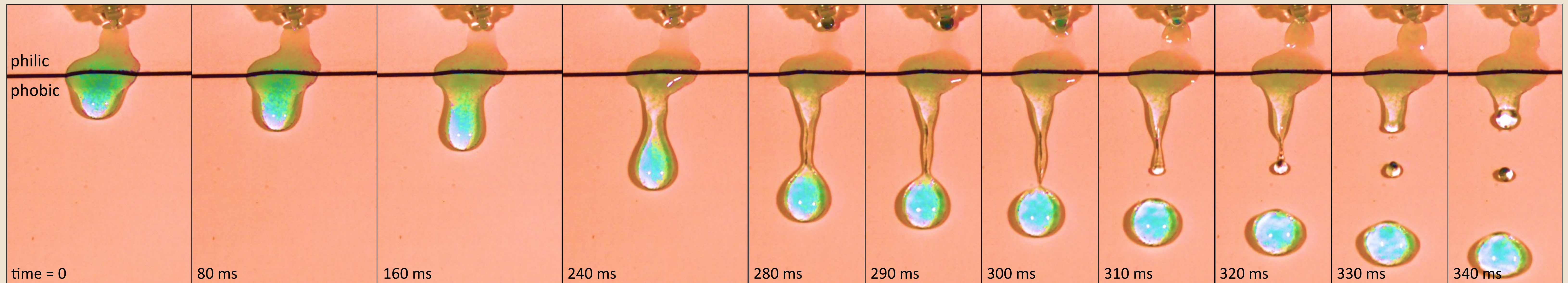




Interaction of Water with Hydrophobic and Hydrophilic Surfaces

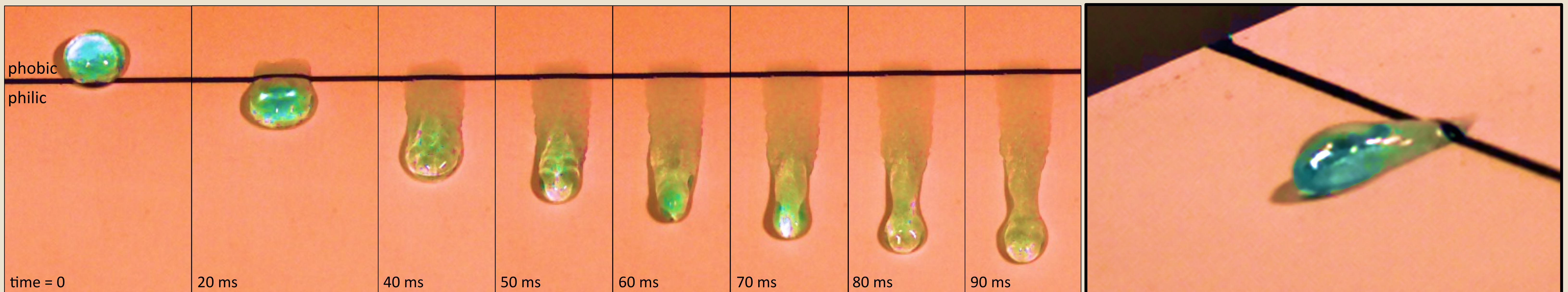
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Above: A puddle of water on an inclined hydrophilic surface drips onto a hydrophobic surface. Here, the familiar Rayleigh-Plateau instability is modified, since the fluid thread is in contact with a surface.

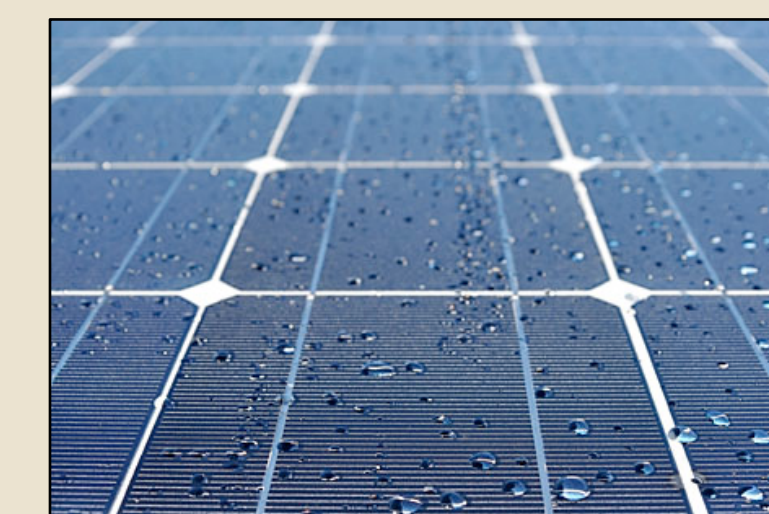
Below: Water droplets transition from rolling down an inclined hydrophobic surface to skidding down a hydrophilic surface. The isometric view shows a long “tail” is stretched out behind the droplet.



Hydrophobic and -philic surfaces play an important role in many engineering applications. For example, hydrophobicity can be used to make self-cleaning surfaces for car windshields, solar panels, and surgical tools [1]. Hydrophobic textiles are in development, with application to culinary, athletic, and outdoor gear [2]. Superhydrophobic surfaces have also been proposed as a means to reduce skin-friction drag and increase propulsion efficiency of marine vessels [3]. A pattern of hydrophobic and hydrophilic patches can be used to enhance condensation, say for water harvesting from fog as in the Namib desert beetle [4]. Researchers are studying these surfaces from the macro- to the nano-scale. Variables from surface roughness to the surface molecular chemistry can have a dramatic impact on performance [5]. These molecular-scale effects are beyond the consideration of classical fluid dynamics (which has traditionally lumped intermolecular forces into the macroscopic parameter we call surface tension), giving rise to fertile ground for research.

In the two series of images above, the substrate is foamcore board coated either with NeverWet spray to create a hydrophobic surface or with Purell hand sanitizer to create a hydrophilic surface. The board is inclined 8 degrees, and the flow is visualized using dyed water (Powerade). The images are digitally enhanced by adjustment of color saturation and tone. The philic-to-phobic series is reminiscent of a dripping faucet; a puddle above the transition line is created by slowly adding Powerade using a syringe (tip barely visible). When a critical mass is reached, a droplet begins to slide down the inclined hydrophobic surface. Surface tension forces cause the fluid thread to pinch off at multiple locations and form the main droplet and a series of smaller sub-droplets, as clearly visible in the 320ms image.

In the phobic-to-philic series, droplets are created using a syringe located approximately 10 cm above the transition line. The droplets roll down the hydrophobic surface and approach the transition line with speed. When the droplets encounter the hydrophilic surface, a long “tail” forms behind the droplet as the water is deposited on the surface. This transition is abrupt, resulting in ripples on the droplet surface, as clearly visible in the 40 and 50 ms images.



Self-cleaning solar panels



Hydrophobic chef jacket repels olive oil and red wine [7].



Water-harvesting Namib desert beetle [8].

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