Synthetic polymers to generate artificial biofilms to study oral microbiome

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MOTIVATION

The microbiome is being appreciated as a major contributor to oral and general health. Natural biofilms consist of an extracellular polymeric matrix that takes days to weeks to develop and mature. This has been a major limitation to their lab analyses.

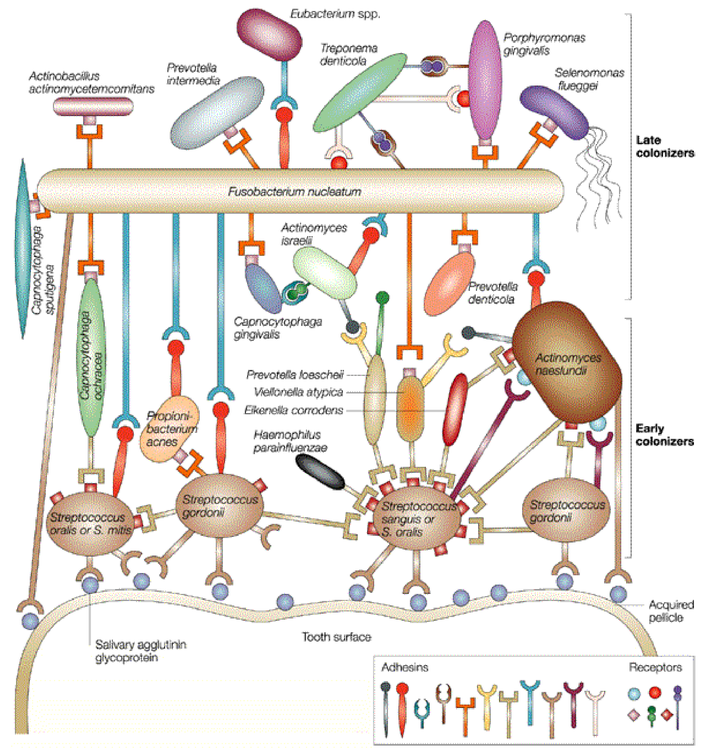
METHODS

Microbes

Our project deals with six types of oral bacteria: *Streptococcus mutans*, *Streptococcus gordonii*, *Moraxella catarrhalis, Fusobacterium nucleatum*, *Porphyromonas gingivalis*, and *Escherichia coli*. Our objective is to utilize synthetic polymers to instantly generate naturally occurring biofilms to study the role of these bacteria in health and disease states.

Electrospinning

Using electrospinning, a synthetic extracellular matrix using polymers polycaprolactone (PCL) and poly lactic-co-glycolic acid (PLGA) mixed with Alginate (anionic polysaccharide) or carboxymethyl cellulose (CMC) will be utilized. The Alginate and CMC allow for attachment of microbes via adhesive extracellular matrix proteins. However, they cannot be electrospun alone and hence, require combinations with PCL or PGLA.

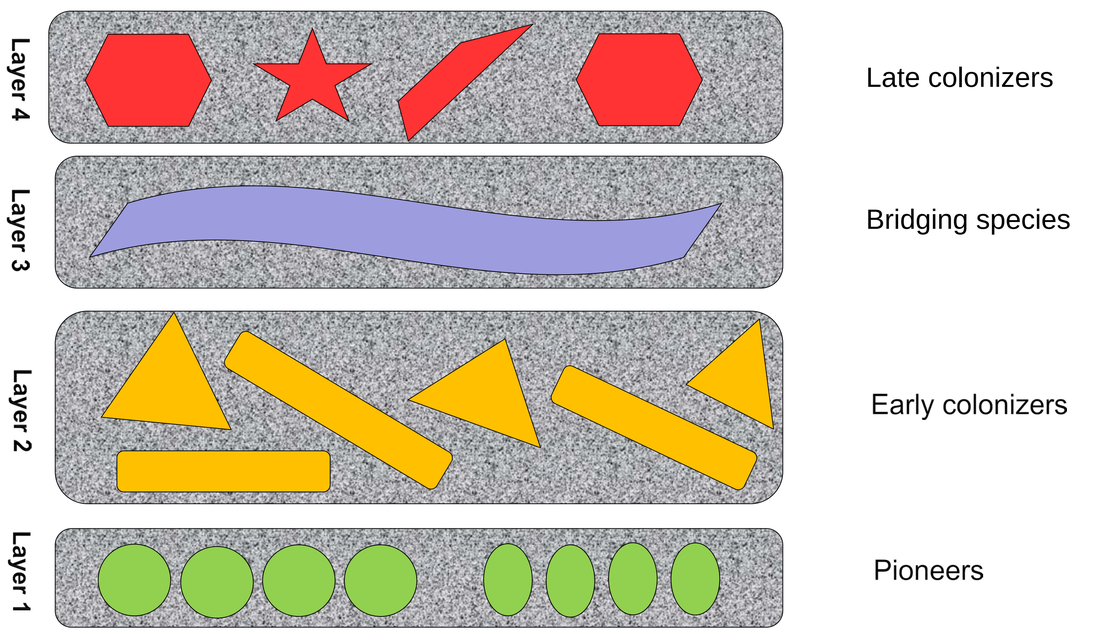


Mimicking a Natural Biofilm

A natural biofilm goes through the following succession.

1. Individual bacteria bind to a protein layer. On a tooth, this protein layer originates from saliva or crevicular fluid.
2. Pioneering bacteria multiply, creating microcolonies of a single species. These bacteria are usually streptococci.
3. Early colonizers attach to the pioneers by coaggregation. The molecules used for coaggregation are usually lectin and a carbohydrate receptor.
4. Bridging species arrive and bind to early colonizers.
5. Late colonizers bind to bridging species.

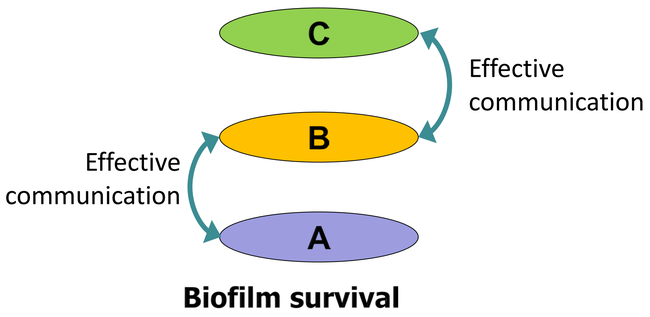
This succession and attachment pattern creates a structure of bacteria seen in the figure above. This natural interwoven structure necessitates the use of electrospinning in making a synthetic biofilm, as opposed to the use of a gelatinous material (alginate or CMC) alone. Electrospun mats will more accurately resemble natural biofilm succession because it will allow the bacteria to be layered after the maturation of the pioneering bacteria and early colonizers.

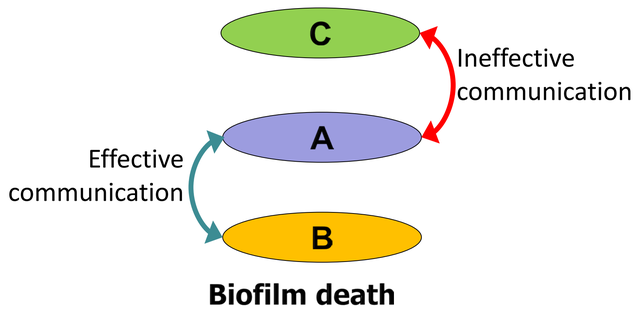


APPLICATIONS

Succession Therapy

We will utilize the electrospun mats with microbes in an origami manner in different combinations. It is very likely that communication between two adjacent layers can be made either impossible or ineffective (Probiotic approach), causing death of the biofilm.





Antimicrobial Photodynamic Therapy

Creating a synthetic biofilm improves both the accuracy and efficiency of biofilm research. It will aid in another major project in the lab that aims to manipulate a *diseased* biofilm to a *healthy* state.

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