

Biofilm controls and what gaps exists in our knowledge?

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What are biofilms?

What are they made of?



Water 98-99%



Microbes 1-2%



Complex mixture of many different micro-organisms working together, e.g., pseudomonads, listeria, staphylococci, coliforms (dependent on many factors)

SLIME



Polysaccharides
+ nucleic acids
+ glycoproteins
= *Extracellular* or *Exopolymer* matrix

What is needed for them to form?



Microbes

+



Water

+



Food

+



Surface

+



Time

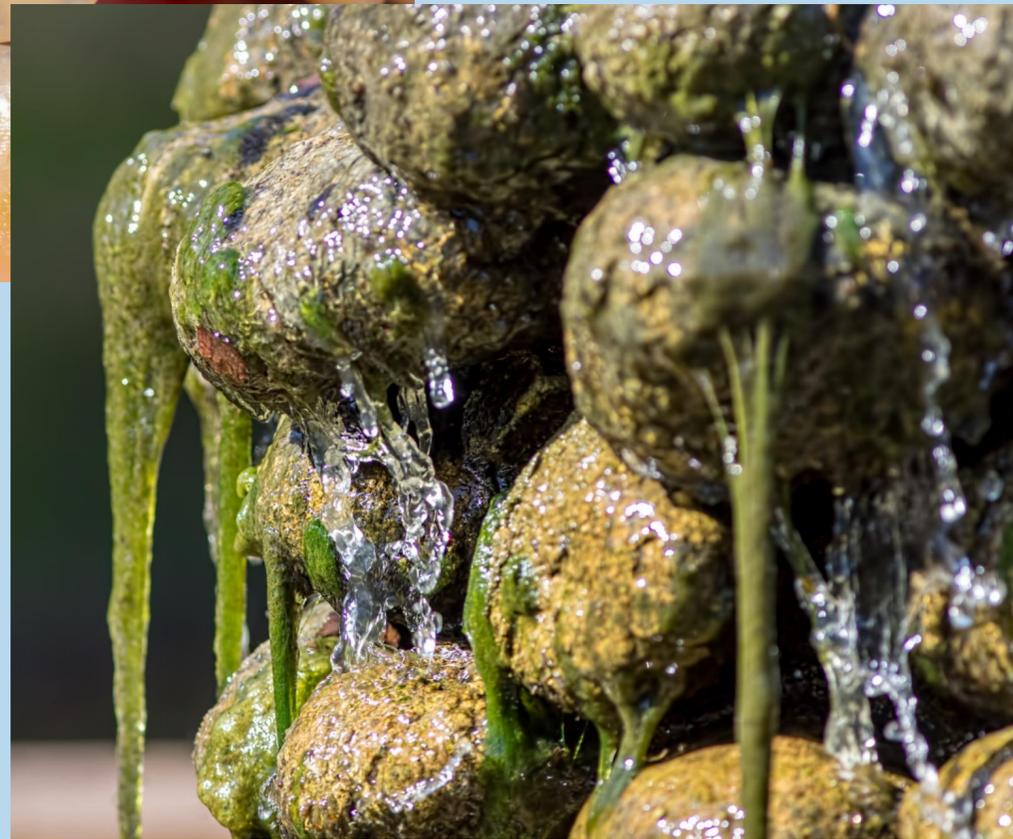
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Biofilm

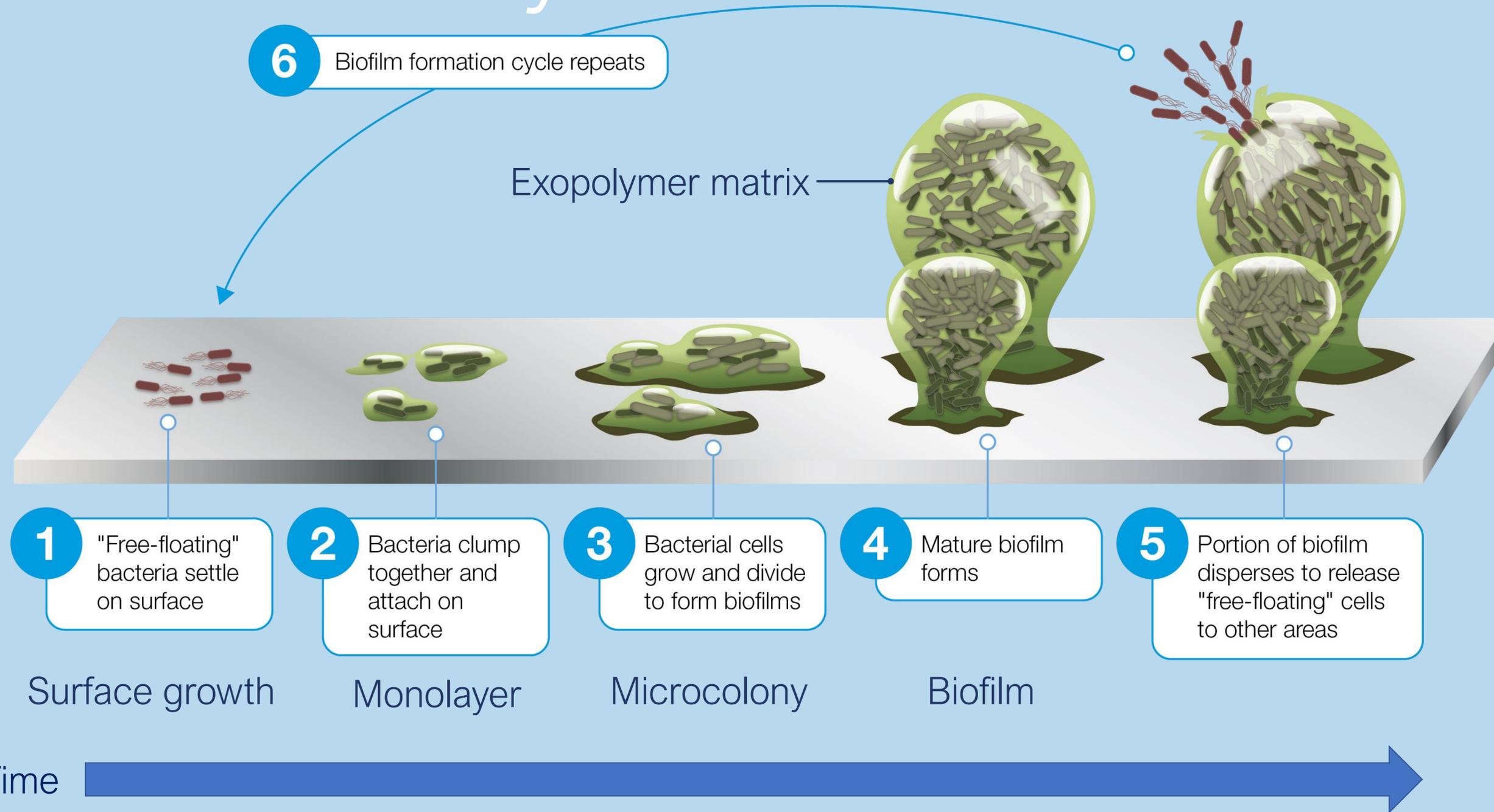
Temperature,
Oxygen levels

Where can they be found?

Biofilms are found on almost every surface in nature

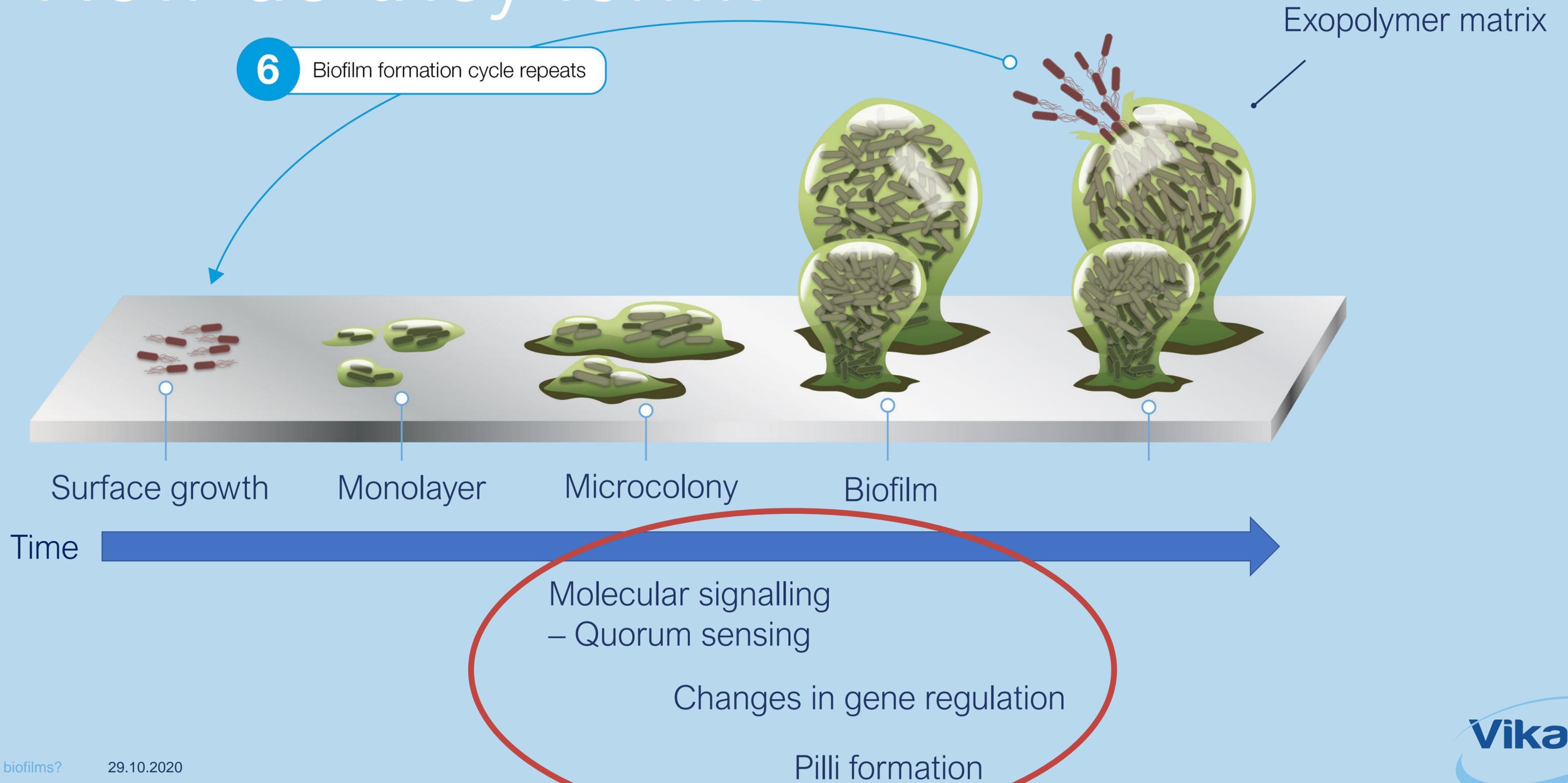


How do they form?





How do they form?

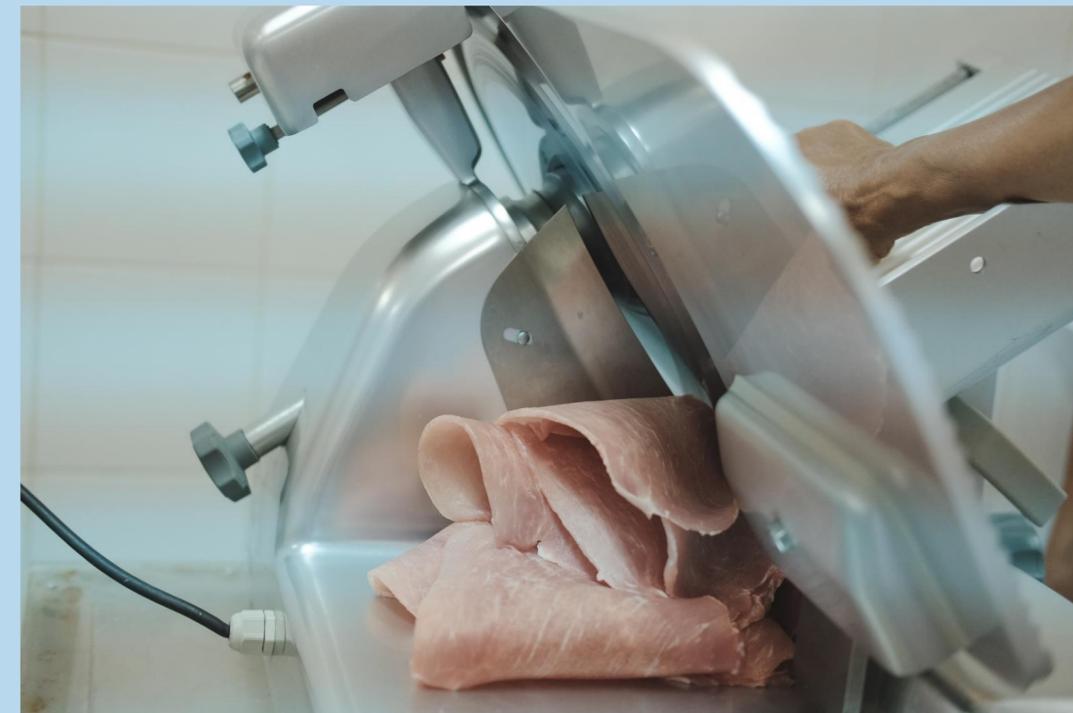


Biofilms in food production

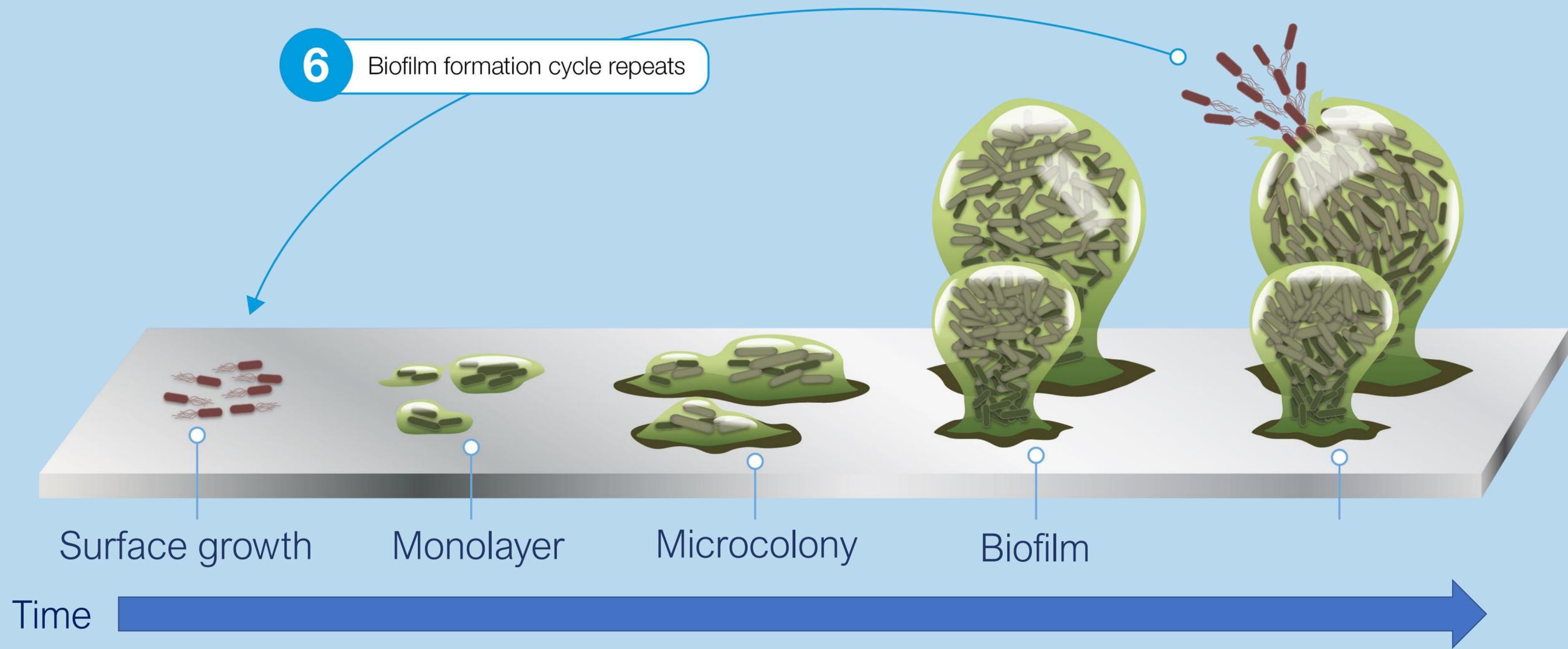
Biofilms are commonly found in old or poorly designed and/or maintained buildings and equipment

including,

- food processing equipment
- drains and pipework
- behind poorly fitted and sealed, and damaged wall and door cladding and floors
- in leaky roof cavities and on damp ceilings
- the underside of surfaces, and
- cleaning equipment and utensils
- Places we don't yet know about!



Mature biofilm development is rare



*65% monolayer

*28% microcolonies

*7% 'true' biofilms

Decontamination

*120 surfaces tested. Campden BRI

@ 8hours

@ 16 hours

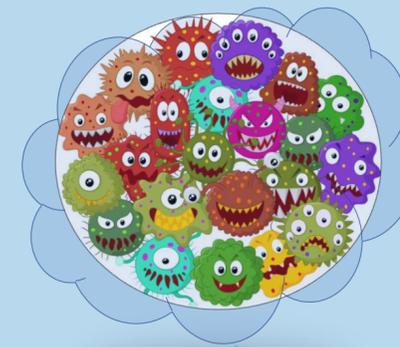
Why are they a problem?

Biofilms aid the survival, growth and transfer of microbial contamination

- from the environment to food contact surfaces
- from food contact surfaces to the food product

Via people, air, moisture, equipment, and pests.

We can only control what we can decontaminate – some biofilms can go undetected for years



Why are they a problem?

Biofilms protect microbes

from,

- detergents
- disinfectants
- preservatives
- antimicrobials
- biocides
- heat
- radiation (UV)



* Microbes in biofilms may be up to

3000

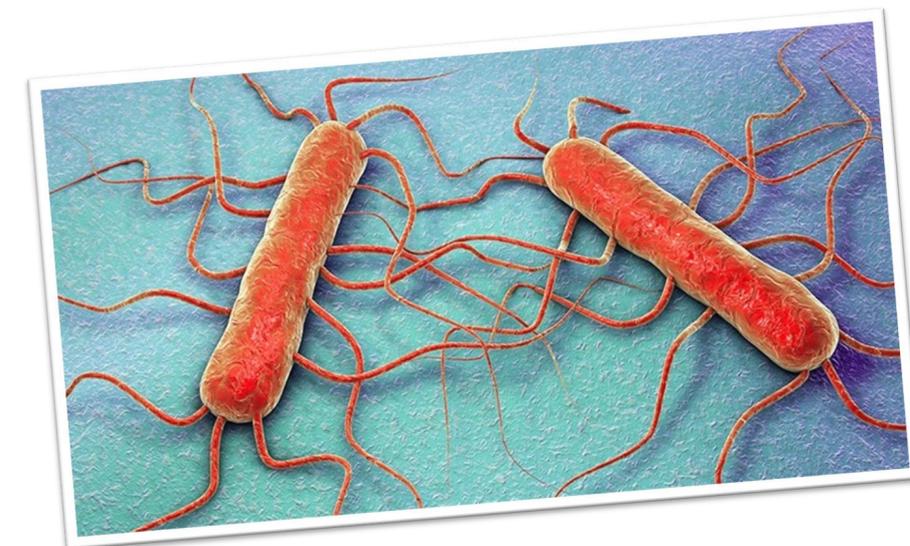
times more resistant to hypochlorous acid than free cells

(Le Chevalier *et al*, 1988)

When biofilms attack!

2008: Listeria outbreak in Canada

- 57 cases of listeriosis (24 fatal)
- Found in meats packed by Maple Leaf Foods, Canada
- **Source** – biofilm in meat slicing machines
- **Vector** – slicing blades
- Slicers were cleaned on a daily basis
- During full disassembly (periodic deep clean), areas found inside where Listeria could survive the daily cleaning process
- Total costs of outbreak ~ \$242 million
- Total costs to Maple Leaf Foods ~ \$77 million



When biofilms attack!

2014: Listeria outbreak in Denmark

- Rolled lamb sausages (rullepølse) from the company Jørn A. Rullepølser near Copenhagen
- 41 cases of listeriosis (17 fatal cases)
- **Source** – biofilm in a production area drain
- **Vector** – aerosols from water poured into the drain cross-contaminated the cooked rolled lamb sausages handled in the same area
- The rolled lamb sausage was served health impaired and elderly people



Where will they
attack next?!



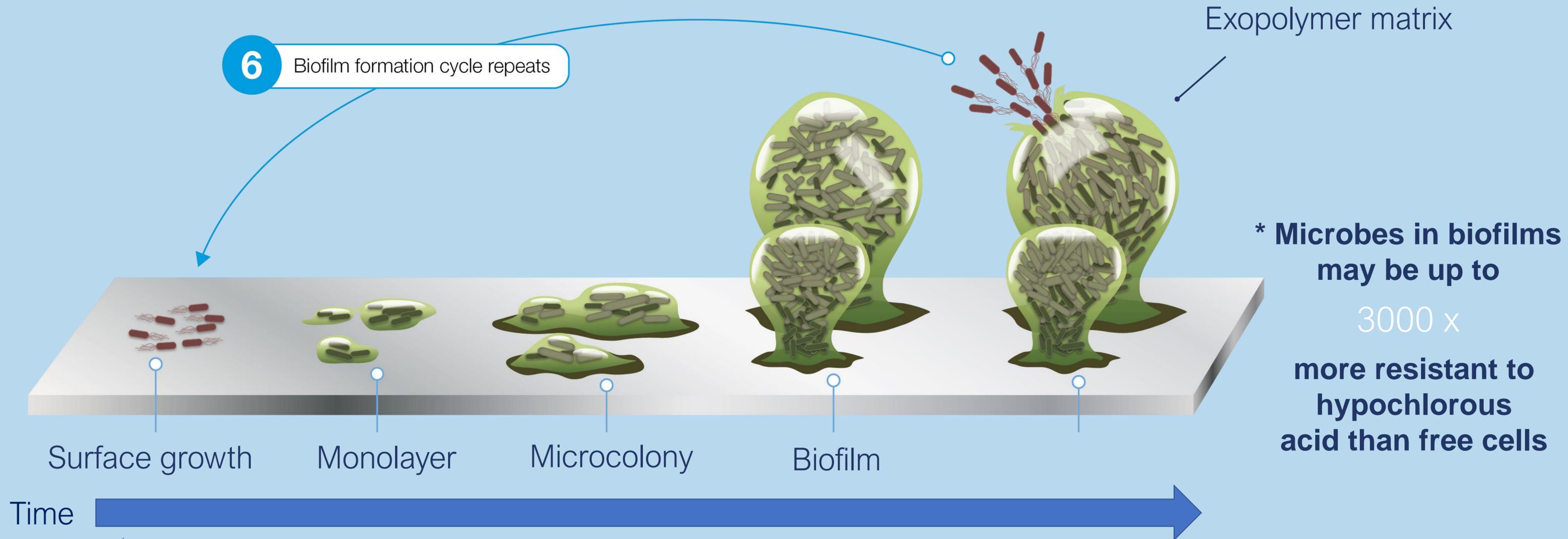
Biofilm control

- Novel control methods
 - Enzymic detergents
 - Competitive exclusion
 - Bacteriophages
 - Non-thermal atmospheric plasma
 - Electrolysed water
 - Surface modifications
- Traditional cleaning and disinfection (decontamination) practices
- Good hygienic design
- Regular maintenance and replacement of equipment and facilities

Back to basics



Effective decontamination



*** Microbes in biofilms may be up to 3000 x more resistant to hypochlorous acid than free cells**

The most effective way to control biofilms is to decontaminate at a frequency that prevents them reaching their mature phase. Frequency determined through monitoring biofilm formation



Effective decontamination

Definitions:

Cleaning

– physical removal of contamination (food debris, allergens, microbes, foreign bodies).

Disinfection

– use of heat, radiation or chemicals to reduce microbial load to an acceptable level.

Detergent

– a chemical used to aid physical removal of contaminants (food, debris & microbes).

Disinfectant

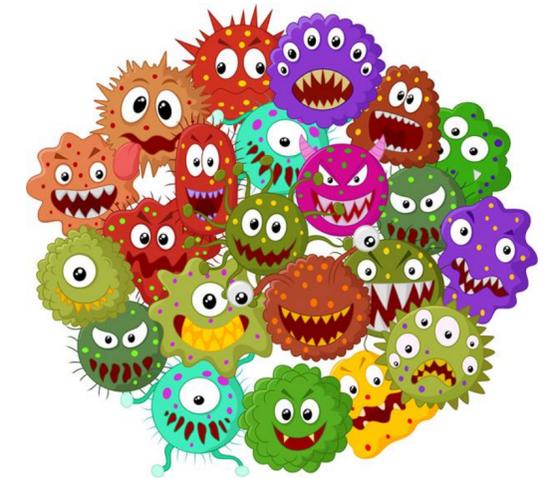
- a chemical that lowers the level of microbial contamination to an acceptable level.

Sanitiser

– a combined detergent/disinfectant chemical.

Sterilisation

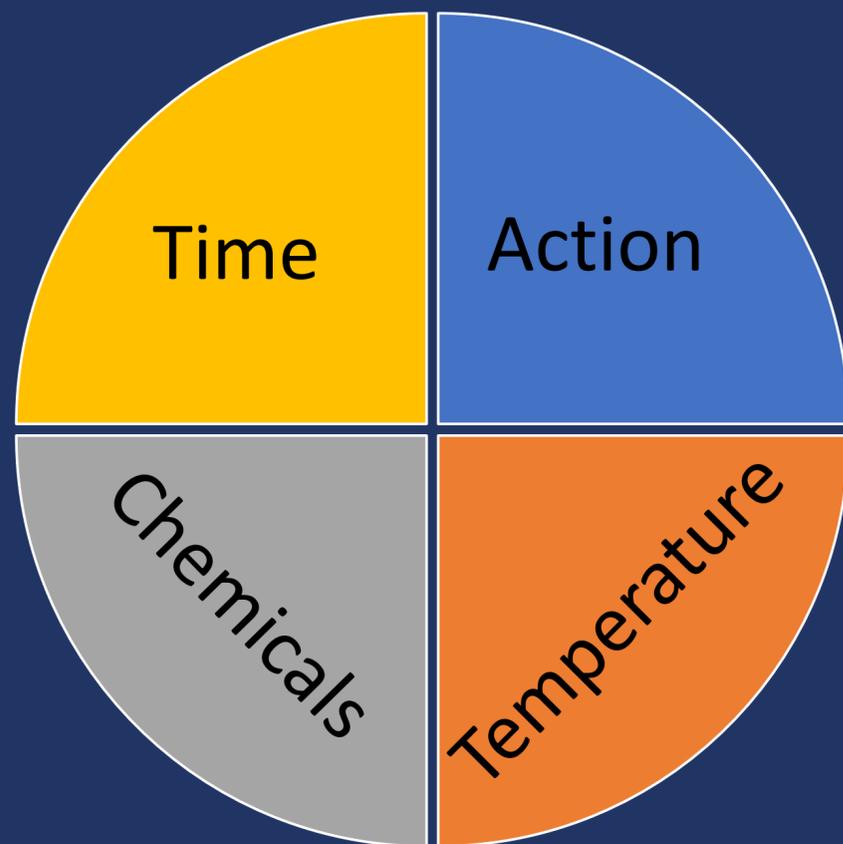
– complete destruction of all microorganisms, including spores, usually by heat or radiation.



Effective decontamination

....is a multi-task force approach that starts with cleaning

Cleaning removes most of the contamination and makes disinfection more effective



Factory trial data – Courtesy of Campden BRI

Before cleaning	After cleaning	After cleaning and disinfection
1,320,000 microbes	86,700 microbes	2,500 microbes
Microbial reduction	1,233,300 microbes 93.4%	84,200 microbes 6.4% (99.8%)

Selection of chemicals

Cleaning chemical suppliers can provide:

- advice (and training) on the types, concentrations, application, temperature, contact time, and health & safety information.
- dosing and foaming equipment

Cleaning chemicals must be:

- made up and used as per cleaning chemical manufacturers instructions
- applied and left in contact with the item being cleaned for long enough to be effective
- thoroughly rinsed from the surface after use (in most cases)



Selection of decontamination method

Foaming

- Common method of decontamination used in food production
- A spray nozzle is used to cover equipment with a foam sanitiser. The sanitiser is given time to act on the soil and is then rinsed off with the released soil
- Good for decontaminating large areas such as floors, walls, conveyors, and tables and large, open production equipment
- Manual cleaning tools required for detail/deep cleaning
- Wet cleaning only



Selection of decontamination method

Cleaning in Place (CIP)

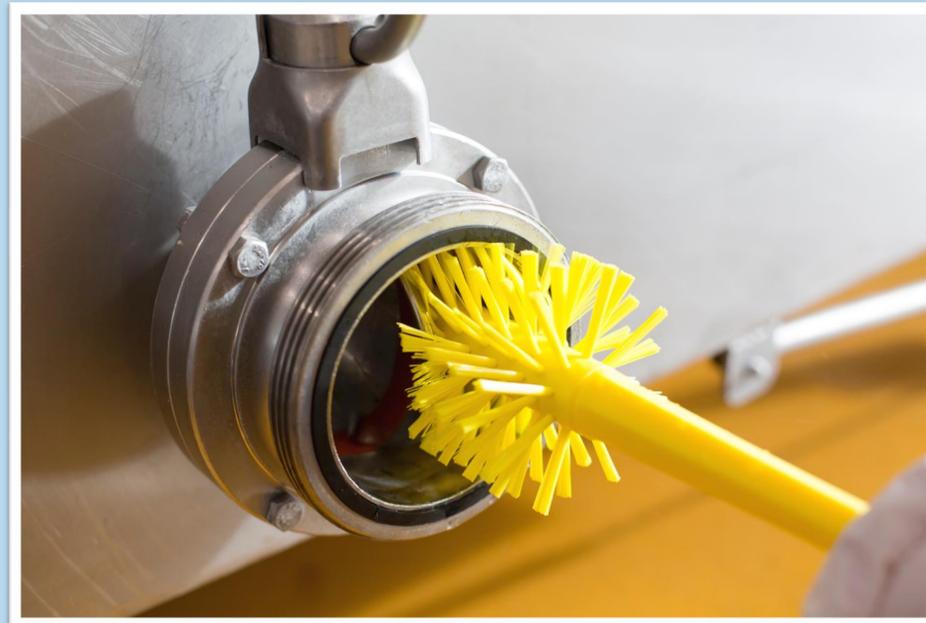
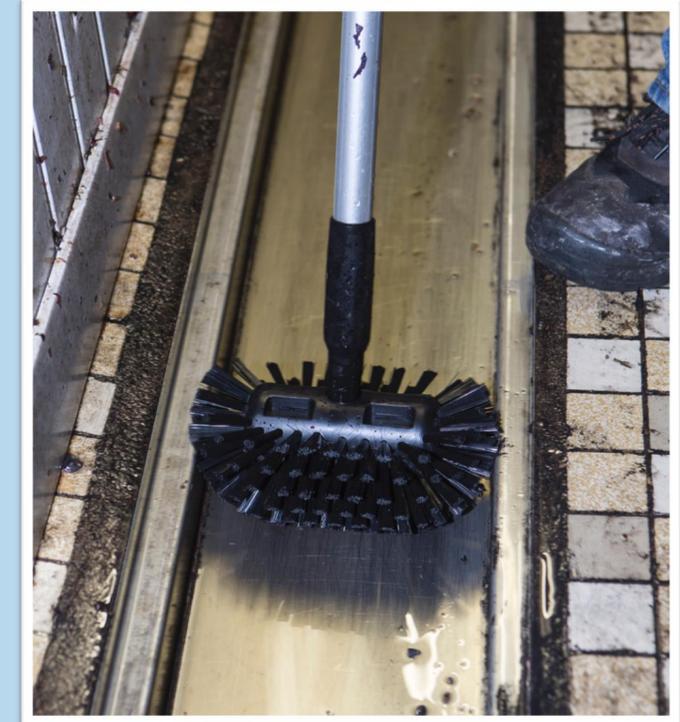
- Commonly used to clean pipework used for liquid/semi-solid foods, e.g. dairy products, sauces. Uses:
 - automated CIP system
 - aggressive chemicals
 - high temperatures
 - turbulent flow rates (Action)
 - Good for cleaning closed pipework and vessels
 - Manual cleaning tools required for detail/deep cleaning
 - Predominantly wet cleaning



Selection of decontamination method

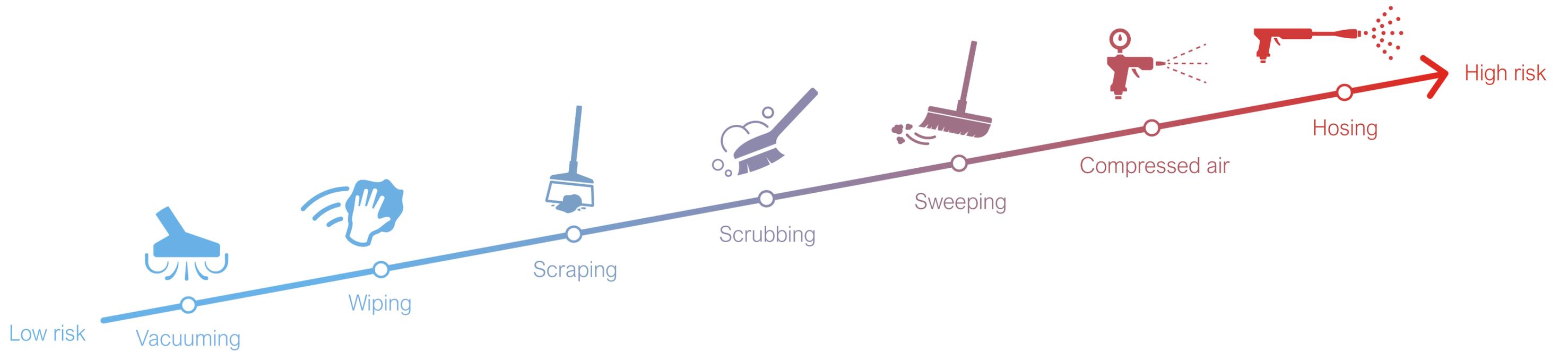
Manual cleaning

- Common method of decontamination used in food production.
- Good for
 - Decontaminating small to medium sized production areas/equipment;
 - Deep cleaning
 - Detail cleaning; and
 - Cleaning of complex equipment
- Requires trained staff (to apply Action); appropriate equipment & chemicals.
- Wet or dry cleaning



Selection of decontamination method

Most cleaning activities increase the risk of cross-contamination

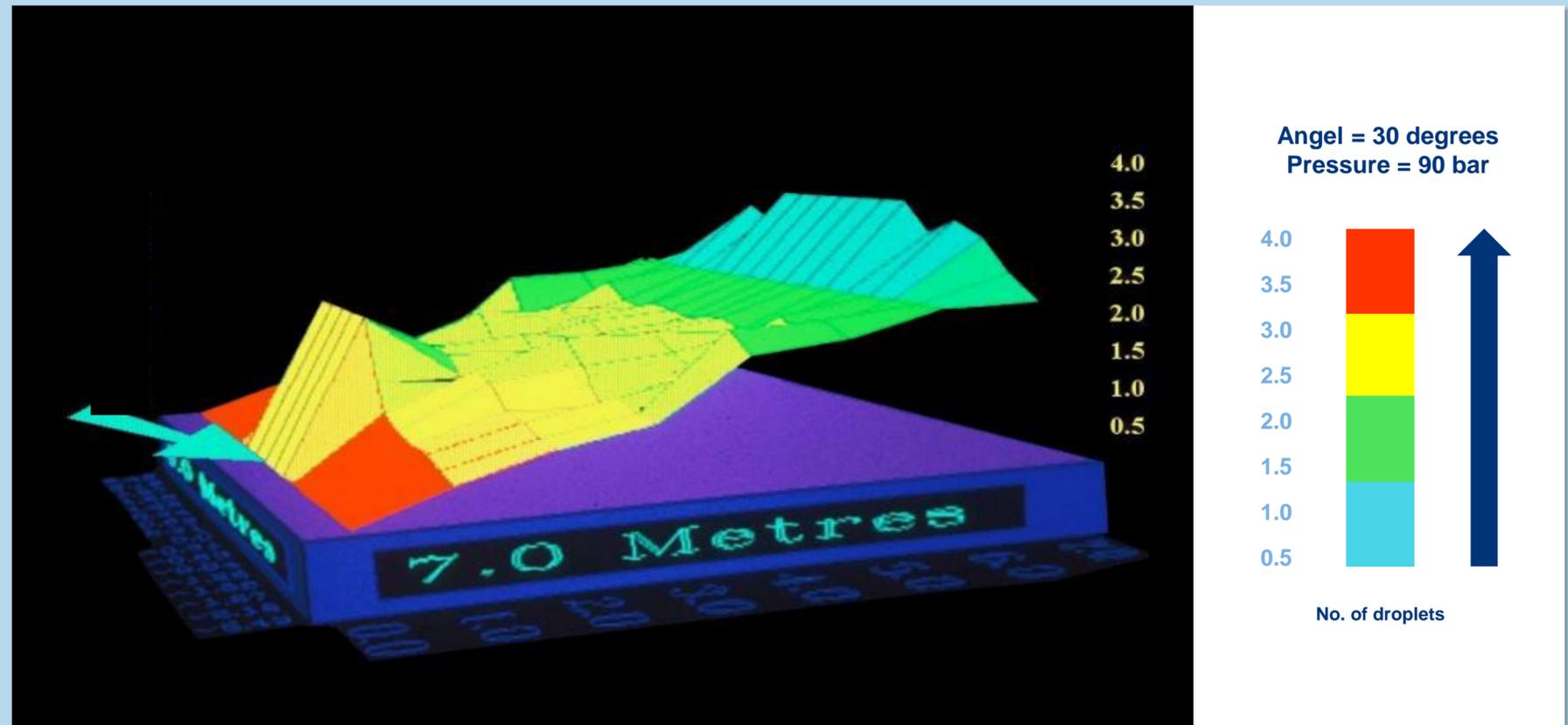


Selection of decontamination method

Spread of contamination: High pressure hosing



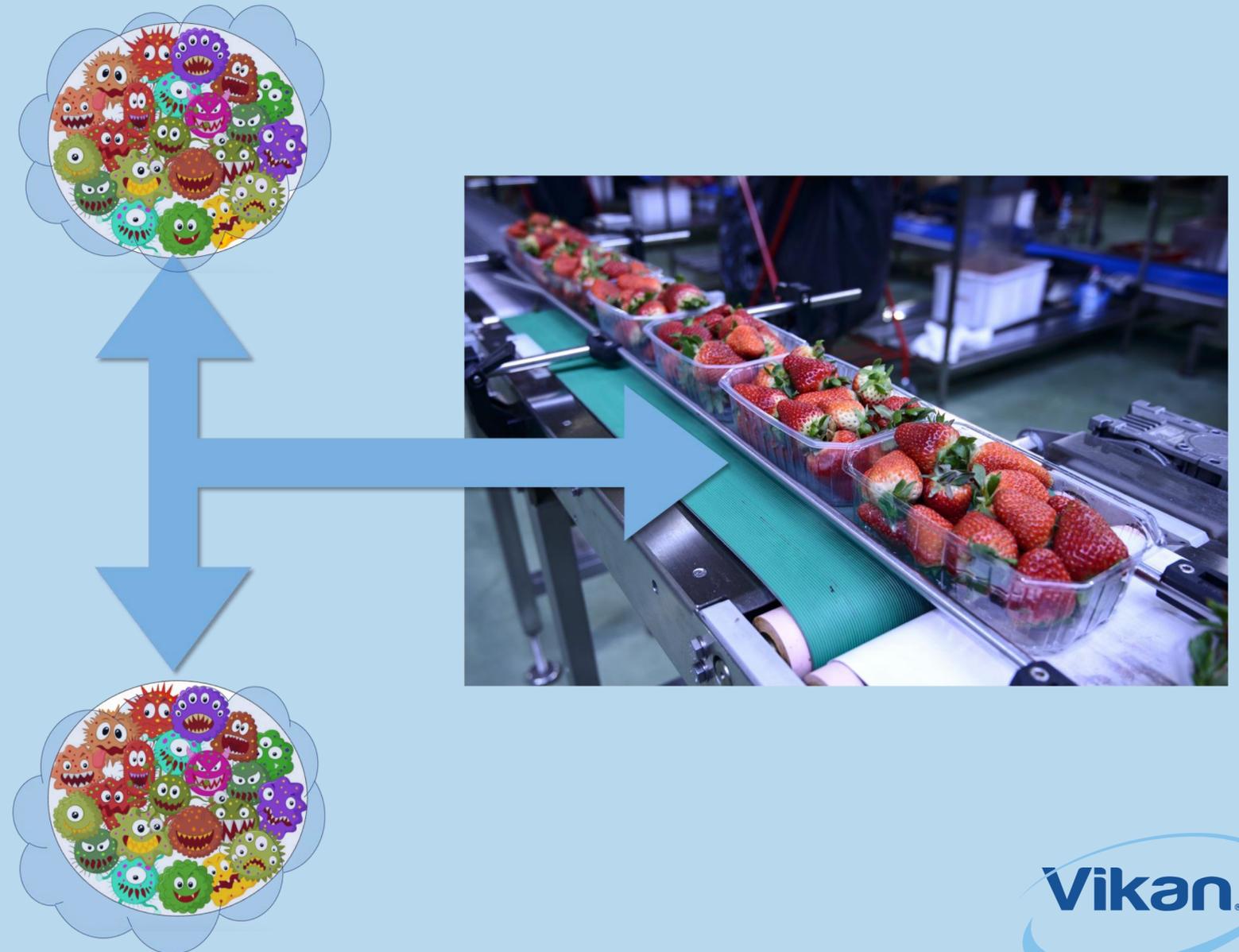
Courtesy of Campden BRI



Selection of decontamination method

Cleaning activities can lead to product cross-contamination and aid the transfer of biofilms

- Choose cleaning equipment and methods that maximise contamination removal and minimise its spread
- Don't clean / minimise cleaning during production
- Clean things as far away as possible from open product (spacial segregation)
- Clean in physically segregated areas to protect product from splashes etc. (separate cleaning rooms / screens)



Hygienic design

Equipment needs to:

- Be easy to clean (and dry)
 - absence of holes, recesses, crevices, contamination traps, sharp internal angles and difficult to clean areas
- Be of one piece construction or easy to dismantle and re-assemble
- Have a smooth surface finish
- Have no paint or coatings
- Be made of appropriate materials
 - Suitable for use in food handling environments, i.e. EU and FDA compliant
 - Temperature and chemical resistant
 - Well constructed and durable



EHEDG Guideline 8 Document
"Hygienic Design Principles",
see,
<https://www.ehedg.org/guidelines/free-documents/>



Bad hygienic design / poor maintenance



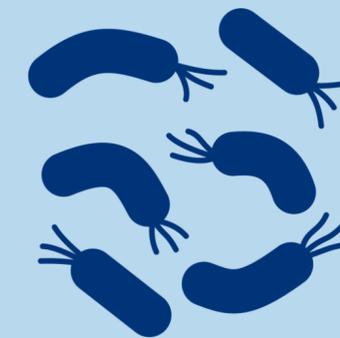
Courtesy of: Dr. Cath Rees, The University of Nottingham

Bad hygienic design / poor maintenance



Cleaning equipment and utensils as a source of Listeria

- Campden BRI¹
- 47% of cleaning equipment
- Schäfer²
- 67% of equipment and utensils used in a poultry processing plant were contaminated with *L. mono*, even after cleaning.



1. Holah, J.T. (1998). Effective microbiological sampling of food processing areas. Guideline No. 20, Campden & Chorleywood Food Research Association.

2. Schäfer, D., Steffens, J., Barbosa, J., Jamile Z., Rogério L. C. (2017). Monitoring of contamination sources of Listeria monocytogenes in a poultry slaughterhouse. LWT – Food Science & Technology. Dec 2017, Vol. 86, p. 393-398.

Good hygienic design

Global food safety standard requirements

New GFSI Benchmarking requirements on Hygienic Design

- https://mygfsi.com/news_updates/built-in-hygiene-from-farm-to-fork-an-update-from-the-gfsi-technical-working-group-on-hygienic-design/
- BRCv8 Global Standard for Food Safety
 - 4.11.6. *'cleaning equipment should be hygienically designed'*
- FSSC 22000
 - ISO/TS 22002-1:2009 (2013) Prerequisite programmes on food safety Part 1: Food manufacturing
 - 11.2 *Cleaning and sanitising agents and tools:*
 - *'Tools and equipment shall be of hygienic design...'*

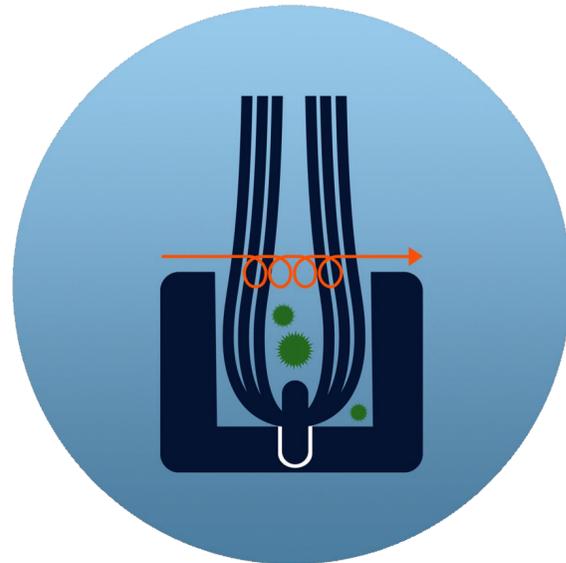


BRCv8

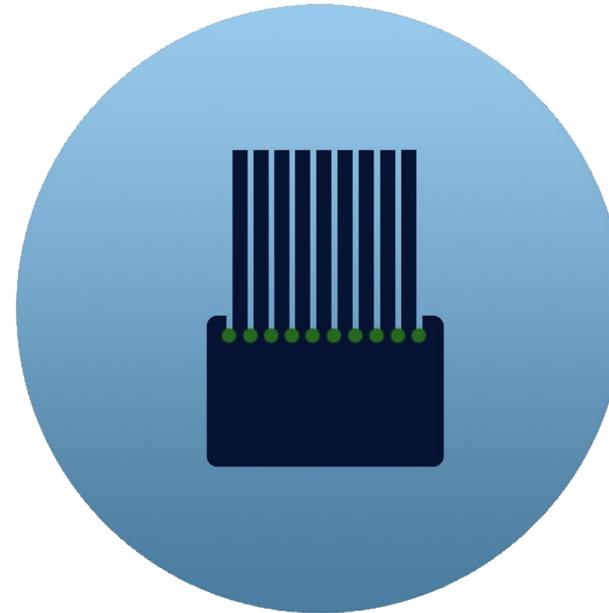
The logo for FSSC 22000, featuring a stylized green and grey circular graphic to the left of the text 'FSSC 22000'.



Good hygienic design



Drilled and stapled construction



Fully moulded construction



Guideline 44: (2014)
Hygienic Design Principles
for Food Factories
Site location; construction
and placement of lighting,
doors, windows, walls,
floors, ceilings, drainage
systems



Good maintenance

Regular decontamination, inspection, replacement and maintenance of equipment and facilities



Clause 11.3 Cleaning and sanitizing programmes:

- Cleaning and sanitising programmes shall be established and validated by the organisation to ensure that all parts of the establishment and equipment are cleaned and/or sanitised to a defined schedule, including the cleaning of cleaning equipment.



<http://viewer.ipaper.io/vikan/white-papers/cleaning-tool-maintenance/cleaning-tool-maintenance-whitepaper-en-300/#/>

Top tips for biofilm control

1. Understand your biofilm challenges (as much as you can!)
 - where and how biofilms are formed
 - why they are such a problem
2. Back to basics
 - understand the decontamination process
 - cleaning is an essential pre-requisite to disinfection
3. Use appropriate controls
 - methods
 - equipment
 - chemicals
4. Understand the importance of
 - hygienic design
 - regular decontamination, inspection, replacement and maintenance of equipment and facilities.



Further information about biofilms and their control

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