Water in Space: A Drop in the Cosmic Pool

Goals:

Make order-of-magnitude estimates
Learn strategies for estimating “astronomical” quantities
Gain experience with the metric system for volume measurements
Gain an appreciation of the amount of water in space through analogy

Task One: Estimating Small and Large Quantities

In the next step you will measure the number of drops of water it takes to fill a medicine cup to 5 mL (or CC).

Write down your estimate for this number before making the measurement.

Now, consider an Olympic-sized swimming pool of dimension 50m (length) x 25m (width) x 2m (depth).

Write down your estimate for the number of drops of water it would take to fill the pool.

Task Two: Measurements

Now use the dropper to fill the medicine cup to the 5 mL mark and count the drops as you fill your medicine cup.

Record the number of drops.

For a group of participants, use all reported values to get an average for the number of drops of water in 5 mL volume.

Task Three: Calculate The Drops of Water in a Pool

Using the dimensions of an Olympic-sized swimming pool, calculate the number of drops of water it takes to fill the pool. (You can use the measurements to
determine the number of water drops per mL of volume. You can also calculate the number of mL of water in the pool using the metric system.

How well did you do estimating “everyday” quantities (water drops in 5 mL) compared to “astronomical” quantities (water drops in the pool)?

**Task Four: Assessing the Size of an “Astronomical Number”**

To get a sense of the size of the previous result, imagine filling the pool a “drop at a time.” If you add one drop to the pool every second (and there is no evaporation!), how long will it take you to fill the pool? Give your answer in years.

**Task Five: Water in the Universe and the Seeds of Life**

One idea for the way that life starts on a habitable planet is that the necessary molecular building blocks are delivered to the planet. These can be obtained from the interstellar chemistry and delivered by objects such as comets.

Does it make any sense that this could happen for the important case of water?

How much of the available “cosmic pool” of water would need to end up on the planet to support life?

Consider the Orion nebula, an active region of interstellar chemistry, star formation, and possibly planet formation. Measurements from radio astronomy estimate that there is 1x10^{32} kg of water present. For water, 1 g of water has a volume of 1 mL under ambient conditions.

On Earth, the total amount of water is estimated to be 1x10^{21} kg.

If we make the analogy that all of the water in the Orion region is a “cosmic Olympic pool”, how much of this water would need to “splash” onto a planet to give it as much water as Earth?