

This photo was made with food coloring, milk, and dish soap. These amazing beautiful shapes and lines are representing flow visualization at its best! There were handfuls of pictures to choose from, and I recommend everyone to take the time to do this lovely experiment – even if you aren't going to photograph it!

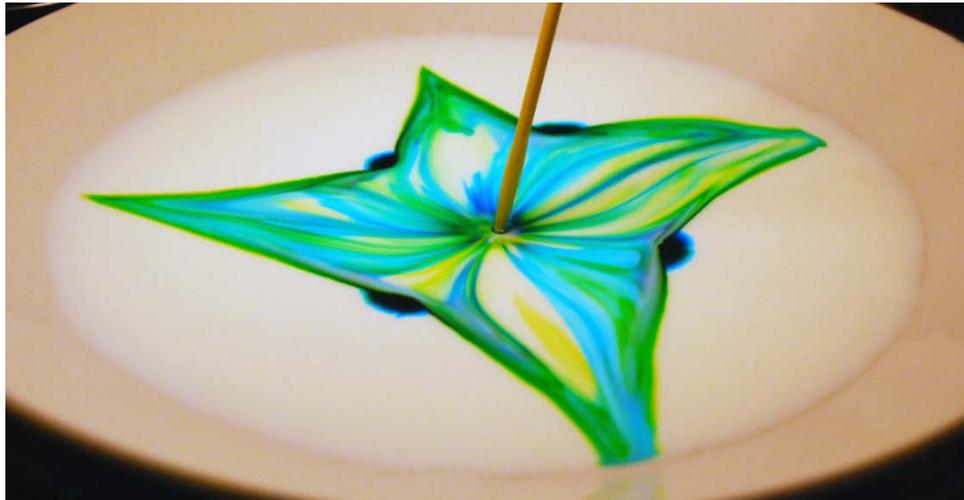


Figure 1: Post-Photoshop Photo

The physics of this phenomenon can be described as a weakening in chemical bonds and surface tension bonds. Milk is made up of water, proteins, and fats. Soap is made up of particles that have hydrophobic (water-fearing) and hydrophilic (water-loving) ends. The hydrophobic ends surround fats, and we see the spreading of color because soap is trying to diffuse into the milk and engulf all the fat particles that it bumps into. [1]

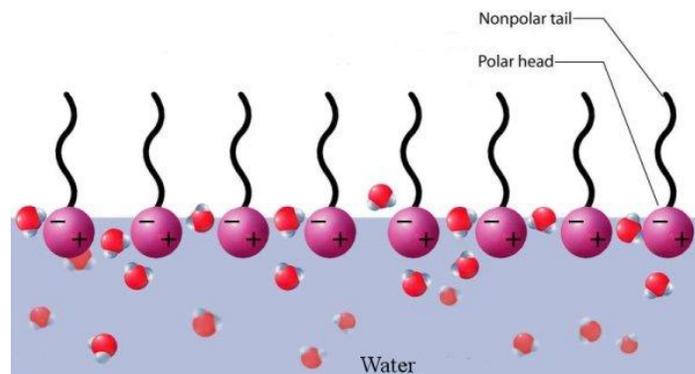


Figure 2: Soap interaction with water's surface tension [2]

You can also see in the above picture how soap can reduce surface tension. Instead of all the water molecules being attracted to each other and having a tight hydrogen bond, those bonds are broken and polar/nonpolar regions are attracted to each other. Soap's hydrophobic regions are nonpolar and its hydrophilic regions are polar. [3]

### **My experiment:**

I did this experiment with skim, 2%, and whole milk and found that whole milk had the best spread of color. I also did several different takes with heated and chilled milk. Heated milk makes more of an “umbrella” spread, while the chilled milk makes a “star” spread.

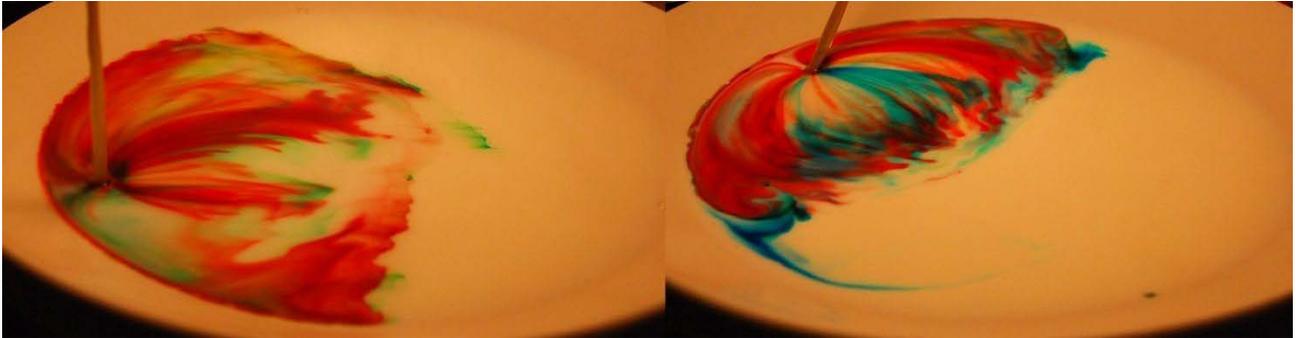


Figure 3: "Umbrella" effect

### **Why does it make a star?**

I believe it makes a star formation due to the bond angles between the water molecules...although this is not an exact science since I could make stars with 4, 5, and 6 points (and there are plenty of youtube videos that have more than 6 points).

### **The difference between hot and cold milk...**

Besides the obvious difference that hot milk doesn't create a star I think this is due to the fact that the surface tension is already lowered from the surface tension of cold milk. Here the soap is just trying to find the fats and it travels in the way that hot milk tries to swirl and cool off – remember here the milk is already “moving” because the heat from the stove was convecting through it and bumping all the fat and water molecules around.

### **What kind of milk is the best to use?**

Whole milk is the best because it has the most amount of fat molecules in it!

I used the following items to make my photo:

- Dinner plate
- Wooden skewer
- Green Works (water lily) dish soap
- Market Pantry food coloring
- Whole milk

I placed just enough milk to cover the bottom of the plate making a pool about 7 inches in diameter (the shallower the pool of milk the better – too much milk and the heavy food coloring just sinks to the bottom) and then in the middle added 6 drops of blue, green, and yellow food coloring. 2 blue drops on bottom, followed by 2 green drops, then 2 drops of yellow on top (all on top of each other).

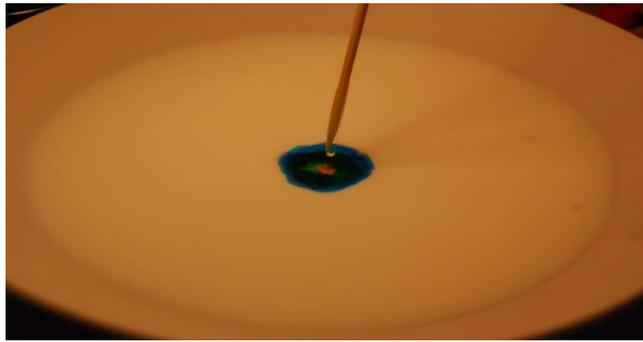


Figure 4: Placement of food coloring

Then I placed the skewer (with the end already covered in a droplet of soap) in the middle of the food coloring. The picture was taken in my kitchen with a 26 watt helical CFL light bulb illuminating the plate.

In Photoshop I edited my picture by cropping and adjusting the brightness. I didn't want to change any of the colors because they were naturally so pretty (although they were prettier in person!)

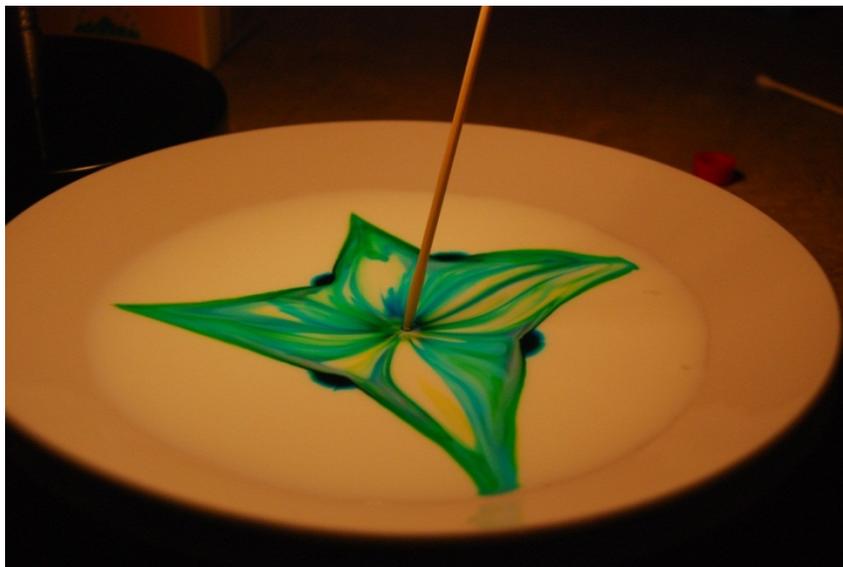


Figure 5: Pre Photoshop Photo

I used a Nikon D80 Digital camera with the following specifications:

Table 1: Camera Settings & Specifications

Size of Field of View	Left to right – 10 in
Distance from object to lens	16 in
Lens focal length	40 mm
Aperture	f/5.6
Shutter Speed	1/250 sec
ISO	500

I think the shutter speed was fast enough and the ISO and aperture were fitting for this picture. It helped to use a tripod for this shoot, and the only thing I would do differently is maybe to take a video – because the flow was so cool to see!

Table 2: Pixel Count

	Height	Width
Pre Photoshop	2592	3872
Post Photoshop	1623	3142

My favorite pictures are when stars are formed, and my favorite color patterns are blue, red, and green or blue, green, and yellow. If I were to take this photo again I would set up the lighting a bit different – the colors that are produced are so vivid and I feel my pictures do not accurately represent that. I would also try and take aerial shots from straight above, though that could be difficult with the reflection of your light source. Another potentially awesome photo shoot that would be interesting is using different kinds of soap or even alcohol agents. Frame worthy art!

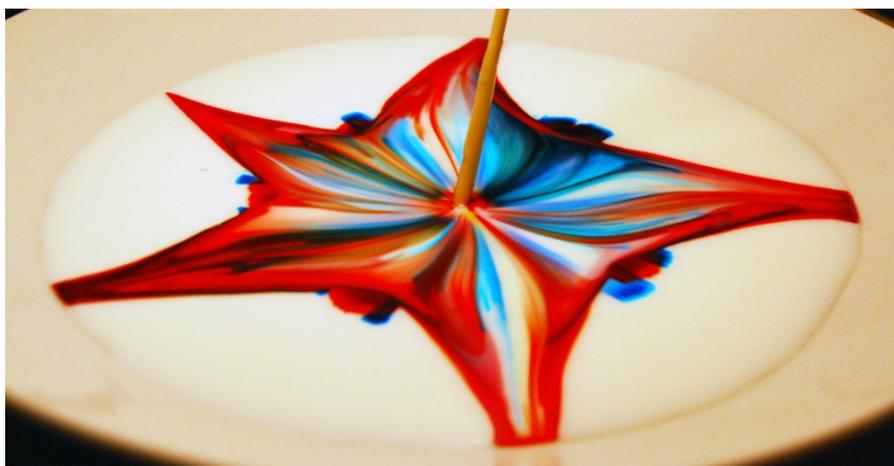


Figure 6: Runner up photo - Blue (bottom ring), Red (middle ring), Yellow (top center)

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- [1] "Color Changing Milk" Steve Spangler Science. Website. Accessed May 2012. < <http://www.stevespanglerscience.com/experiment/milk-color-explosion>>
  - [2] Major measure. "surfactant.jpg" Wikipedia. Uploaded December 2008. Website. Accessed May 2012. < <http://en.wikipedia.org/wiki/File:Surfactant.jpg>>
  - [3] Hessong, Athena. "How Does Detergent Breaks a Surface Tension?" eHow. Website. Accessed May 2012. < [http://www.ehow.com/how-does\\_5452223\\_detergent-break-surface-tension.html](http://www.ehow.com/how-does_5452223_detergent-break-surface-tension.html)>