Bacterial transmission

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chapter **ONE**

General introduction

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(submitted)

Bacterial Transmission

The biofilm mode of growth is greatly preferred by most bacterial strains and species [1,2]. The sequence of events leading to biofilm formation is generally considered to commence with bacterial transport by convective-diffusion from a liquid suspension of planktonic bacteria to a substratum surface or impingement from aerosols **(see Figure 1)** [3].

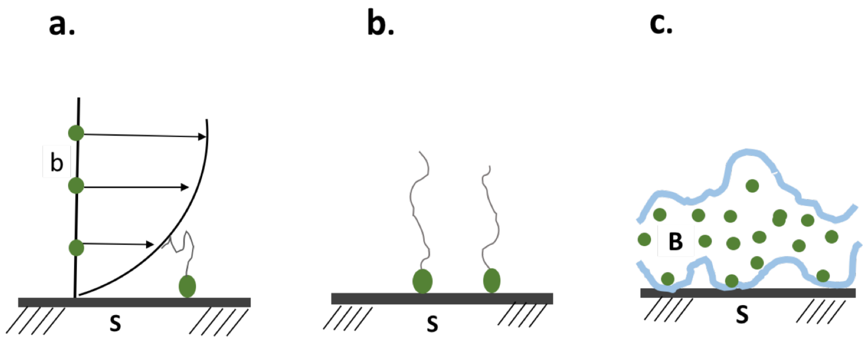

Figure 1. Transport in bacterial adhesion to a substratum surface and biofilm growth.
(a) Bacterial transport from a flowing suspension by convective-diffusion.
(b) Bacterial transport by impingement from aerosols.
(c) A multilayered biofilm resulting from growth of adhering bacteria.

Initially, bacterial adhesion is reversible, but production of extracellular polymeric substances (EPS) can rapidly lead to an irreversible state and subsequent growth of a bacterial (sub)monolayer into a multilayered biofilm. Transmission of sessile bacteria from one substrate to another is a less commonly highlighted means of bacterial transport, but equally if not more prevalent in many environments. Bacterial transmission frequently occurs in hospital environments and nursing homes among hands of healthcare workers [4] and patients [5,6]. Bacterial transmission also occurs during insertion of indwelling urinary [7] or vascular catheters, either from the peri-urethral area or subcutaneous layers of the skin [8,9], respectively and similarly may occur towards endoscopes [10,11]. Transmission of microorganisms from contaminated lens cases to contact lenses followed by transmission to human cornea is a well-known cause of microbial keratitis, posing a general healthcare threat due to the large number of people wearing contact lenses [12,13]. Toothbrushes are mentioned more and more as a source for microbial transmission [14,15]. Also in the domestic environment transmission is inevitable, but usually involves less pathogenic microorganisms than present in biomedical environments [16,17]. Finally, bacterial transmission occurs in industrial environments, including slaughterhouses [18,19], agriculture [20,21], forest [22,23] and sea-water environments [24,25].

Mechanism of Bacterial Transmission

Mechanistically different from bacterial adhesion, transmission involves adhesion of donor bacteria to a receiver surface and subsequent detachment from the donor surface [26,27] , a complicated process that will be influenced by intrinsic factors such as the bacterial species involved [28,29], and environmental factors, like the properties of both the donating and the receiving surfaces [30,31], contact time, moisture level [26] and the application of friction and pressure [32]. Although inherently more complex than adhesion, bacterial transmission can be described according to similar surface thermodynamic principles as microbial adhesion to surfaces [33]. As a result of these considerations, a hydrophobic surface reduces the ability of hydrophilic bacteria to adhere closely to the surface, leading to a higher bacterial transmission from a donor [34]. However, hydrophobic bacteria adhere more strongly to hydrophobic surfaces than hydrophilic ones, leading to less transmission [35]. In addition to hydrophobicity, also surface roughness and structure is generally considered as a key factor in bacterial adhesion and therewith in bacterial transmission. A smooth surface supports more contact area between receiving and donating surfaces, and therewith creates a higher transmission [27]. Although many factors are influential upon bacterial transmission, it is important to distinguish between transmission from a donor surface contaminated with a (sub)monolayer of adhering bacteria **(Figure 2a)** or from a donor surface fully covered with a multilayered bacterial biofilm **(Figure 2b)**.

In the latter case, transmission from a donor surface can occur either through cohesive failure in the biofilm or interfacial failure at the donor-biofilm interface. As EPS molecules can act as bridging molecules between donor and receiver surfaces they thus affect transmission depending on the balance between the cohesive strength and the adhesion force on either the donor or the receiver.

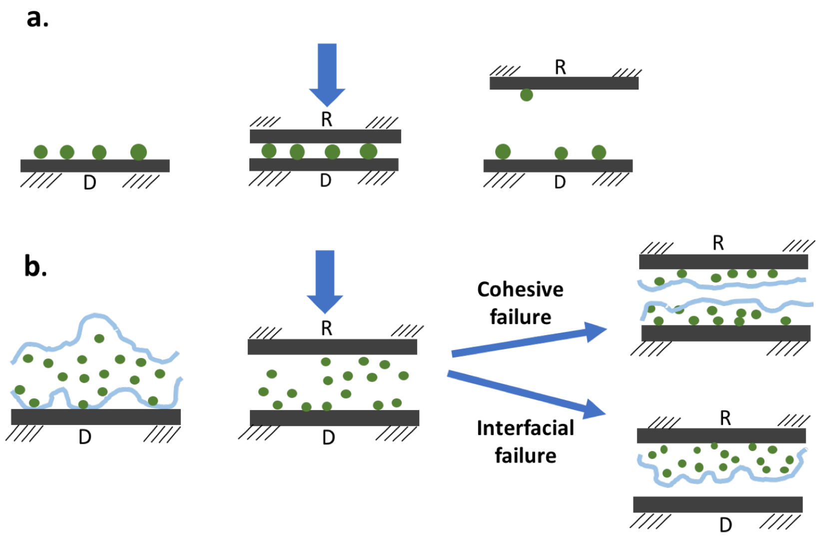

Figure 2. Distinction between bacterial transmission from a (sub) monolayer of contaminating bacteria *versus* transmission from a multilayered biofilm.
(a) Transmission from a bacterial (sub)monolayer, involving interfacial failure at the donor-bacterium interface.
(b) Transmission of bacteria from a multilayered biofilm, involving either cohesive failure in the biofilm (b1) or interfacial failure at the donor-biofilm interface (b2).

Aim of The Thesis

The aim of this thesis is to study the effect of various environmental and intrinsic factors on bacterial transmission from a donor surface covered with a multilayered bacterial biofilm. The main environmental factors studied are the surface (nano-)structure of receiving surfaces and the pressure and shear forces applied during transmission. The main intrinsic factors are the bacterial species and in particular the impact of the visco-elastic properties of the EPS matrix on biofilm transmission.

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