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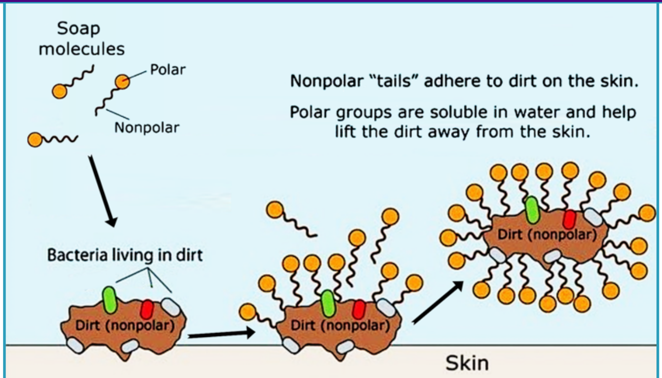
Soap: Our Saviour!



How soap removes dirt and bacteria from the skin - similar to how the virus is washed off the skin

Deadly viruses are no match for plain old soap and here's the science behind it

So why does soap work so well on the coronavirus and indeed, most viruses?

Most viruses consist of three key building blocks: proteins, lipids and RNA (RNA is the viral genetic material — it is similar to DNA).

The proteins have several roles, including breaking into the target human cell, assisting with virus replication and basically being a key building block in the virus structure. The lipids then form a coat around the virus, both for protection and to assist with its spread and human cell invasion.

The RNA, proteins and lipids self-assemble to form the virus. The viral self-assembly is like Velcro, so it is hard to break up the self-assembled viral particle. But we *can* do it — with soap!

Soap dissolves the lipid membrane and the virus falls apart and 'dies' – or rather, it becomes *inactive,* as viruses aren't really alive.

Most viruses, including the coronavirus, are nanoparticles. Nanoparticles have complex interactions with surfaces they are on. When a virus invades a human cell, the RNA 'hijacks' the cellular machinery and forces the cell to make fresh copies of the virus RNA and the various proteins that make up the virus.

These new RNA and protein molecules self-assemble with lipids (readily present in the human cell) to form new copies of the virus. The virus does not photocopy itself; rather it makes copies of the different building blocks, which then self-assemble into new viruses.

All those new viruses eventually overwhelm the host cell, and it dies or explodes, releasing viruses that then go on to infect more cells. In the lungs, viruses end up in the airways and mucous membranes.

Skin is an ideal surface for viruses

When you cough, or especially when you sneeze, tiny droplets from the airways can fly up to 9 metres. The larger ones are thought to be main coronavirus carriers, and they can go at least 2 metres. So cover your coughs and sneezes!

These tiny droplets end up on surfaces and dry out quickly. But the viruses are still active. What happens next is all about how self-assembled nanoparticles (like the viruses) interact with their environment.

Now, similar molecules appear to interact more strongly with each other than dissimilar ones. Wood, fabric and skin interact fairly strongly with viruses. Contrast this with steel, porcelain and some plastics, such as Teflon. The surface structure also matters. The flatter the surface, the less the virus will 'stick' to the surface.

So why are surfaces different? The virus is held together by a combination of hydrogen bonds (like those in water) and hydrophilic, or 'fat-like' interactions. The surface of fibres or wood, for instance, can form a lot of hydrogen bonds with the virus. In contrast, steel, porcelain or Teflon do not form much of a hydrogen bond with the virus. So the virus is not strongly bound to those surfaces and is quite stable. The coronavirus is thought to stay active on favourable surfaces for hours, possibly a day.

The skin is an ideal surface for a virus. It is organic, of course, and the proteins and fatty acids in the dead cells on the surface interact with the virus through both hydrogen bonds and the 'fat-like' hydrophilic interactions.

So when you touch a steel surface with a virus particle on it, it will stick to your skin and, hence, get transferred on to your hands. But you are not (yet) infected. If you touch your face though, the virus can get transferred. And now the virus is dangerously close to the airways and the mucus-type membranes in and around your mouth and eyes. So the virus can get in and you are infected. That is, unless your immune system kills the virus.

If the virus is on your hands, you can pass it on by shaking someone's else hand. Kisses? well, that's pretty obvious. It goes without saying that if someone sneezes in your face, you're stuck. So how often do you touch your face? It turns out most people touch their face once every two to five minutes. So you're at high risk once the virus gets on your hands, unless you wash off the active virus. So let's try washing it off with plain water. But water 'only' competes with the strong 'glue-like' interactions between the skin and virus via hydrogen bonds. The virus is sticky and may not budge. Water isn't enough.

Soap dissolves a virus' structure

Soapy water is totally different. Soap contains fat-like substances structurally similar to the lipids in the virus membrane. The soap molecules 'compete' with the lipids in the virus membrane. That is more or less how soap also removes normal dirt of the skin (see image above).

The soap molecules also compete with a lot of other bonds that help the proteins, RNA and the lipids to stick together. The soap is effectively 'dissolving' the glue that holds the virus together. Add to that all the water. The soap also outcompetes the interactions between the virus and the skin surface. Soon the virus gets detached and falls apart due to the combined action of the soap and water. Then the virus is gone!

The skin is rough and wrinkly, which is why you need a fair amount of rubbing and soaking to ensure the soap reaches every nook and cranny on the skin surface that could be hiding active viruses. Alcohol-based products that contain a high share of alcohol solution, typically 60%-80% not only readily form hydrogen bonds with the virus material but, as a solvent, are more lipophilic than water. Hence, alcohol dissolves the lipid membrane and disrupts other supramolecular interactions in the virus.

Overall, alcohol is not as good as soap at this task, in soapy water the virus detaches from the skin and falls apart readily.

This article was adapted from an article by Palli Thordarson, Professor at the School of Chemistry, University of New South Wales, Sydney