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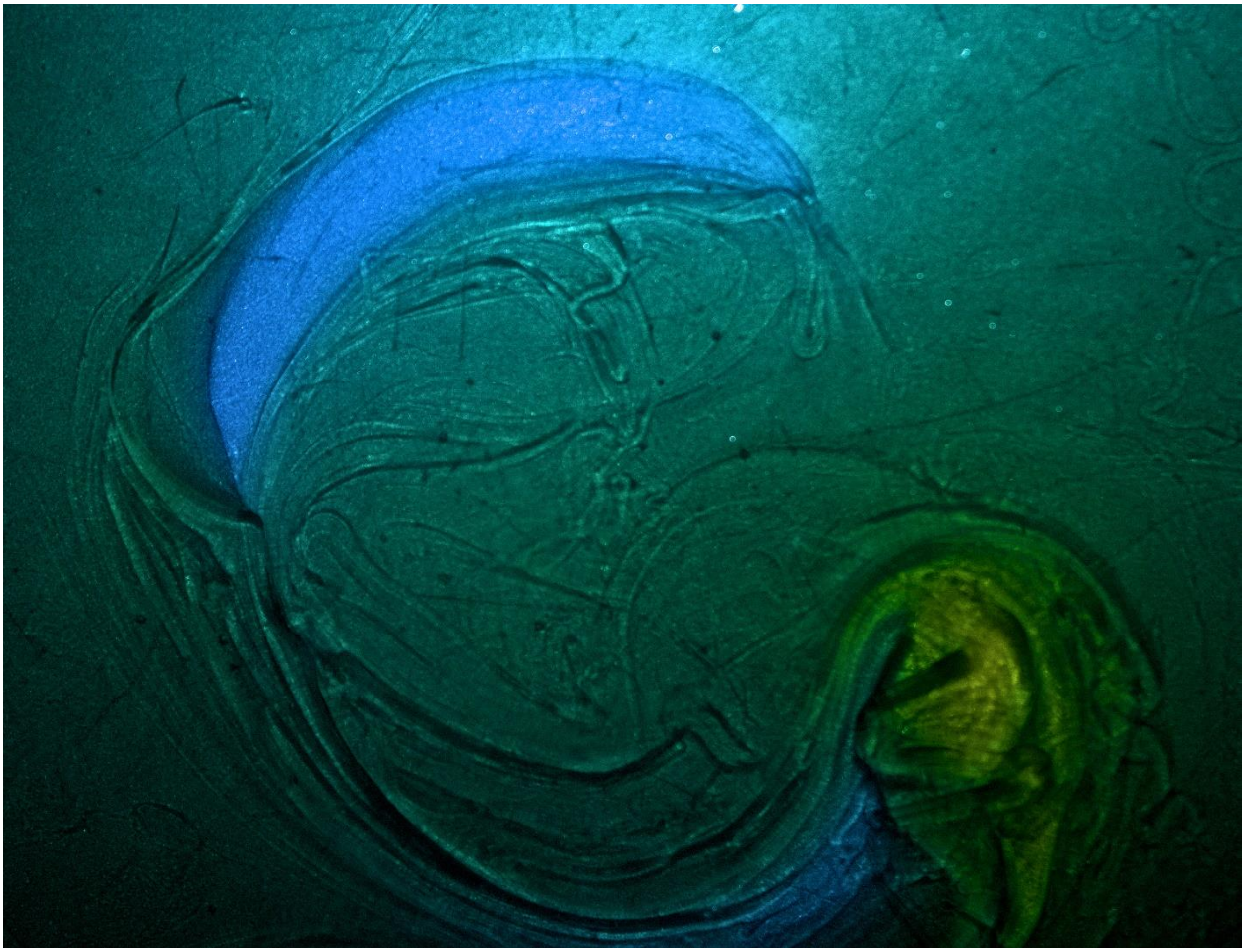
Get Wet

MCEN 4151

9/18/23



1. **Introduction**
   The image above shows a layer of honey beneath a layer of water colored with blue dye. The significant difference in density between the two liquids allows them to stay separated into two distinct layers even when disturbed. To create the image, a spoon was dragged in a "C" shape motion through both layers across the bottom of the pan. The light blue areas are where the water has already returned to its steady state while the honey is still reforming due to its higher viscosity. Unexpectedly, the image also shows residual currents in the water along the path of the spoon as well as a small eddy that was created at the end of the spoon's movement (bottom right). We are able to view this because of the difference in viscosity between the two layers. The water which "flows" more easily along the path of the spoon drags along the top of the honey layer creating a visual indication of the currents.

2. **Set up**
   The process for developing this image started with the desire to capture the flow of a highly viscous liquid (i.e. honey). This can be seen in **IMAGE 1**. From there, the decision was made to photograph a layer of honey that had been disturbed and was re-settling back to its original state. I**MAGE 2** shows a spoon being drug through a layer of honey approximately 1cm thick on the bottom of a pan with a 30cm diameter. The final set up was determined after considering how a difference in viscocity might be shown in a still image. With the knowledge that the densities of honey and water were significant enough (honey: ρ=1.4g/mL, water: ρ=1g/mL)[1-2] not to allow much (if any) mixing should the solution be disturbed, the decision was made to add a layer of colored water on top of the layer of honey. Once the setup was complete, a spoon was dragged through both layers of the solution in a similar manner to **IMAGE 2**, with the result shown in **IMAGE 3**.

IMAGE 1

IMAGE 2

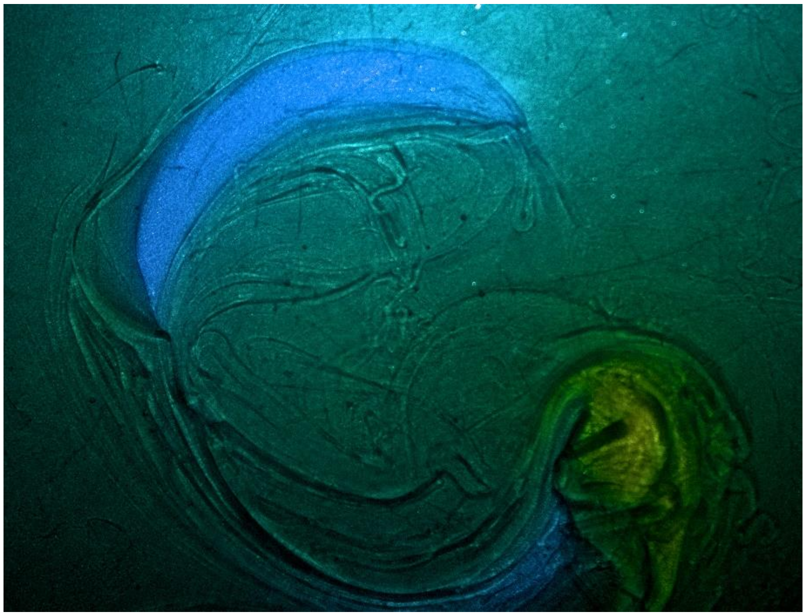


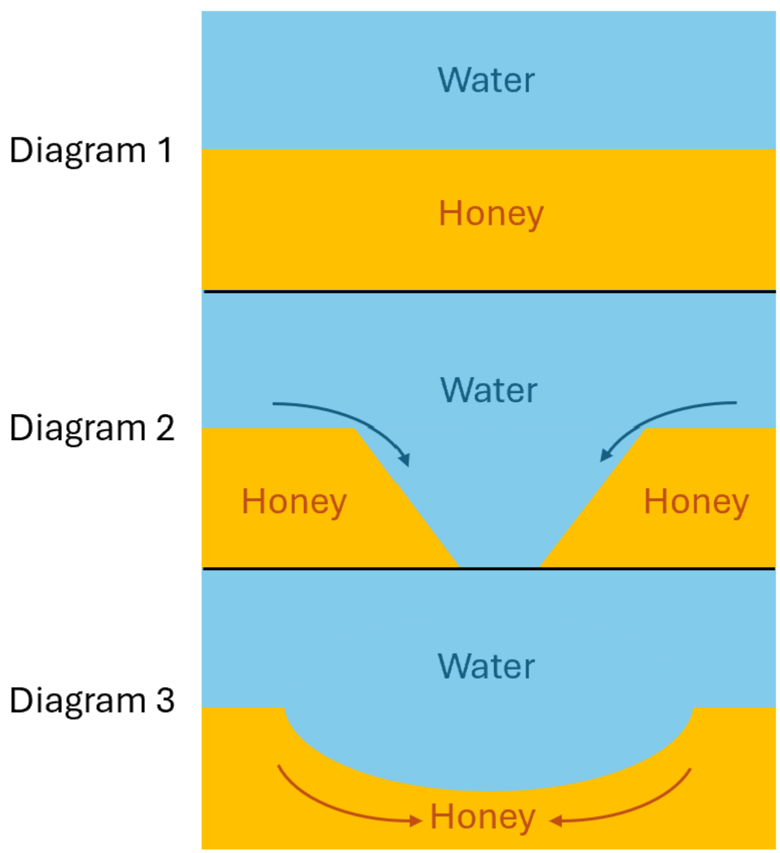
IMAGE 3

The viscosity of honey at room temperature is estimated to be approximately μ=10000mPA.s,[2] whereas the viscosity of water at the same temperature is only approximately μ=1.0016mPA.s.[2] Thus, when the spoon is dragged through both layers of liquids, the water almost immediately fills in the empty space (**DIAGRAM 1&2**). The honey's properties cause it to reform more slowly. The benefit in having the densities of the two liquids being significantly different is that the disturbence did not cause the two liquids to mix and therefore need time to settle out. Instead, the honey simply settles back underneat the water layer as depicted in **DIAGRAM 3**.

An unexpected outcome of this experiment was how the water on top of the honey was able to show how it flowed in the path of the spoon. Along most of the path we can observe the flow to mostly laminar. When it reaches the end we can see that it starts to fall into some eddies and becomes slightly more turbulent. The reason for this can be determined through an estimation of the Reynolds number for both liquids.

$$Re = \mu u L / \rho$$ [3]

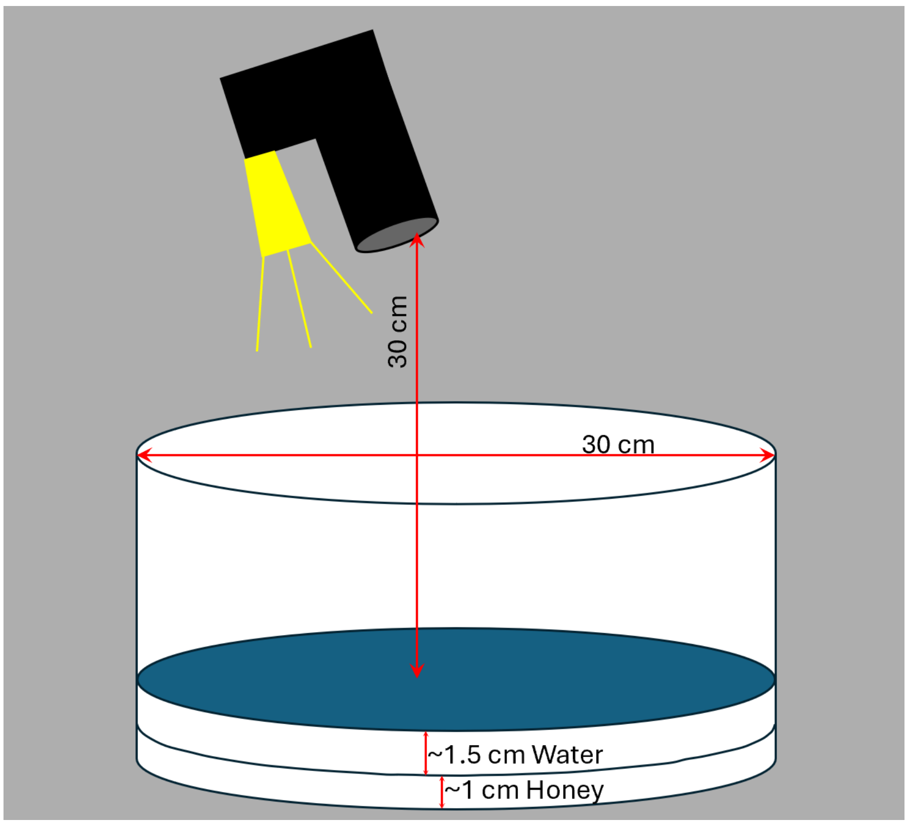
Using the values for density and viscosity stated above we can determine that the ratio of Reynold's numbers for water to honey are approximately 1000/.14. This means that we expect the chances for turbulent flow to be much higher in the water than the honey. Where the water flows over the honey, we can see the "lines" it leaves that indicate its' flow. At the end of the spoons path of travel it was lifted quickly out of the water causing the "u" (flow speed) to reach it's maximum and is likely why we are seeing the vorticies develop. However, the vorticies do appear to still be primarily laminar.



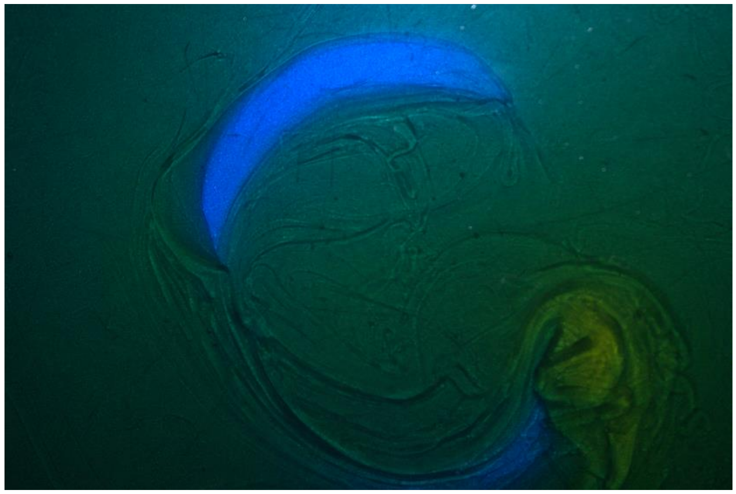
3. **Visualization Technique**
The experiment was conducted at room temperature using Food Lion 100% Honey, Color Right Blue food coloring and regular tap water. The honey was set as a base layer

approximately 1cm thick. The water and food coloring was then mixed and poured over the honey. The solution was then allowed to settle before the disturbance was created.

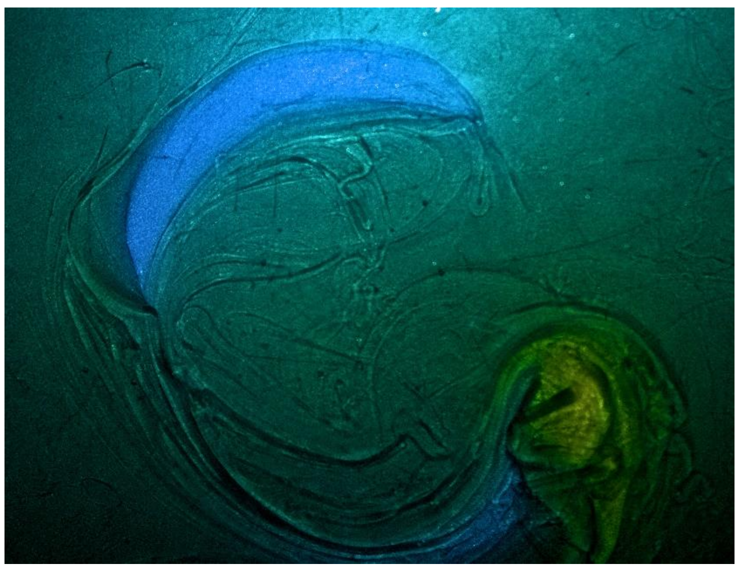
4. **Photographic Technique**
The camera (Canon Rebel T7) was held approximately 30 cm above the surface of the water and was manually focused on the surface of the water. The camera was tilted approximately 20 degrees off 90 to allow for the flash to hit the entire area while not casting significant shadows from the camera itself. The field of view of the camera spanned the majority of the container that held the solution. The aperture was f/5, exposure time was 1/60 sec and ISO speed was 400. The focal length was 44mm which gave the original photo dimensions of 6020x4015. The photo was edited using the program Darktable.



To find the settings to edit, a tutorial by TG Photoblog on Youtube[4] was followed. To create the final image the photo was cropped and the the exposure was increased slightly. Then the white exposure was decreased while the black exposure was slightly increased. The global vibrance was increased and the contrast was maxed out. The global saturation was maxed out and the global brilliance was increased. Finally, the highlights were decreased until the final image was created. The final image dimensions were 5256x4003. The original and edited images are shown below.



Original



Edited

5. Conclusion

The experiment yielded both expected and unexpected results. It demonstrates how fluids of different viscosity return to their rested states at different rates as expected. What wasn't expected was how clearly it showed the flow of the water over the surface of the honey. This was positive because we are able to view multiple events at the same time. However, it also indicates that a still image might not have been the most effective medium to capture these events and that possibly it would have been better to take a video. If this experiment were to be repeated, it would be advantageous to attempt to take a video and possibly use different colors and liquids to determine if they will more effectively demonstrate the characteristics we are trying to depict.

6. References

[1] Behadir Kadric (n.d.). *What Is The Density Of Honey*. Life With Bees. Retrieved September 18, 2024, from https://lifewithbees.com/what-is-the-density-of-honey-in-kg-m-g-cm-g-ml-kg-l/

[2] Anton Paar (n.d.). *Viscosity of Flower Honey (Blended)*. Retrieved September 18, 2024, from https://wiki.anton-paar.com/us-en/flower-honey-blended/

[3] The Engineering ToolBox (2003). *Reynolds Number*. [online] Available at: https://www.engineeringtoolbox.com/reynolds-number-d_237.html [Accessed 18 Sep 2024]

[4] TG Photoblog (2022, July 20). *Darktable Tutorial - The Four Steps You Need to Know*. YouTube. Retrieved September 9, 2024, from https://youtu.be/sTNkxC69ucE?si=w3jfqJsWnGdZE93c