Fractal Patterns in Turbulence

Overview
Students look at images showing turbulence and then create some turbulence of their own in some experiments.

Appropriate for
grades 2-12 and adults

Objectives
Learn about turbulence in nature and in everyday things

Materials
- Computer/projector
- Turbulence images
- Video from internet: 'Morphalingus' https://www.youtube.com/watch?v=kebjwGe98tQ
- Styrofoam plates – 1 per student
- Water – about 1/3 cup per student
- Ground pepper – 1 tin from the spice aisle
- Liquid dishwashing soap – you just need a small amount, the smallest size will be more than enough
- Whole milk (NOT reduced fat or 1%) – about 1/3 cup per student
- Food coloring – liquid, in droppers
- Q-tips or toothpicks– 1 or 2 per student
- Optional: Skittles candy, about 25 to 30 pieces per student

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Introduction

Ask students to share a place they have been or would like to visit on an airplane. Talk about observing fractal patterns from the air. (Show aerial fractal images. Talk about using Google Earth for exploring places.)

Ask if anyone has experienced turbulence while on a flight. Define turbulence.
Turbulence - violent or unsteady movement of air or water, or of some other fluid.
(We talked about why air is considered a 'fluid' – *"a substance that has no fixed shape and yields easily to external pressure; a gas or especially a liquid."*)

Show turbulence slideshow – example of images: air currents and how they affect airplanes, airplanes engines make their own turbulence patterns, smoke patterns, turbulence on surface of sun, turbulence on Jupiter, turbulence in water, artist rendition of planet HD 189733b, a "hot Jupiter," with turbulent storms of molten silica (glass rain!), Earth's turbulent atmosphere: weather, surface of bubbles, Northern Lights

Experiment One:
Fill plate with enough water to just cover the bottom. Sprinkle pepper onto the water. Take Q-tip or toothpick and touch one end to the dish soap. Have students make a hypothesis about what they think will happen when they put the soap into the water/pepper mixture. Place the soap end of Q-tip or toothpick into the middle of the plate (I had all of them hold up their Q-tips and we all counted to 3 and did it at the same time). Make observations. Most of the pepper moves quickly to the sides of the plate.

Explanation:
Pepper is hydrophobic, so it won't dissolve in the water. The pepper floats on top of the water because of surface tension. When the soap is introduced to the mixture, it breaks the surface tension of the water, but the water molecules pull away from the soap, attempting to keep their surface tension, and they pull the pepper with them.

Rinse all the pepper and soap off the plates from Experiment One.

Experiment Two:
Fill bottom of plate with a thin layer of whole milk. Place a few drops of food coloring into the milk. Use different colors, but don't mix the drops into the milk, just let them sit. Take Q-tip or toothpick and touch one end to the dish soap. Have students make a hypothesis about what they think will happen when they put the soap into the milk/food color mixture.

Place the soap end of Q-tip or toothpick into the middle of the plate (Again, counting to 3 and doing it all at the same time had a great reaction). Make observations. The colors swirl around in the milk.

Explanation:
The fat in the milk is a non-polar molecule, so it doesn't dissolve in water. When the soap is introduced, it breaks up the fat molecules and the non-polar part of the soap attaches to the fat molecules, and the polar end of the soap chases around the polar water molecules in the milk, to try and attach to them. This movement makes the beautiful turbulence patterns in the dish.

Optional Experiments:
Have students arrange Skittles candy in a pattern around the edge of their plates. Pour warm water into the plate to cover the bottom and at least half-way submerge the candy. Watch as the colors from the candy bleed off into the water and swirl and mix.

Another option is to experiment with cold versus warm water and milk to see what medium (cold water, hot water, cold milk, warm milk) is the best for seeing the turbulent patterns.

Conclusion

Talk about how the patterns of movement we observed today can be described using mathematics. Show *'Morphalingus'* fractal zoom (https://www.youtube.com/watch?v=kebjwGe98tQ) – make comparisons between the movement of the fluids (especially the food coloring in the milk) with the images in the zoom.