

## How can bacteria become resistant to Biocides?

Bacteria become resistant to biocide exposure when they are able to limit their internal concentration of active biocide to harmless levels. Bacteria can do this by a number of methods and may combine several.

For instance, some bacteria become resistant by changing the structure of their **cell envelope** so that it lets in smaller amounts of biocides. This is particularly the case of bacteria that grow as biofilms attached to surfaces. The outer layers of biofilms are considerably less permeable than those of free bacteria, and this could lead them to be much less easily affected by biocides and antibiotics.

Some bacteria become more tolerant to biocides by activating a system that “pumps out” toxic compounds generally termed **efflux pump**. This reduces the efficacy of biocides.

Some bacteria use enzymes to cause chemical changes in biocides and to **degrade** them so that they are less effective, but it is not clear whether this mechanism is relevant for the high concentrations of biocides used in practice.

Bacteria can **modify the parts of their structure** that biocides attach to and attack. However, there are many different sites that biocides can target so modifying one of these does not have a large effect on increased resistance.

Bacteria that could previously be controlled by a biocide can develop resistance by **acquiring resistance genes** and this is a serious cause for concern. In some cases, exposure to a low biocide concentration leads to genetic changes that make the bacteria resistant to several unrelated compounds, but the mechanism for this is unknown.

Recent studies have demonstrated that some biocides are able to activate several genes that are involved in the control of resistance mechanisms affecting the activity of biocides and antibiotics.

Sometimes bacteria become resistant once they reach sufficiently high numbers. Bacteria secrete certain “signal” molecules that other bacteria can detect. Once bacteria detect enough of these from neighbouring bacteria, the whole colony activates specific genetic cascades involved in the formation of biofilms. This mechanism is involved in the development of resistance to biocides and antibiotics but more research is needed in this field.