**The coronavirus is no match for plain, old soap — here’s the science behind it**

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**Soap works better than alcohol and disinfectants at destroying the structure of viruses**



**This is how soap removes dirt, and bacteria, from the skin.**

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Why does soap work so well on the new coronavirus and, indeed, most viruses? Because it is a self-assembled nanoparticle in which the weakest link is the lipid (fatty) bilayer.

That sounds scientific. Let me explain.

Soap dissolves the fat membrane, and the virus falls apart like a house of cards and “dies,” or rather, it becomes inactive as viruses aren’t really alive. Viruses can be active outside the body for hours, even days.

Disinfectants, or liquids, wipes, gels and creams containing alcohol (and soap) have a similar effect but are not as good as regular soap. Apart from alcohol and soap, antibacterial agents in those products don’t affect the virus structure much. Consequently, many antibacterial products are basically just an expensive version of soap in how they act on viruses. Soap is the best, but alcohol wipes are good when soap is not practical or handy, for example in office reception areas.

***Soap outcompetes the interactions between the virus and the skin surface, and the virus gets detached and falls apart like a house of cards.***

###### **Supramolecular chemistry**

But why, exactly, is soap so good? To explain that, I will take you through a journey of supramolecular chemistry, nanoscience and virology. I will try to explain this in generic terms, which means leaving out special chemistry terms. (I must point out that, while I am an expert in supramolecular chemistry and the assembly of nanoparticles, I am not a virologist.)

I have always been fascinated by viruses, as I see them as one of them most spectacular examples of how supramolecular chemistry and nanoscience converge.

Most viruses consist of three key building blocks: RNA, proteins and lipids.The RNA is the viral genetic material — it is similar to DNA. The proteins have several roles, including breaking into the target cell, assisting with virus replication and basically being a key building block (like a brick in a house) in the virus structure.

The lipids then form a coat around the virus, both for protection and to assist with its spread and cellular invasion. The RNA, proteins and lipids self-assemble to form the virus. Critically, there are no strong “covalent” bonds holding these units together.

Instead, the viral self-assembly is based on weak “non-covalent” interactions between the proteins, RNA and lipids. Together, these act together like Velcro, so it is hard to break up the self-assembled viral particle. Still, we can do it — with soap!

Most viruses, including the coronavirus, are between 50-200 nanometers — so they truly are nanoparticles. Nanoparticles have complex interactions with surfaces they are on; it’s the same with viruses. Skin, steel, timber, fabric, paint and porcelain are very different surfaces.

When a virus invades a cell, the RNA “hijacks” the cellular machinery like a computer virus and forces the cell to make fresh copies of its own RNA and the various proteins that make up the virus.

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

All those new viruses eventually overwhelm the 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.

When you cough, or especially when you sneeze, tiny droplets from the airways can fly up to 30 feet. The larger ones are thought to be main coronavirus carriers, and they can go at least 7 feet. So, cover your coughs and sneezes!

**Skin is an ideal surface for viruses**

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

Now it is time to introduce a powerful supramolecular chemistry concept that effectively says: 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 at least some plastics, such as Teflon. The surface structure also matters. The flatter the surface, the less the virus will “stick” to the surface. Rougher surfaces can actually pull the virus apart.

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 fibers 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.

For how long does the virus stay active? It depends. The novel coronavirus is thought to stay active on favorable surfaces for hours, possibly a day. What makes the virus less stable? Moisture (“dissolves”), sunlight (UV light) and heat (molecular motions).

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 — voila! — 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 the 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. It might just work. 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 known as amphiphiles, some 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 graphic at the top of this article).

The soap molecules also compete with a lot other non-covalent 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 like a house of cards due to the combined action of the soap and water. Boom, 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 include all “disinfectants” and “antibacterial” products that contain a high share of alcohol solution, typically 60%-80% ethanol, sometimes with a bit of isopropanol, water and a bit of soap.

Ethanol and other types of alcohol do not only readily form hydrogen bonds with the virus material but, as a solvent, are more lipophilic than water. Hence, alcohol does dissolve the lipid membrane and disrupt other supramolecular interactions in the virus.

However, you need a fairly high concentration (maybe 60%-plus) of the alcohol to get a rapid dissolution of the virus. Vodka or whiskey (usually 40% ethanol) won’t dissolve the virus as quickly. Overall, alcohol is not as good as soap at this task.

Nearly all antibacterial products contain alcohol and some soap, and that does help kill viruses. But some also include “active” bacterial killing agents, such as triclosan. Those, however, do basically nothing to the virus.

###### **Alcohol works — to a degree**

To sum up, viruses are almost like grease-nanoparticles. They can stay active for many hours on surfaces and then get picked up by touch. Then they get to our face and infect us because most of us touch our face frequently.

Water is not effective alone in washing the virus off our hands. Alcohol-based products work better. But nothing beats soap — the virus detaches from the skin and falls apart readily in soapy water.

Supramolecular chemistry and nanoscience tell us not only a lot about how the virus self-assembles into a functional, active menace, but also how we can beat viruses with something as simple as soap.

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**Watch:** [**https://laughingsquid.com/alton-brown-soap-is-better-than-hand-sanitizer/**](https://laughingsquid.com/alton-brown-soap-is-better-than-hand-sanitizer/)