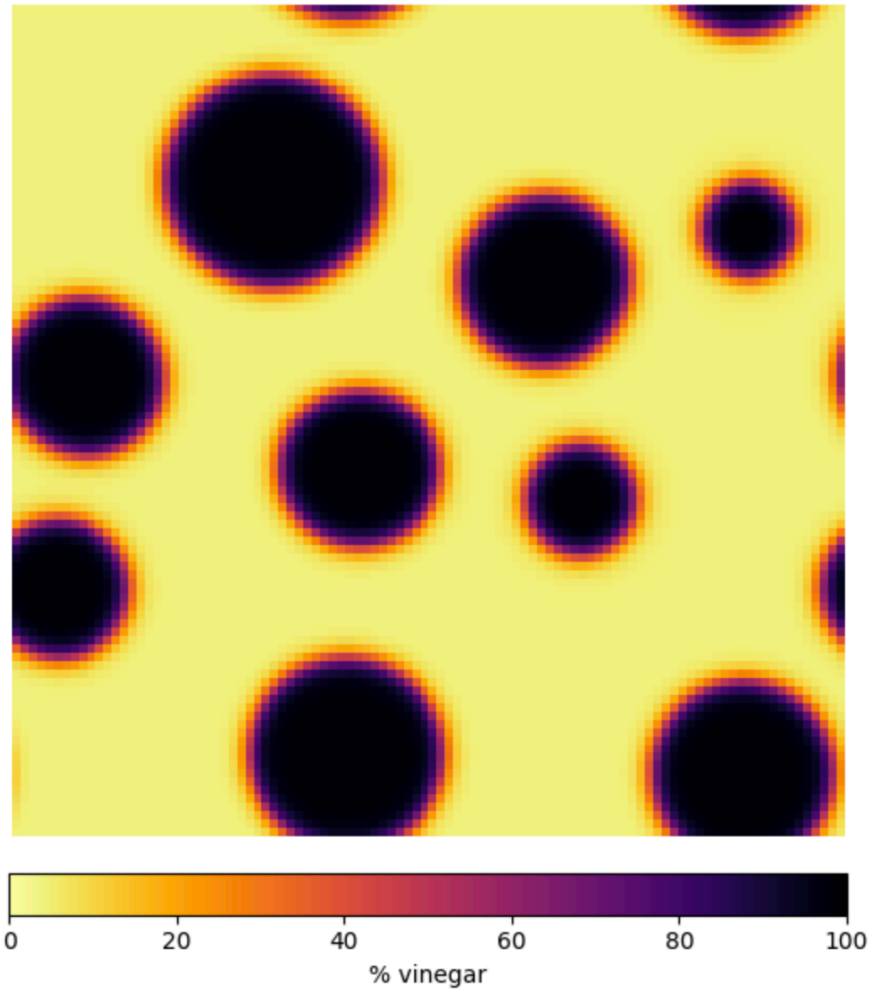
What would happen if there were no surface tension?

https://www.jessicagavin.com/what-is-an-emulsion/

Phase separation model

```
run_simulation(
    surface_tension = 1.0,
    percent_oil = 70.0
)
```

...



Here, a site's **state** is a number from 0 to 100, representing how much oil or vinegar is there.

Black (100) = all vinegar
Yellow (0) = all oil
Red (50) = mixture or *interface*
(where oil meets vinegar)

Rules of the model:

1. **Like likes like:** 0 or 100 is "good". 50 is "bad".
2. **Surface tension**: more interface is "bad", less interface is "good"
3. **Update step** nudges system from bad toward good.
4. **Total amount** of oil **can't change**. Neither can the total amount of vinegar. They can only move around.

Phase separation model: Activity 1

1. Change `surface_tension` without changing `percent_oil = 70`.
   - Compare `surface_tension = 1.0` vs `surface_tension = 0.4`.
     - *How does surface tension affect how quickly phase separation happens? Make a hypothesis!*
   - Test your hypothesis for some other values of `surface_tension`.

Emulsifiers, such as the eggs in mayonnaise, help to decrease surface tension. Think about why this is desirable in our food products.

2. Change `percent_oil` while leaving `surface_tension = 1.0`.
   - Change `percent_oil` to 30. Do you notice any similarities and differences with the results from `percent_oil = 70`?
   - Change `percent_oil` to 5 or 95. What happens?
   - `percent_oil = 50` is a special case. Trick question: are there vinegar droplets or oil droplets now?

Which ratio of oil and vinegar would you use if you want them to stay mixed?

Phase separation model: Activity 2

1. Find the **critical value** of `percent_oil`, to the nearest 5%.
   - Below this value there is no phase separation; above this value there *is* phase separation.
   - Keep `surface_tension = 1.0`.
2. Repeat step 1 for several values of `surface_tension`. Make a scatter plot in a spreadsheet of critical `percent_oil` vs `surface_tension`. What trends do you notice?
   Hint: Organize with your group mates to share the work!