Bacterial biofilms and disease

Bacterial Biofilms and Disease A bacterial biofilm is a structured community of bacterial cells enclosed within a self-produced polymeric matrix and sticking to an unmoving or living surface (Costerton, Stewart, & Greenberg, 1999). Bacterial biofilms are present mostly in wet surfaces and are visible to the naked eye. In 1970s, it was found that sessile (attached or immobile) bacteria make up a major portion of the bacterial biofilms in many environments. Bacterial biofilms consist of microcolonies on a surface and develop into organized communities with functional heterogeneity (Figure 1). Different bacterial species specifically attach to different surfaces and could aggregate with other species or a combination of species.

The organization and structure of biofilms are elaborate. Channels are present for the circulation of nutrients. The different regions show different expression of genes, pointing to functional heterogeneity. Sessile or attached biofilm communities can give rise to nonsessile microbes that can rapidly multiply and disperse. Thus, bacterial biofilms are not easily eradicated by conventional antibiotic therapy, which can lead to chronic bacterial infections.

Some biofilms have beneficial effects, i. e. the prevention of colonisation of tissues by exogenous pathogens (" colonisation resistance"). Biofilms prevent pathogen colonisation is due to the production of acids, hydrogen peroxide, biosurfactants. In some cases, the disappearance of protective biofilm indicates the presence exogenous pathogens. Dental plaque, found on teeth surface also protects by the same mechanism. The proliferation of biofilms in certain cases can result in biofilm that can cause medical diseases such as caries, gingivitis, and periodontitis.

Aside from oral infections, use of implantable medical devices and

impairment in the individual’s host defence mechanism results in biofilm diseases. Acute infections can be treated effectively with antibiotics except those that are caused by antibiotic resistant strains. However, many infectious diseases are caused by bacterial species by bacteria that are common in the environment or are living in the human bodies. However, more than half of the infectious diseases that affect mildly compromised individuals involve bacterial species that are commensal with the human body or are common in our environments. Surfaces of medical devices that are used in diagnosing or treating bacterial infections can harbour the presence of slime-encased bacteria (Table 1 and Figure 2). Chronic bacterial infections that are not device-related also show the presence of biofilm bacteria surrounded by an exopolysaccharide matrix. These biofilm infections may be caused by a single species or by a mixture of species of bacteria or fungi.

Biofilm infections are difficult to treat. Growth is normally slow and obvious symptoms are not readily observed. In living tissue, sessile bacteria release antigens resulting in antibody production, which are not effective in killing the bacteria in the biofilms. The host defence mechanism is rarely capable of clearing the bacteria. Planktonic (mobile) cells can be killed by regular antibiotics but the biofilm is not affected, and infections can be recurring until the sessile population is removed by surgery. The capacity of the biofilm to escape antimicrobial effects could be due to several mechanisms. One mechanism proposed for biofilm resistance to antibiotics is the inability of an immune agent to penetrate the depth of the biofilm. The polymeric substances in the biofilm matrix impede diffusion of antibiotics although some antibiotics can penetrate biofilms readily in some cases, depending on

the biofilm and immune agent.

Another hypothesis, which can explain reduced biofilm susceptibility to antibiotics, is that the bacteria in the biofilm are starved for nutrients and thus exist as slow-growing bacteria. Slow-growing cells are not susceptible to antimicrobial agents. The heterogeneity of biofilm structure is an important survival strategy during an attack.

The challenge is to come up with therapies that can combat the diseases brought by biofilm. The current understanding of its molecular structure gives an insight as to what needs to be done. Areas that need to be met are as follows: development of antibiotics that can defeat the phenotypic traits of the biofilm, and the interaction of the community members of the biofilm. These techniques are the prevention and promotion of the detachment of the biofilm from environmental surfaces and human tissues.

Table 1. Partial list of bacterial diseases from biofilms (Costerton, Stewart, & Greenberg, 1999).

Figure 1. The biofilm life cycle, from the Biofilm hypertext book of the Montana State University Center for Biofilm Engineering. (1) individual cells populate the surface; (2) extracellular polymeric substances are produced and attachment becomes permanent; (3 and 4) the biofilm structure develops, grows and expands; (5) single cells are released from the biofilm, which could proceed to attach to other surfaces.

Figure 2. Bacterial biofilm found on a catheter. (From www. cdc. gov)

General References

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