PROFESSOR: So we've discussed the extent to which the size of a droplet can influence the infectivity or the ability of a virion to escape from that droplet and, also, to be transmitted to the deepest, smallest passages in the lungs as a function of its size.

There is also a dependence on the relative humidity of the air, which is related to size.

And so, as we've seen, humidity does vary the size, but there's believed to be also a more direct effect of humidity, as I will now try to explain.

So I'm relying here on the recent work of the group of Linsey Marr, two papers cited here.

So we can distinguish between two different types of pathogens.

The first are the bacteria.

And here there's a monotonic dependence of the relative viability of the pathogen, of the bacteria, after a certain time period.

Let's say one hour.

And what is found is that, above a certain threshold of humidity, around 80% relative humidity, that there's, essentially, no change in the viability of the bacteria.

They're alive.

They're infectious.

But, as the humidity, relative humidity, is reduced, then there's a significant drop off in viability, which depends on the specific type of bacteria, but it's a fairly general trend that it comes down significantly as you approach more dry air.

Now what's happening is the size of the droplets is shrinking.

In the case of the bacteria, we can understand, to some extent, why this dependence might be here by thinking about solutes that are present, especially salts, in the system, but, also, mucus-- mucosal proteins that we've also discussed.

And, when the particles become more dry, then what happens is that the concentration goes up, and there's an increase in the osmotic pressure of the fluid around the bacteria relative to the inside.

And, as with many other kinds of cells, when exposed to such high osmotic pressures, that can cause stress on the cell and, potentially, even rupturing of membranes or other structures within the cell.

And, obviously, then it is not good for the viability of that cell and leads to deactivation.

The case of viruses is a bit more complicated.

So some old data of Harper from the 1960s on the seasonal flu, in particular, human influenza virus A, which was recently analyzed by Marr's group, showed that there was a viral deactivation rate that, essentially, was scaling linearly with the relative humidity.

So there's a faster deactivation rate in more humid air, less in dry air.

This is one way we can understand the seasonal nature of the flu in that, in more dry, wintry environments, especially away from-- in sort of the northern or southern hemispheres, we can expect that then the virus would be deactivating less.

But, of course, that's compounded by the effect that, in the winter, people spend more time indoors, and so that's also leading to more seasonal transmission.

Now, if we convert the deactivation rate into relative viability again, then we see an interesting dependence in recent experiments, which were done using bacteriophages, which are models of different kinds of human pathogens, including the seasonal flu and influenza viruses.

And, in particular, there's a non-monotonic dependence where, essentially, there's a maximum rate of deactivation around the range of 70% or 80% humidity, or 60% to 80%.

And, similarly, the viability was the lowest in that range.

And the way the authors proposed to explain that was a hypothesis that there are solutes that are present, which may be, for example, sodium chloride or, in particular, chloride ions, perhaps, that, when we reach the higher concentration in the shrunken droplets, that there is, again, a stress on the virus, but, in this case, regardless of the details of the mechanism of deactivation for these encapsulated viruses, the idea is that the cumulative dose or exposure of those solutes is what's important.

So, if the shrinking happens very fast, and we end up with a droplet nucleus of, mostly, bound water, and it happens over a short period of time, the exposure to those solutes is limited.

And, hence, we end up with high viability, low deactivation rate in dry conditions.

Conversely, in very humid conditions, the droplets stay big.

In fact, they may even grow because of the hygroscopic solutes.

And, in that case, there's plenty of solutes present, but they're very dilute.

And so, again, the effect on the virus is minimal.

And the greatest deactivation and, also, the maximum-- the sort of minimum viability is actually at an intermediate range of humidities.

So this tells you that maintaining a comfortable humidity in the range of 50% to 80% may, actually, be the best for minimizing the viability of viral pathogens.