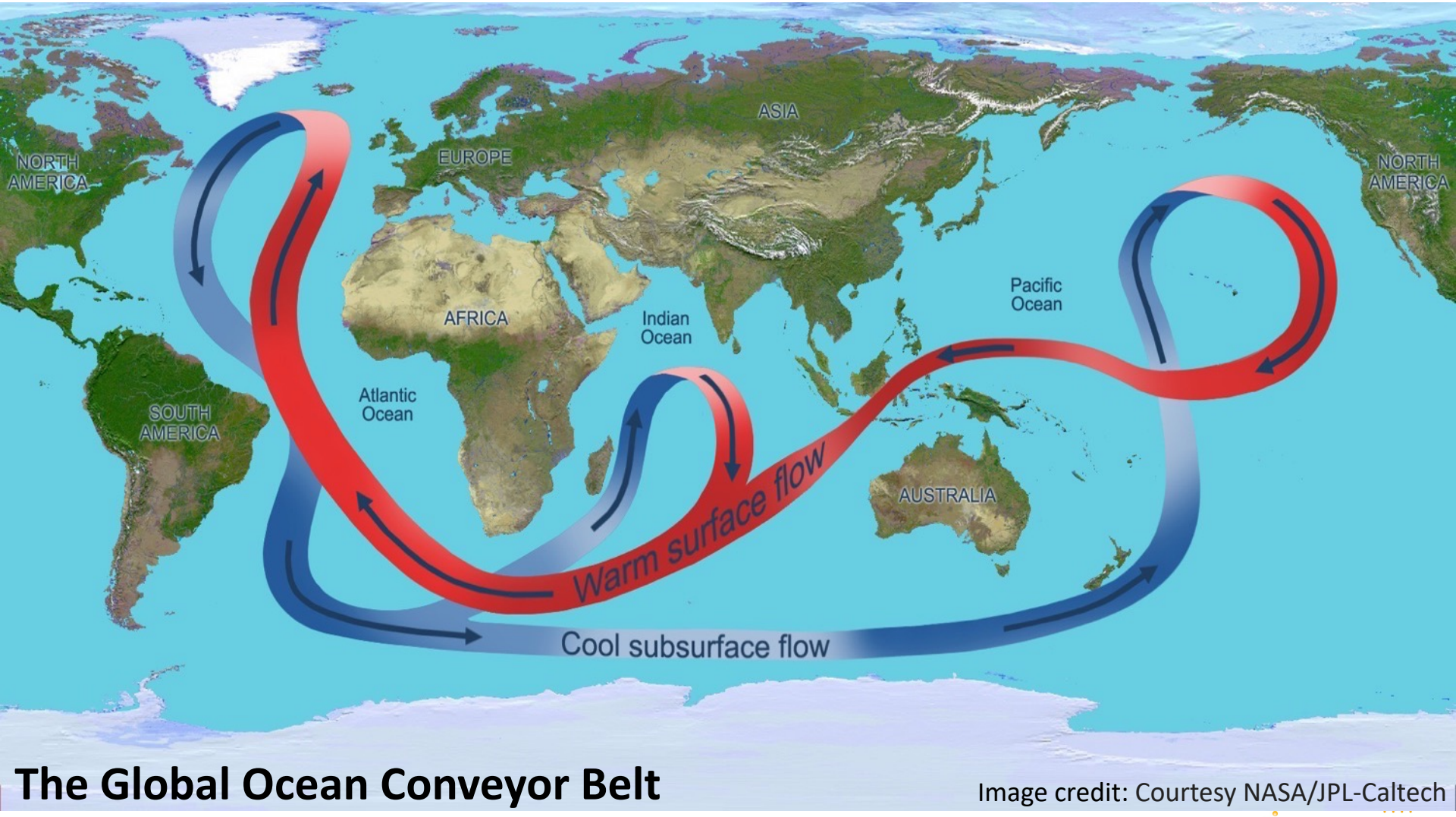
Oceanic Circulation: What Keeps the Ocean in Motion?

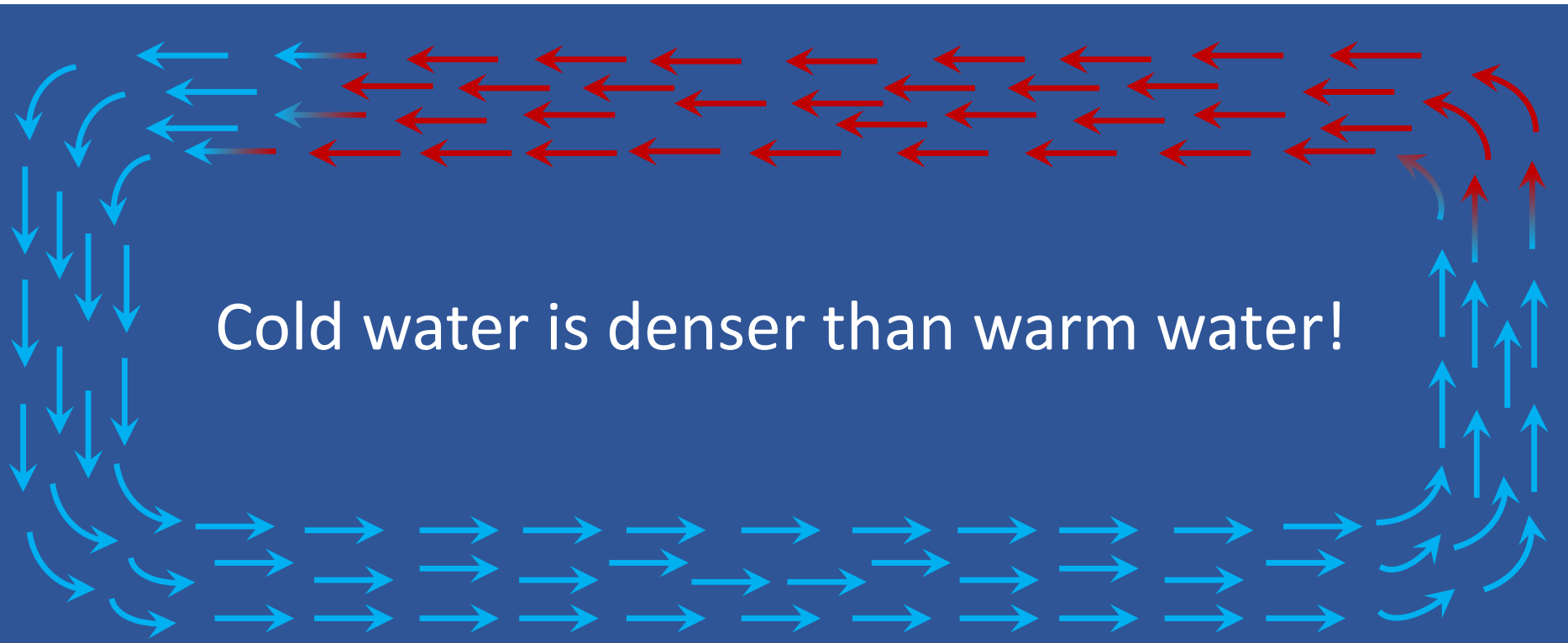


The Global Ocean Conveyor Belt

Image credit: Courtesy NASA/JPL-Caltech

Uneven heating by the sun

Ocean Surface



Ocean Floor

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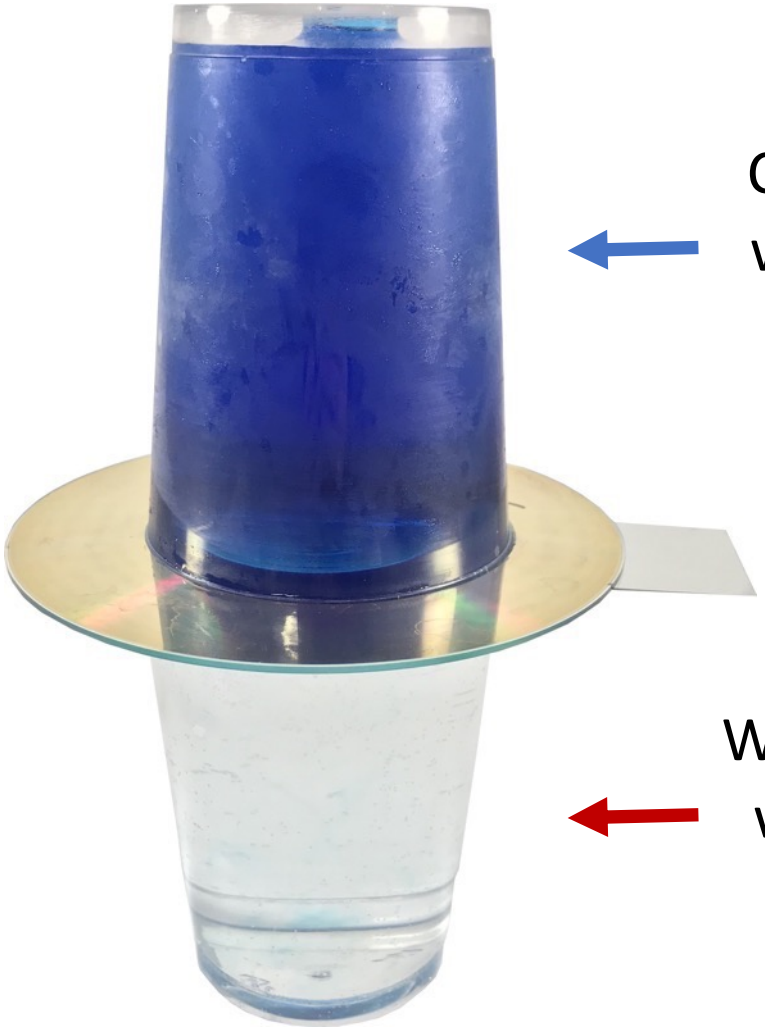
Small-scale model of ocean currents



Cooler water layer

Warmer water layer

How do temperature differences drive water movement?

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Materials you need

- Aluminum tray
- Hot water
- Ice water or cold water
- Plastic strip
- Cups, 9 oz. (2)
- Spoon
- Thermometer
- CD
- Flashlight
- Food coloring
- Small box
- Phone equipped with a sensor app that includes a light sensor

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Preparing the two water layers

Fill one cup with hot water and the other one with ice water

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Preparing the two water layers

- Add five drops of food coloring to the cold water
- Remove the ice cubes and fill the cup up to the top with cold water

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Measuring temperatures

Measure temperatures in both cups

Record temperatures in your data table

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Stacking the water layers

- Place the CD on top of the cold cup
- Put the plastic strip on top of the CD to cover the hole

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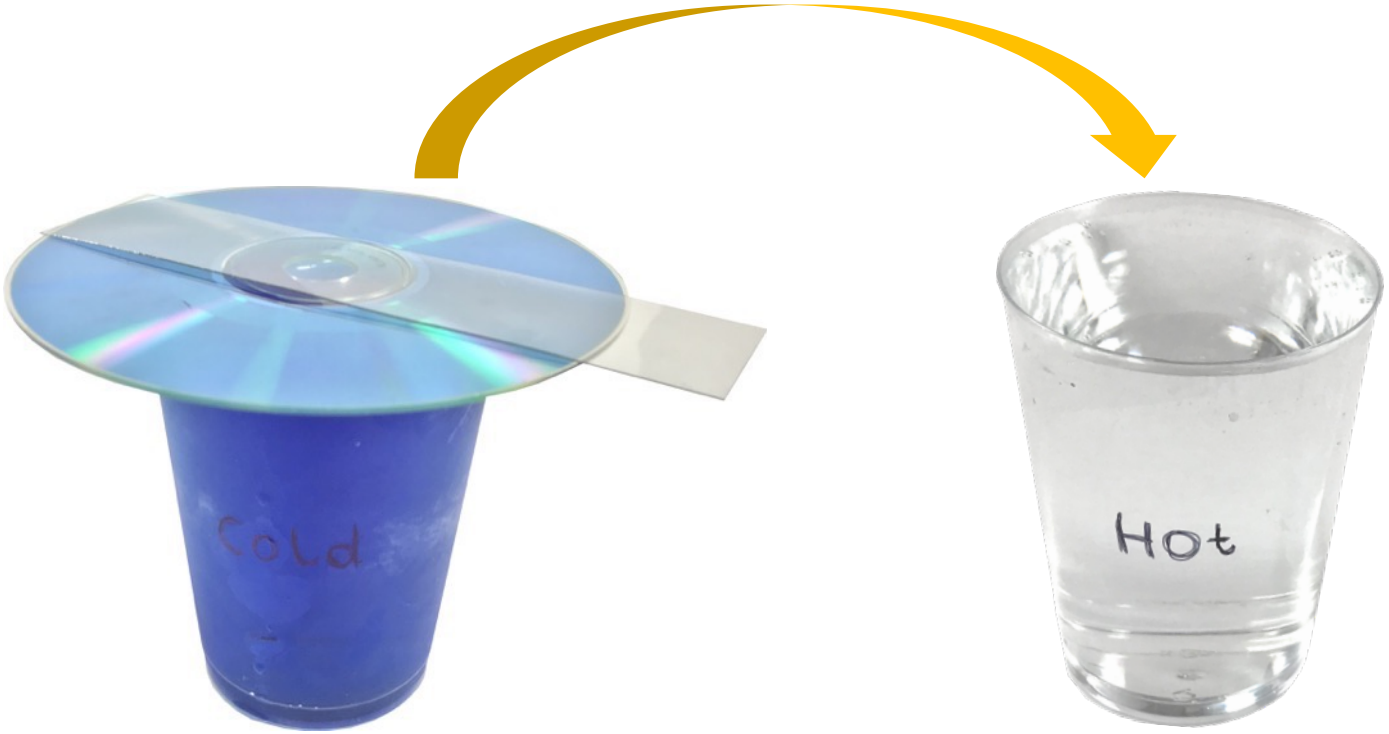
Stacking the water layers



- Carefully flip the cold cup over while holding the CD with the plastic strip against the opening with the other hand
- Place the inverted cold cup on top of the other cup

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Video:

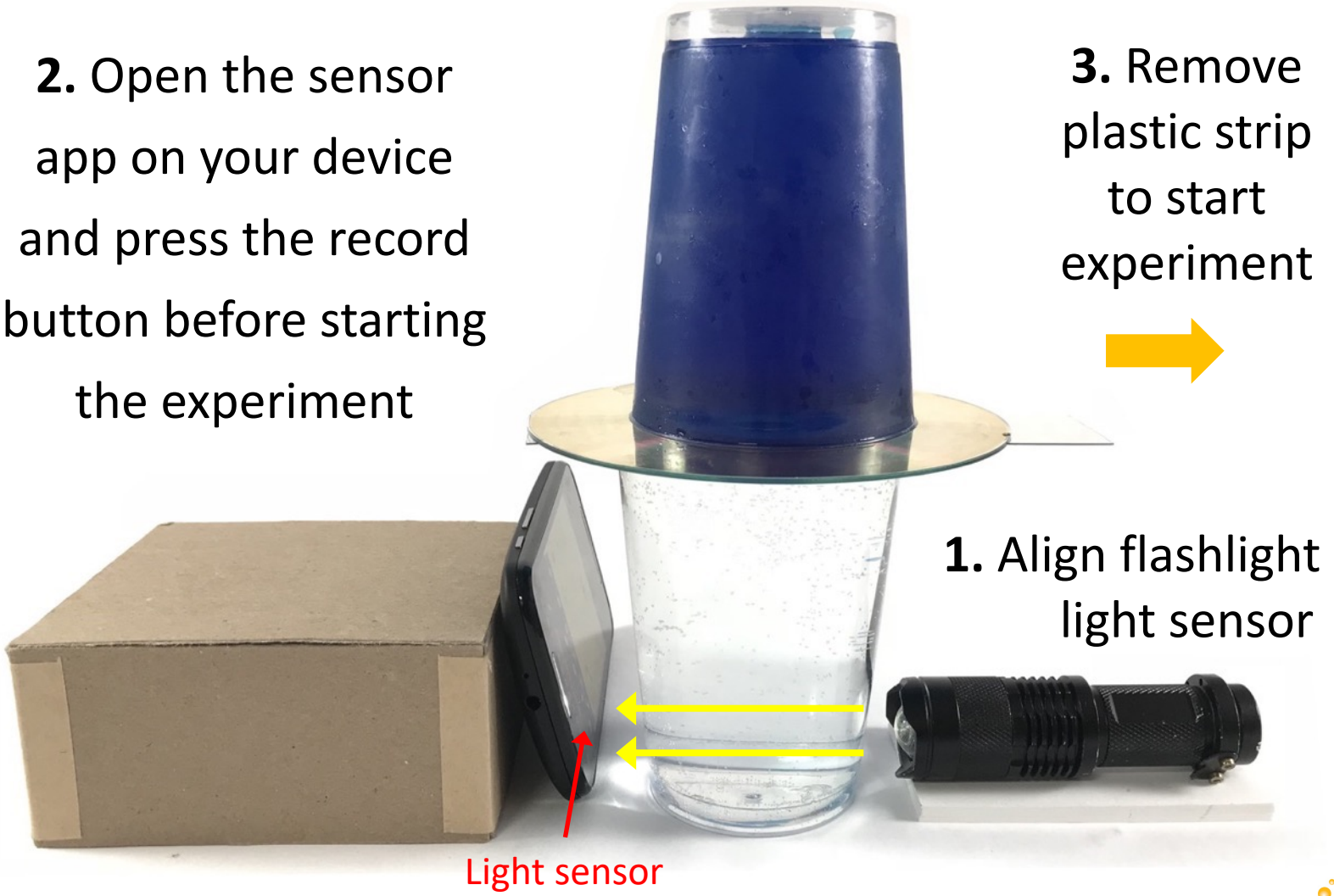
How to stack the cups

(first part of video)

Setting up and starting your experiment

2. Open the sensor app on your device and press the record button before starting the experiment

3. Remove plastic strip to start experiment



1. Align flashlight with light sensor

4. Collect your data and stop the recording after five minutes

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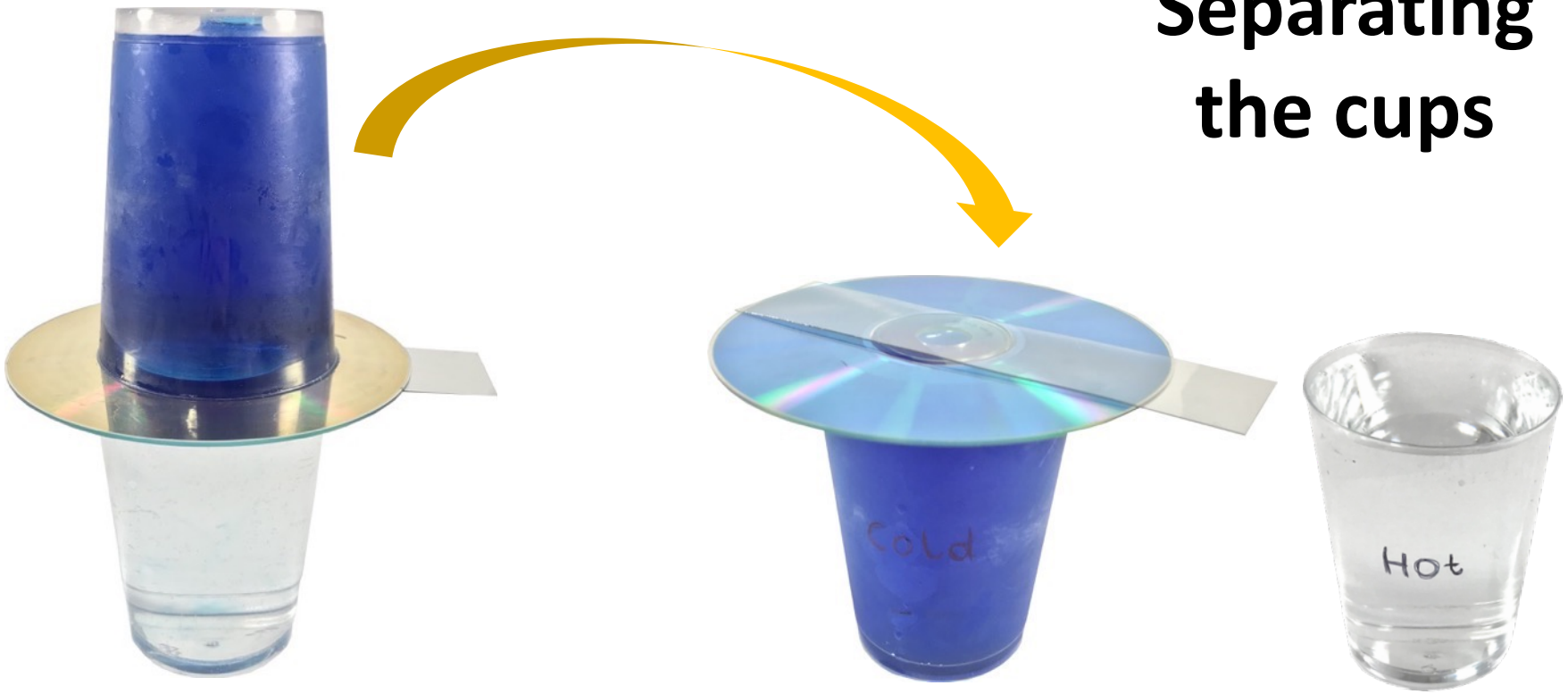
Separating the cups



- Slide the plastic strip back in between both cups to cover the hole of the CD
- Carefully flip the cup over, keeping the CD pressed tightly against the opening

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Video:

How to separate the cups

(second part of video)

Measuring temperatures

Measure temperatures in both cups again

Record temperatures in your data table

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Changing temperature differences

Repeat experiments so that you have **three trials in total**

- **High** temperature difference (30-40°C)

  ⇨ Ice water and hot water

- **Low** temperature difference (10-20°C)

  ⇨ RT* water and hot water

- **No** temperature difference (0°C)

  ⇨ RT water and RT water

* RT = Room temperature

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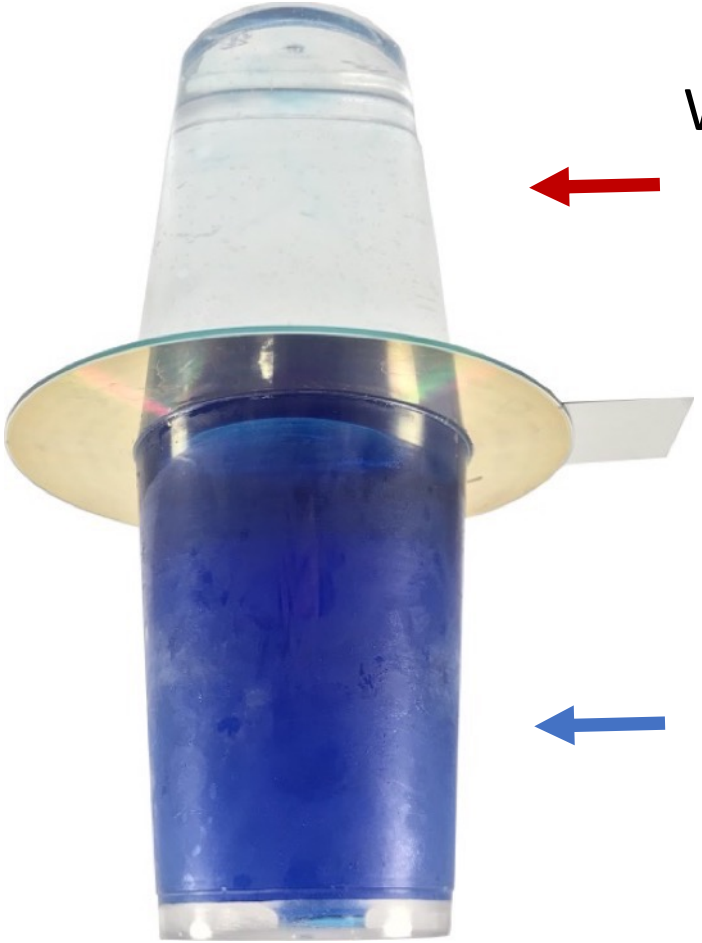
Reversing water layers



Warmer water layer

Cooler water layer

Repeat the experiment but this time stack the **hot water on top of the cold water**!

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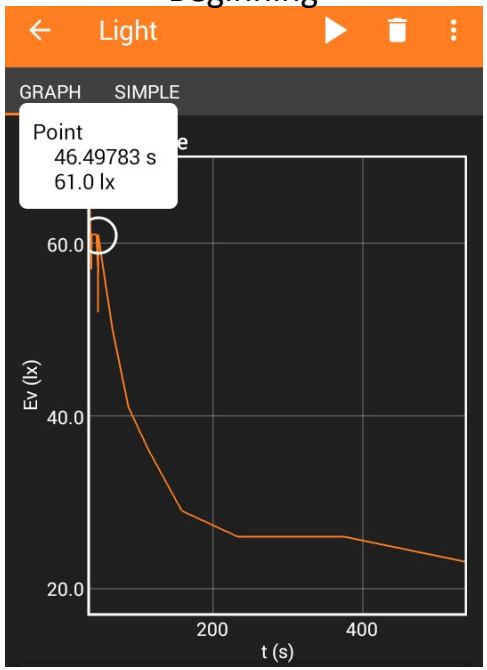
Analyzing your data

- Calculate temperature differences between both water layers from your data for each experiment
- Record the results in your data table

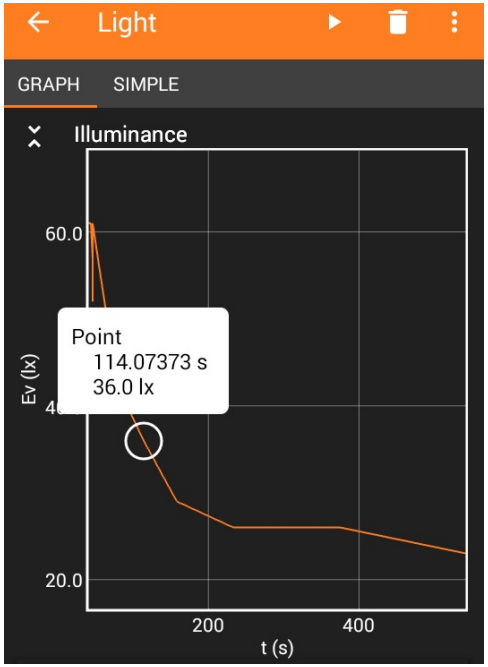
		Water temperature in top cup [°C]	Water temperature in bottom cup [°C]	Water temperature difference between both cups [°C]
Experiment 1	Start			
	End			
Experiment 2	Start			
	End			
Experiment 3	Start			
	End			
Experiment 4	Start			
	End			

Analyzing your data

Beginning



About 1 minute later



Determine the initial rate of color change (initial mixing rate) from your light sensor recordings

(graphs shown here were recorded with the phyphox app)

- Pick and select the data points with the light intensity values at the beginning of your experiment (when you removed the plastic strip) and (the closest to) one minute after
- Record your light intensity readings in your data table

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Analyzing your data

Calculate the initial mixing rate from your data

$$Rate\ of\ color\ change\ (mixing\ rate) = -\frac{\Delta\ Light\ intensity}{\Delta\ Time}$$

Change in (Δ) Light intensity:

Light intensity after about 1 minute – Light intensity at start

Change in (Δ) Time:

About 1 minute

Record the results in your data table

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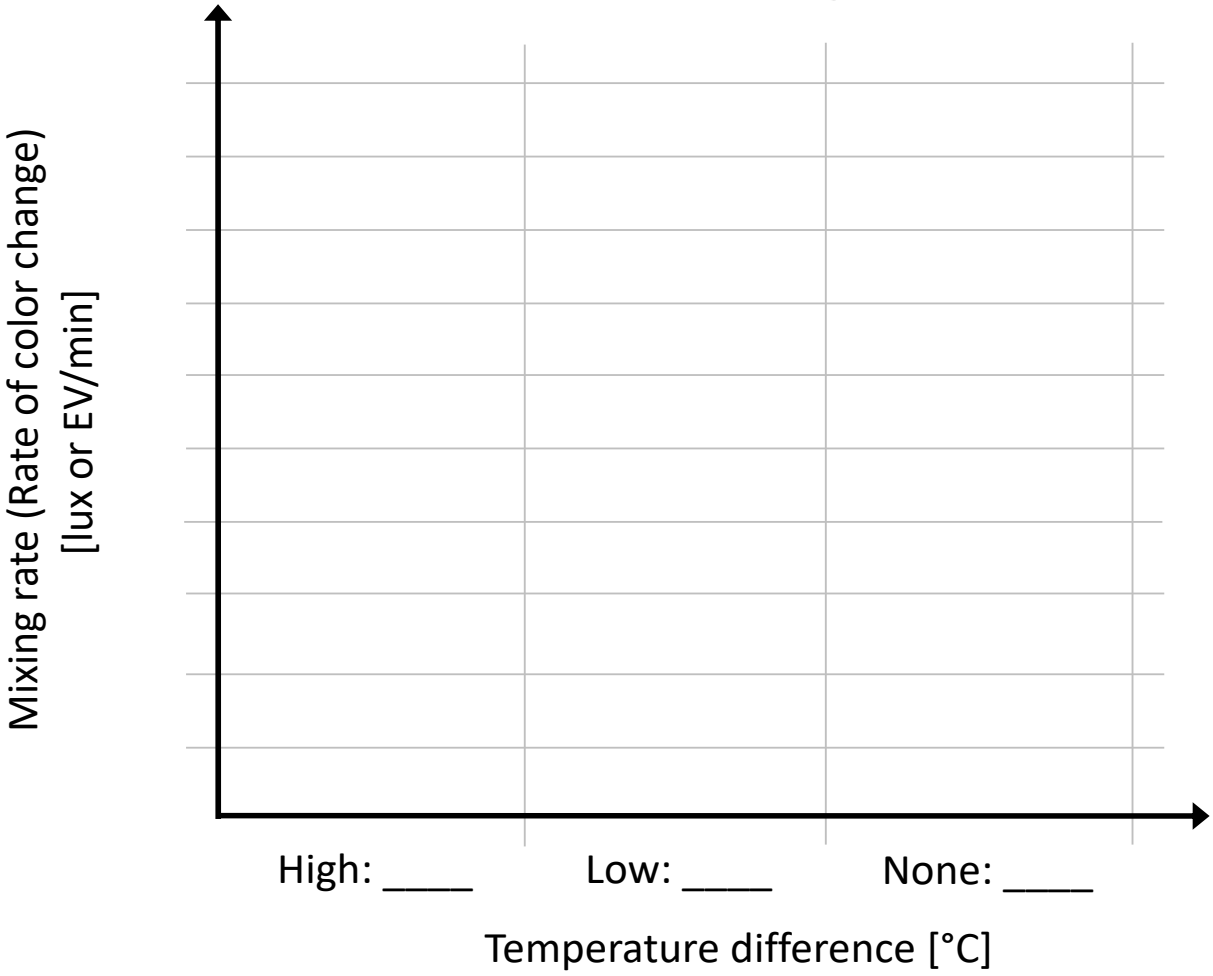
Visualizing your data

Make a bar graph that shows how temperature differences affect water mixing rates



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