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Different Effects of Roughness (Granularity) and Hydrophobicity

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Superhydrophobicity is an interesting effect that appears to be simple on the outset; increased surface area from roughness increases interfacial area and therefore energy loss or gain. More extreme roughness prevents total wetting, resulting in gas pockets present at the surface and a drastic change in the properties of the system. Increases in complexity of the system, by adding porosity (granularity), allowing the structures to move, varying the shape of the roughness or the composition of the liquid used often has unexpected effects. Here we will consider a few of these related to complex topography.

Overhanging features are commonly used in test samples as they perform better in some tests than simple roughness. It has been shown to be a prerequisite for superoleophobic surfaces as it allows liquids to be suspended for contact angles considerably below 90°. It also allows trapping of gas in lower layers even if the first layer is flooded. This is important in soils as a fixed bed of granules behaves just like a surface with overhanging roughness. Using simple geometry it is possible to predict at what contact angle penetration will occur.

Plants have some structured superhydrophobic surfaces and we have shown that some use them in conjunction with other structured surfaces to control water flows. This allows some plants to survive in difficult environments and shows us how subtly different structures interact completely differently with water. Long fibres can either cause water droplets to roll over a plant surface or halt it in its tracks. Implications of this in soils include predicting when particles will adhere more strongly to water drops and why organic fibrous material may play a greater role in the behaviour of water in soils than may be expected from the amount present.

The garden snail uses a biosurfactant that is very effective at wetting surfaces and can crawl over most superhydrophobic surfaces. There are some, however, that defeat even the snail's complex slime. Looking at these surfaces in more detail reveals that some superhydrophobic surfaces are much more resistant to the effects of surfactants than others. As mentioned above, overhanging structures, such as those found in granular materials are particularly effective at suspending liquids. This does not, however, always translate to them being more effective against surfactants, unfortunately, however, surfactants are not always as effective as we would like them to be, although drops do not skate across superhydrophobic surfaces they often do not penetrate into them fully either.