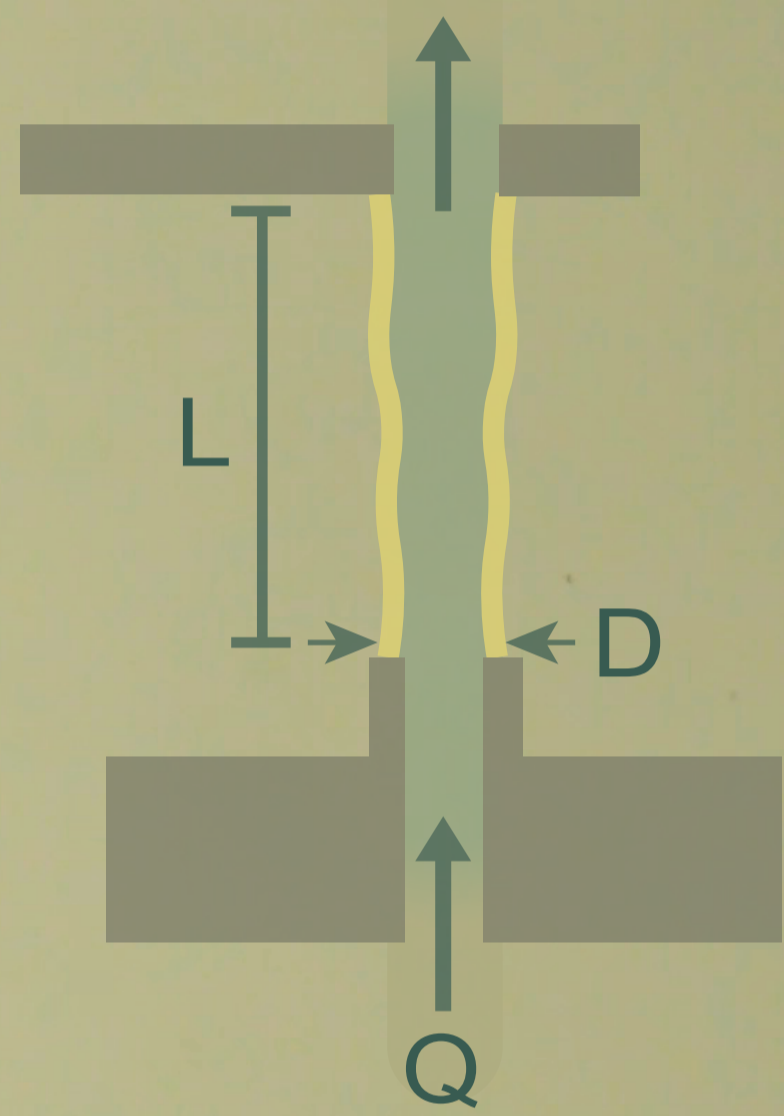


The Fluid Tube

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A thin fluid film spanning two circular rings is known to take the form of a catenoid. Beyond a critical ring spacing, the catenoid solution fails to exist and the structure collapses. However, if a steady laminar flow is introduced through the structure, a stable **fluid tube** forms which can be readily maintained for separation distances significantly greater than achievable without flow, and stable for hours.

In the experiments shown here, a clear acrylic ring is filled with a droplet of olive oil and lowered to a cylindrical nozzle of diameter $D = 4.7$ mm where a steady flow ($Q = 60$ mL/min) of water is introduced which punctures the droplet trapped in the acrylic ring. Then the ring is raised slowly and the oil tube takes shape. As the oil tube's length (L) increases, the tube transitions from one stable shape to the next, a few of which are shown to the right. Beyond a certain length, the tube ultimately ruptures.



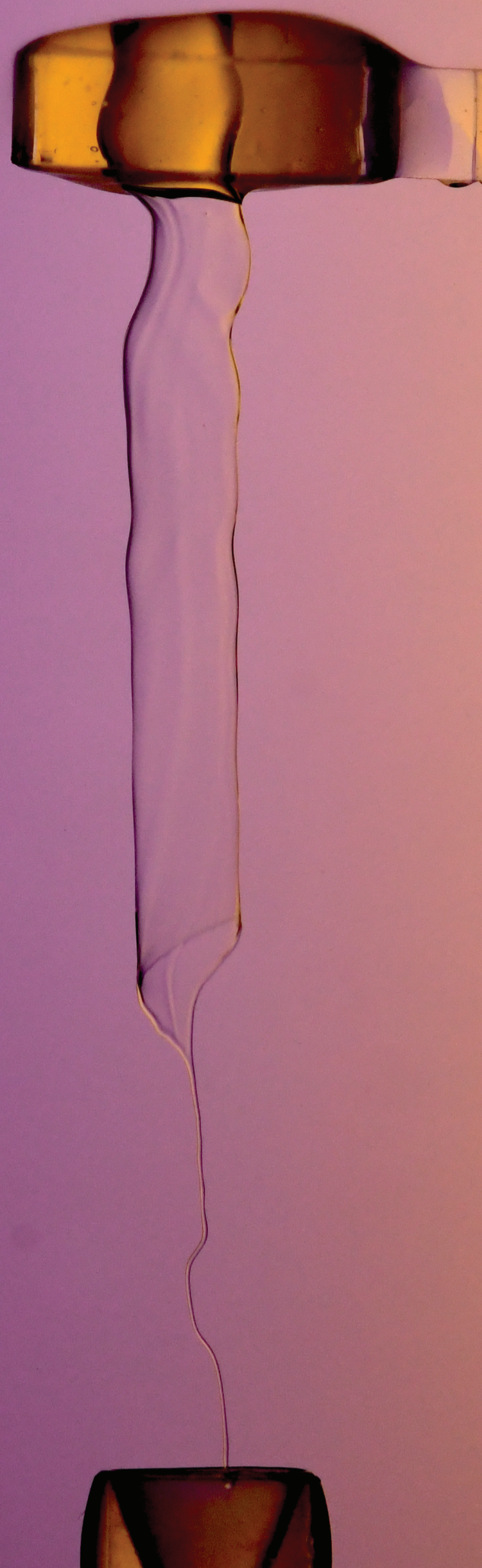
The maximum tube length depends on both the flow rate and nozzle diameter. For each nozzle diameter, we observe that there is an optimal flow rate at which the longest tube can be achieved and have found that fluid tubes can be successfully formed for nozzles as small as 1 mm in diameter. The longest oil tubes we observed were for a nozzle of diameter $D = 4.7$ mm and reached lengths near 65 mm.

In the background image, we introduce blue dye into the water flow upstream of the fluid tube. The laminar jet emerges from the fluid tube nearly undisturbed until reaching the air-water interface above and spreading laterally.

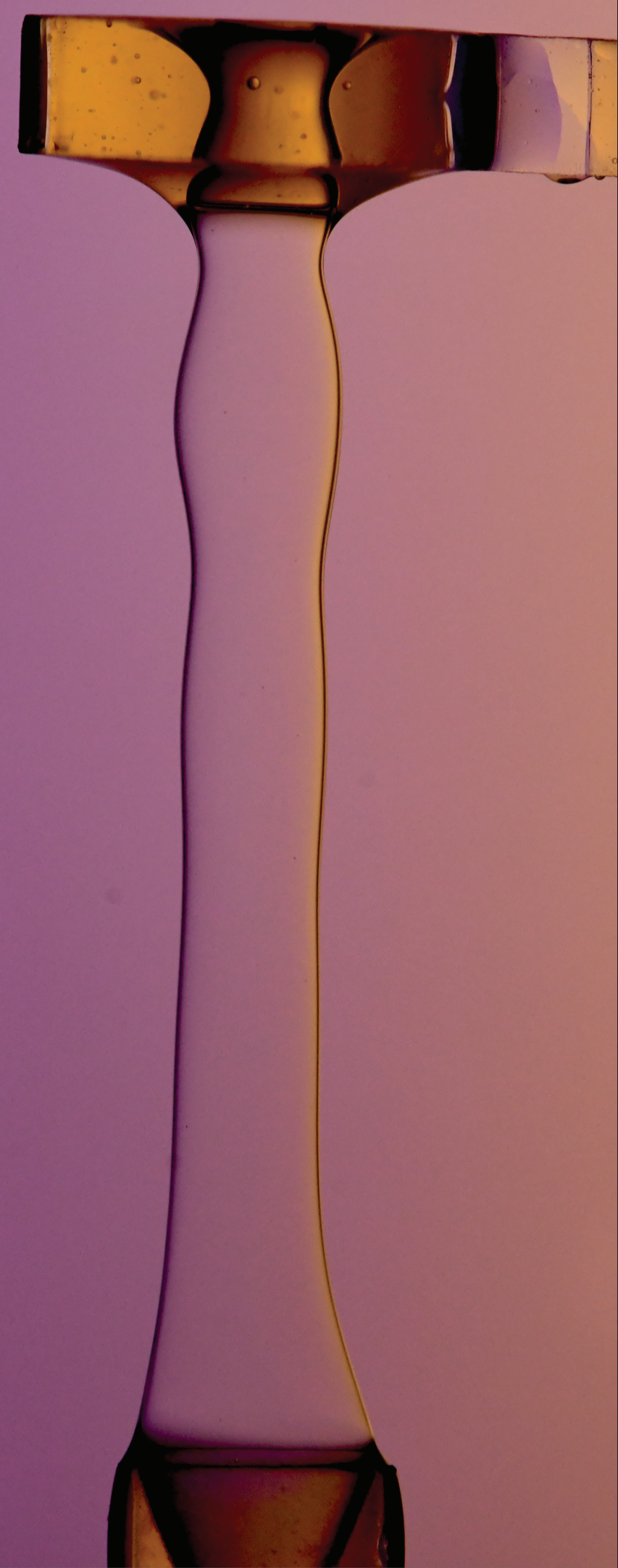


5 mm

$L = 25$ mm



$L = 20$ mm



$L = 17$ mm

