

Institute of Microbiology shows

TRACING THE CRIMINAL



Part Twelve:

Criminal in a Organized Group

Bacterial biofilm

Survey of topics

Clinical cases related to biofilm

Characterisation of biofilm

Diagnostic and experimental method for biofilm

Pictures of biofilm

Clinical cases related to biofilm

Story one (today a real one)

- Male, 58 let, 2001 cardiostimulator, 2002 repeatedly hospitalized on an internal department with **fever of unknown origin**, elevation of inflammatory markers
 - In **blood cultures**, *S. epidermidis*, very good susceptibility
 - Several times treated by **high doses of antibiotics in combinations** (oxacilin, gentamicin, rifampicin, cafazolin, cefalotin, clindamycin)
-

Story – contiuing

- In the beginning, a good response, later **attacks of fever again**
- At transoesophageal examination, **vegetation on a chamber electrode** sized 1,5 × 1,5 cm.
- Cardiologists repeatedly **refuse cardiostimulator removal**. A combination **oxacilin + gentamicine + rifampicine**, patient in a good state.
- Nevertheless, again **temperature and CRP rises**. **Vancomycin and rifampicin** starts to be used, after improval, patient's **trombus is removed** and the **electrode changed** (under antibiotics), so the patient starts to be better.

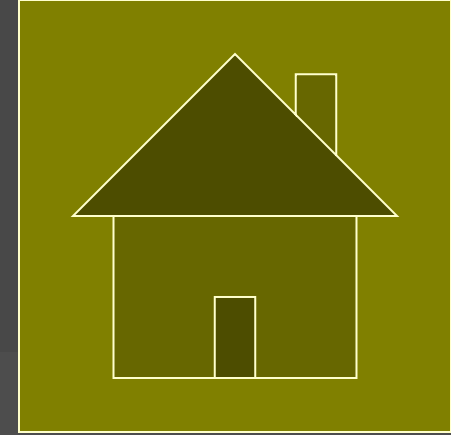
Who is guilty? The biofilm!!!

- The therapy could not be successful, because **high resistance of bacteria growing in form of a biofilm** was not taken into account.
 - The therapy was not strong enough from the beginning and **the biofilm was not eradicated**.
 - Only **electrod removal** (under antibiotic therapy) enabled **patient status improvement**.
-

Story two

- Michal was a **13-year old boy**. He hated his parents and he decided to do anything against them.
- He decided that one of methods to fight them could be to resist everything his parents insist on him to do.
- So he decided to **stop cleaning his teeth**, keeping order in his room and some more activities like that.
- But very soon, a **toothache** started. He had to visit a dentist. The dentist said he has a **severe dental caries**. She repaired his teeth, but also wanted him to clean his teeth again, otherwise he would have problems again – not only with her (and other „come-back-to-your-grave generation), but mostly with his own teeth.

The criminal agent was



- ...an overgrown biofilm again.
- **In oral cavity, a biofilm is normal.** It is even useful: the normal oral microflora is organised in it, and so it is more resistant to outer influences, including pathogenic agents
- Nevertheless, too **overgrown biofilm** (as a result of too many sugars eaten and too little teeth cleaning) makes oral biofilm to be an **enemy instead to be a friend** of a patient.

Characterisation of biofilm

Biofilm: what is it?

- A biofilm is a **complex, organised structure**
 - It consists of **living cells** (mostly bacteria) and **masses** produced by them (mostly polysaccharides)
 - It is present not only inside living body, but also **in the environment**. For example stones in ponds and rivers are often covered by a biofilm that makes them smooth.
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Stages of biofilm development

- Direct contact of a planctonic **bacteria** with a **surface**



- **Attachment** to this surface



- **Adhesion, growth, and aggregation** of cells into microcolonies



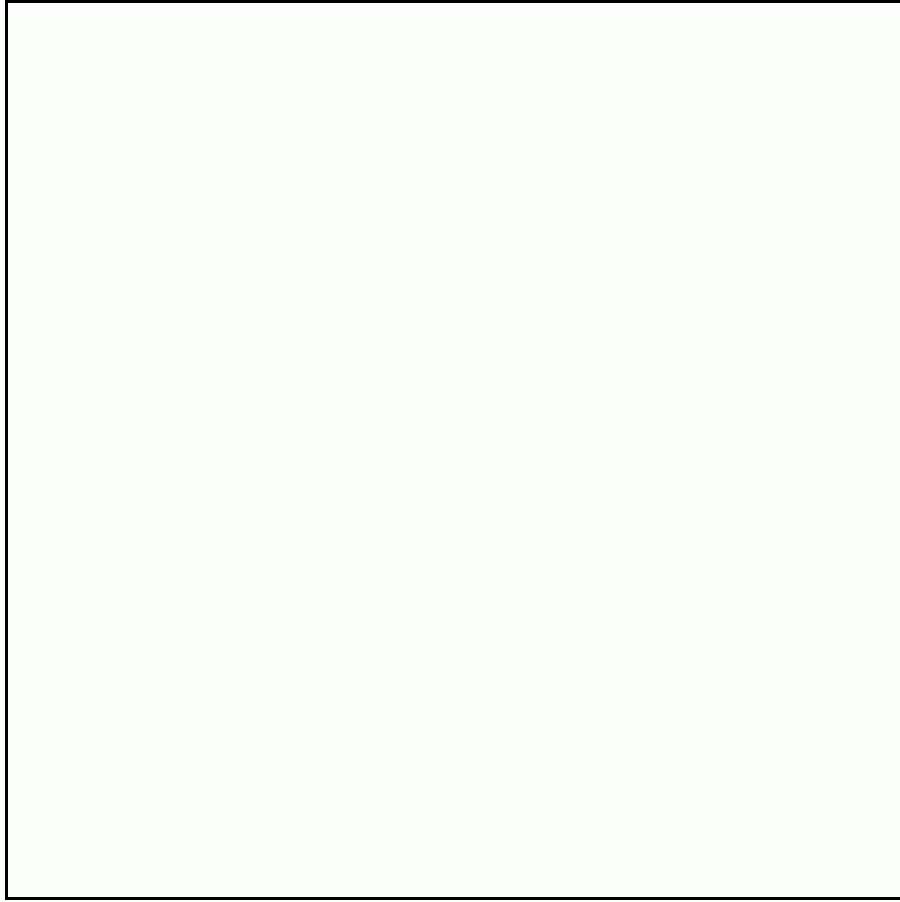
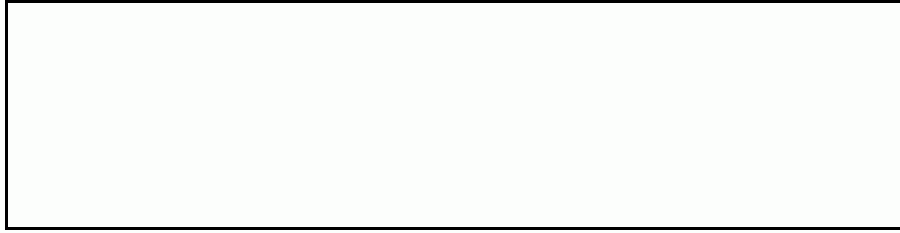
- Production of polymeric **matrix**



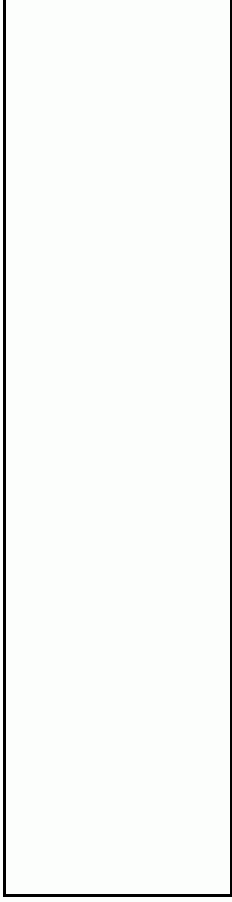
- Formation of three-dimensional structure known as **biofilm**



Development of biofilm – timing



0 h



Importance of biofilm production in bacteria

Bacteria may **better regulate their quantity** – in the biofilm they inform each other by production of various stuffs (quorum sensing)

Bacteria become **more resistant to outer influences**:

- disinfectants
- antibiotics
- host immunity response

Biofilm is formed both by common flora bacteria (rather positive for macroorganism and by pathogens

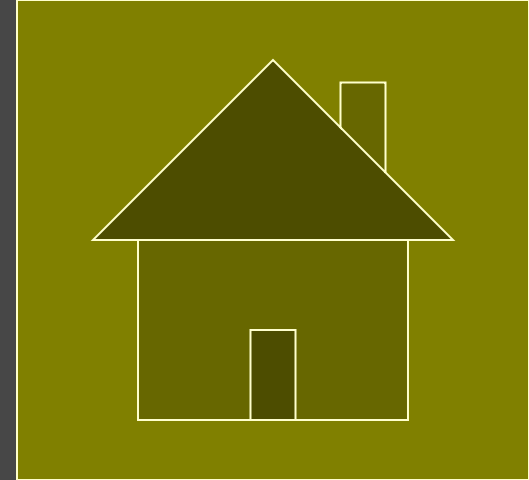
Mechanisms influencing bacterial resistance

- Influence of **surface charge**
 - Decrease of **growth rate**
 - **Penetration barriere**
 - Non-homogenous matrix
 - **Fenotypic differences**
 - **Intercelular signalisation**
 - **Immunity mechanizms...**
-

Biofilm eradication

- Antibiotic therapy often only suppresses symptoms of infection caused by cells released from biofilm matrix and reacting with immunity system. Cells fixed in biofilm matrix cannot be destroyed by such therapy.
- To biofilm eradication it is possible to use high ATB concentrations (monotherapy or combinations), when treatment is not effective, the biofilm focus should be removed.

Prevention



- Catheters and bone cements with **antimicrobial substances**, e. g.
 - minocycline
 - rifampicine
 - Catheter washing
 - Correct asepsis, decontamination methods etc.
-

Diagnostic and experimental methods for biofilm

Diagnostic possibilities

- Biogilm detection by fenotypic methods (Christensen's method, Congo red agar cultivation)



Photo: Archive of Veronika Holá



- Biofilm detection by genetic methods
- Assessment of bacterial susceptibility in biofilm to individual antibiotics (MBIC, MBEC)

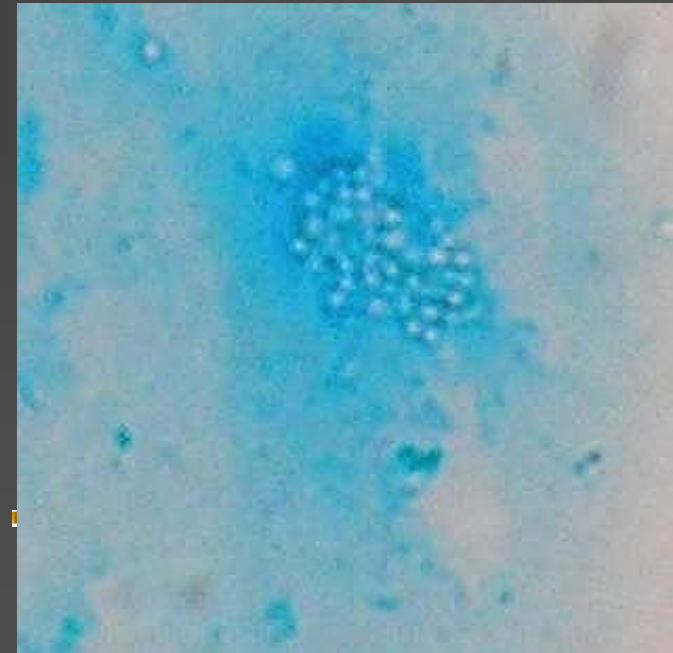
Microscopy of oral biofilm

Besides official methods for biofilm detection there are also other methods how to visualise biofilm.

For oral biofilm:

Gram stain may only visualise cell clusters (both G+ and G-) and eventually macroorganism cells (epitheliae etc.). Polysaccharidic masses remain invisible.

Alciane blue stain enables visualisation of polysaccharic material, i. e. the acellular part of biofilm. Cells are visualized by negative staining.



Proof of influence of tooth cleaning to oral biofilm

Photo: Archive of Veronika Holá



- A volunteer has a iodine solution or pills with a stain effecting to tooth plaque.



- The iodine is let to work in oral cavity during approx. 2 min.

Photo: Archive of Veronika Holá

Culture of biofilm producing bacteria

- In case of likelihood of biofilm formation, it is usually necessary to perform special methods for pre-processing the biological material, that precede the proper culture
 - For central venous catheter culture, there exist two methods. Both of them are better than classical culture in broth without any pre-processing, sonification still remaining better than the Maki method
-

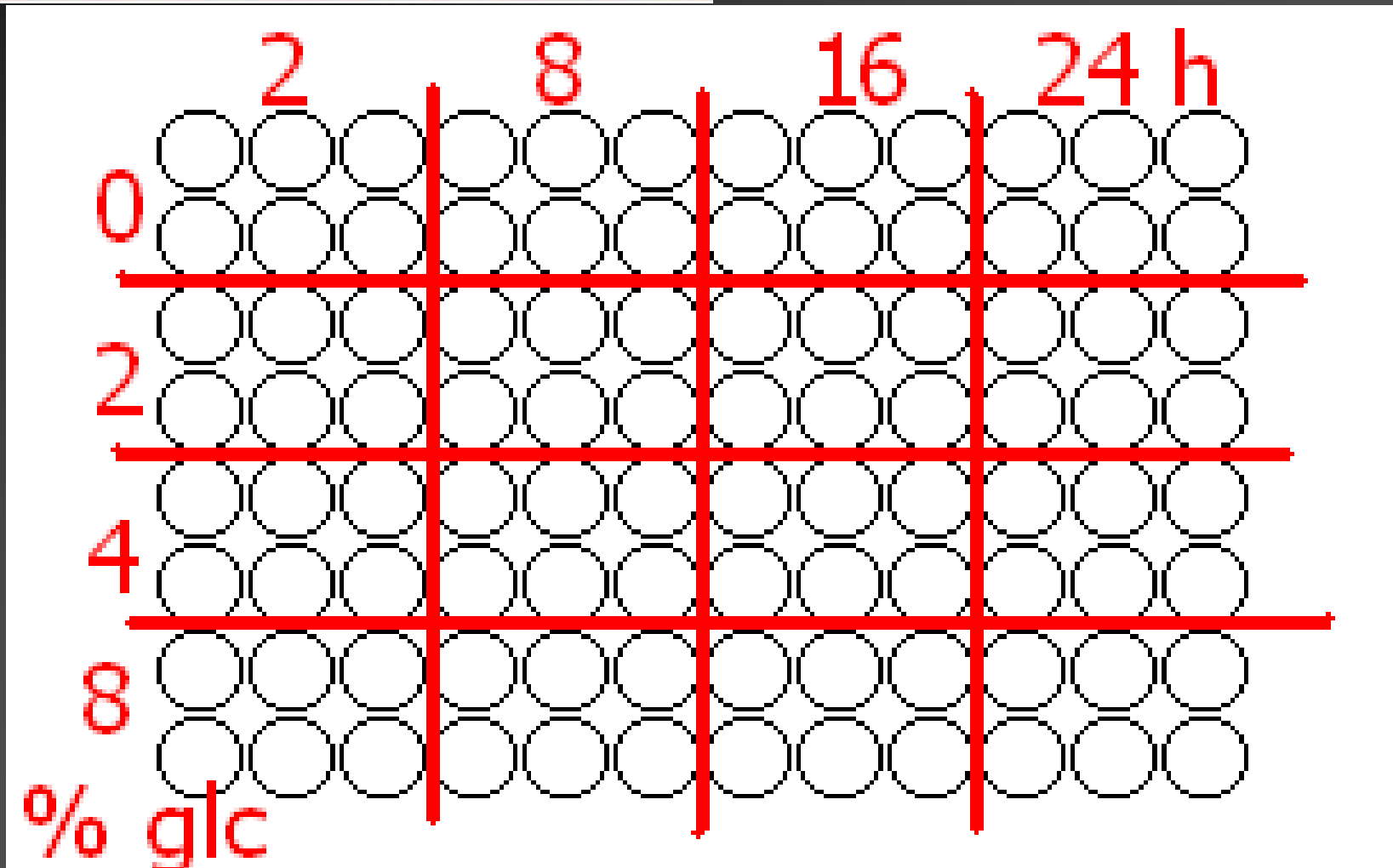
Methods

- **Classical broth culture:** *Bacteria in planktonic form are released. Bacteria in form of a biofilm are released. Bacteria in biofilm form are released less, or not at all. As broth is used as multiplying medium, we know nothing about its quantity (contamination × infection).*
- **Semiquantitative (Maki) method:** It enables us to assess catheter surface and semiquantitatively assess the finding, but we have no information about intraluminal bacteria and bacteria are not necessarily released from the biofilm.
- **Sonification:** destroys biofilm on the catheter surface and catheter lumen. Inoculation of a defined specimen volume is a quantitative method, that enables us to assess microbial amount.

Proof of Influence of saccharides presence to dental plaque formation

- The experiment has a simple principle. One of oral bacteria is cultured on plastic surface (simulating tooth surface) with presence of various concentrations of glucose and for various time value
 - After the incubation, biofilm is visualised using gentiane violet and its density quantified as absorbance using a spectrophotometre
-

To avoid accidental mistake, six adjacent wells have always the same values of both glc concentration and time



Old and new abbreviations in antibiotic effect measuring

MIC – minimal inhibition concentration is the growth limit of bacteria (the lowest concentration that disables bacterial growth)

MBC – minimal bactericidal concentration is the survival limit of bacteria (the lowest concentration that kills bacteria). In viruses, we would use „minimal virucidal“ etc.

MBIC – minimal biofilm inhibiting concentration

MBEC – minimal biofilm eradication concentration

Diagnostic methods

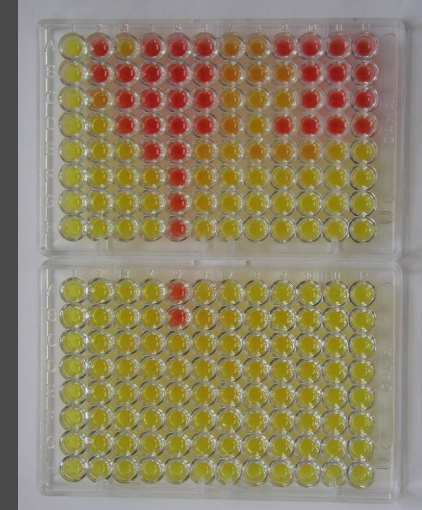
MBEC assessment

MBIC ... minimal
biofilm inhibiting
concentration

MBEC ... minimal
biofilm eradicating
concentration



MIC versus MBEC

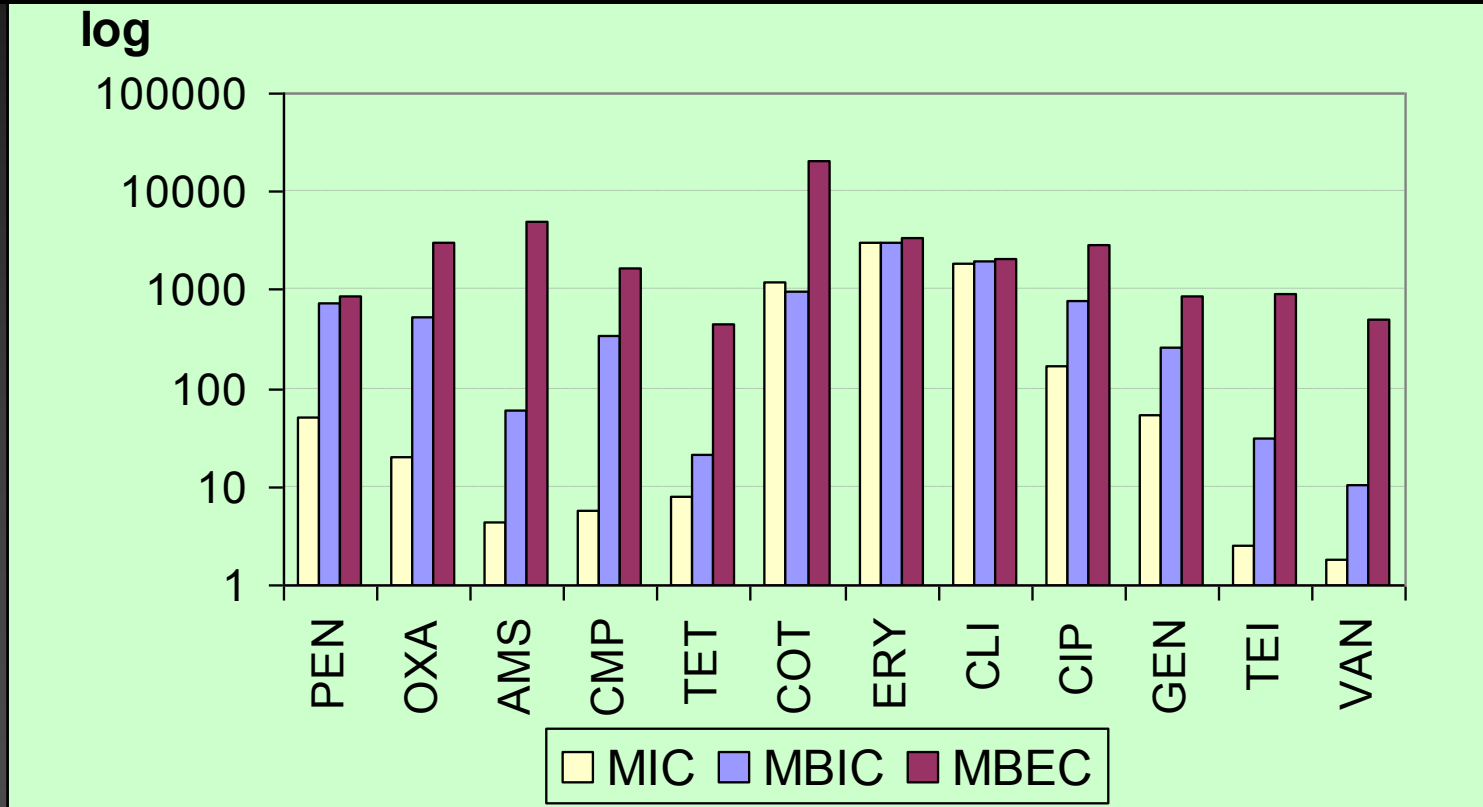


- While MIC determines minimal inhibitory concentration of atb in planktonic form, MBEC shows us if eradication of bacterial biofilm is present.

So it tells us more about effect of antibiotic on normally living bacteria

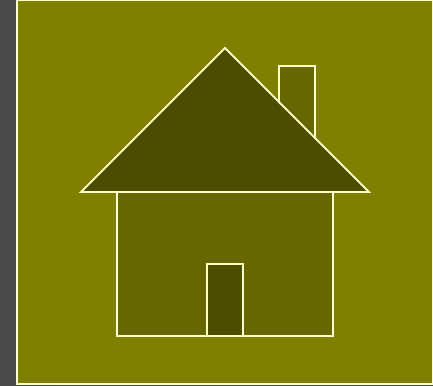
- MBEC corresponds **the lowest concentration of antibiotic, where biofilm eradication is proven** (absence of living cell, no pH medium change, the well remains red)

Differences in MIC, MBIC, MBEC



Abbreviations: pen – penicilin, oxa – oxacilin, ams – ampicilin/sulbactam, cmp – chloramphenicol, tet – tetracycline, cot – co-trimoxazole, ery – erythromycine, cli – clindamycine, cip – ciprofloxacine, gen – gentamicine, tei – teicoplanine, van – vankomycine

Diagnostic methods II.

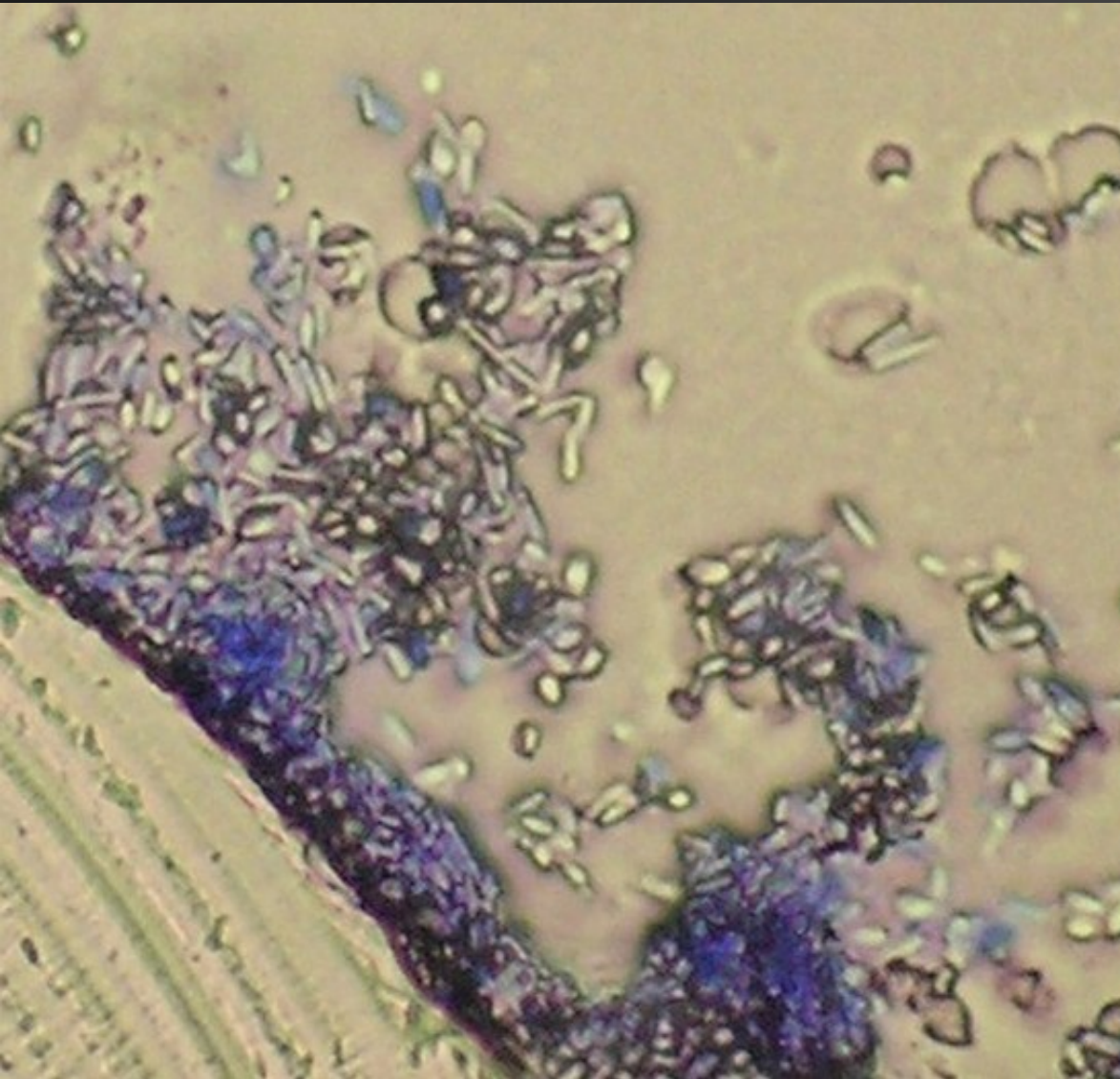


- Values of **MBIC** and **MBEC** are often **over break point** for given antibiotics (bacteria are resistant to them)
 - Values of **MBIC** and **MBEC** are **several times higher than MIC**
 - Microbes in biofilm are usually resistant even to **antibiotic combinations**, the only possibility is then biofilm focus removal (a catheter, joint implants, tooth implants etc.)
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Pictures of biofilm

Pictures of the criminal

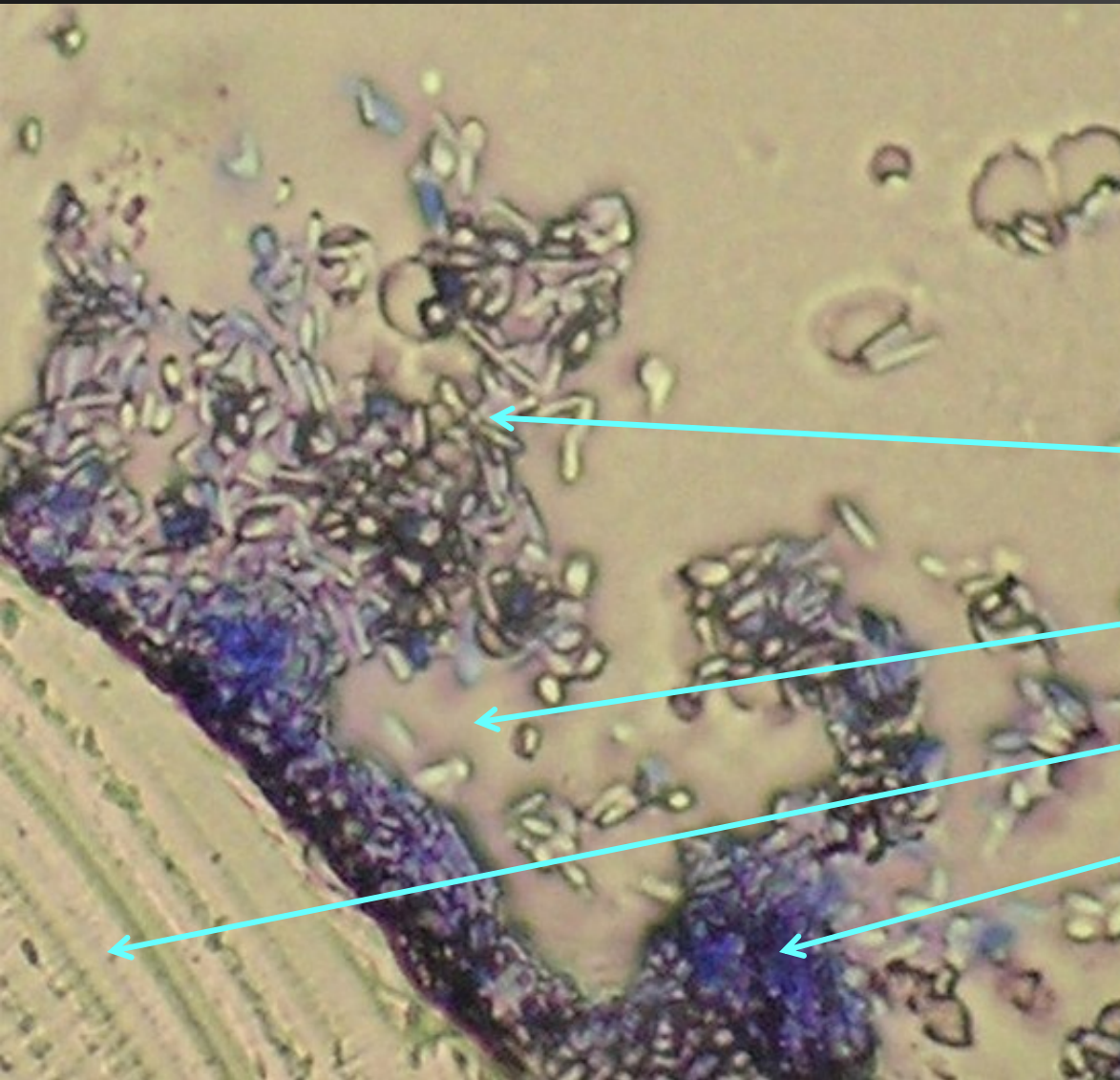
Various pictures of biofilm



Biofilm on a cathetre

Pictures of the criminal

Various pictures of biofilm



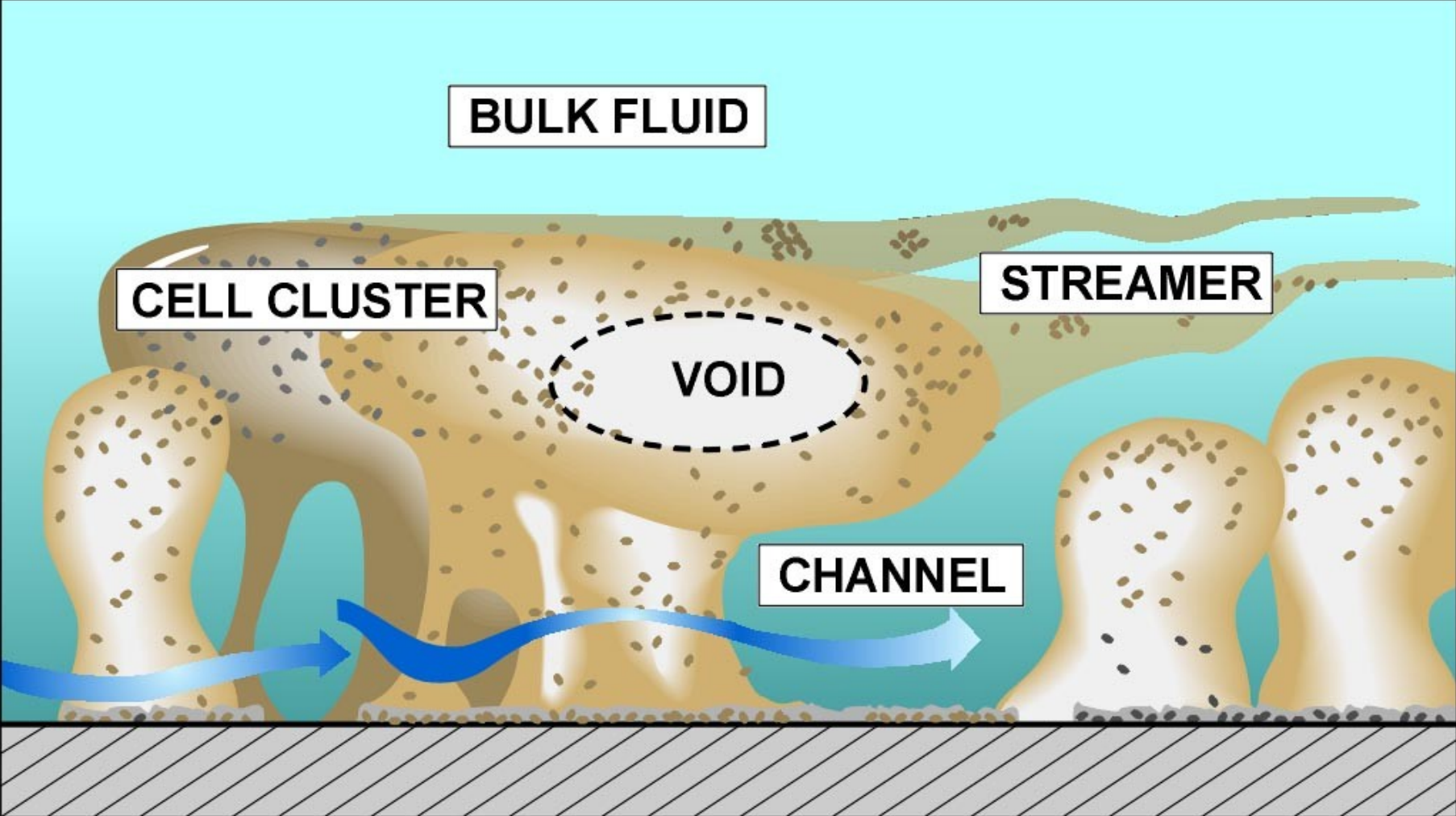
Biofilm on a cathetre

Bacteria

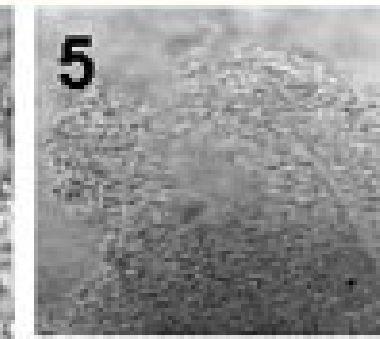
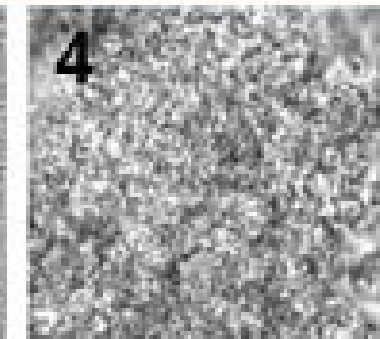
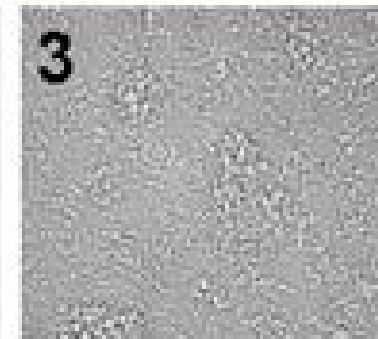
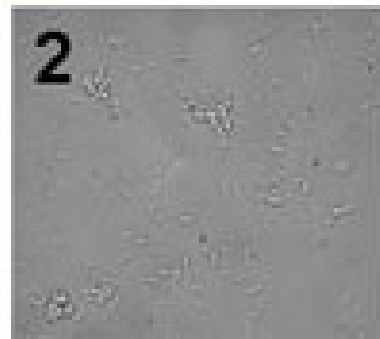
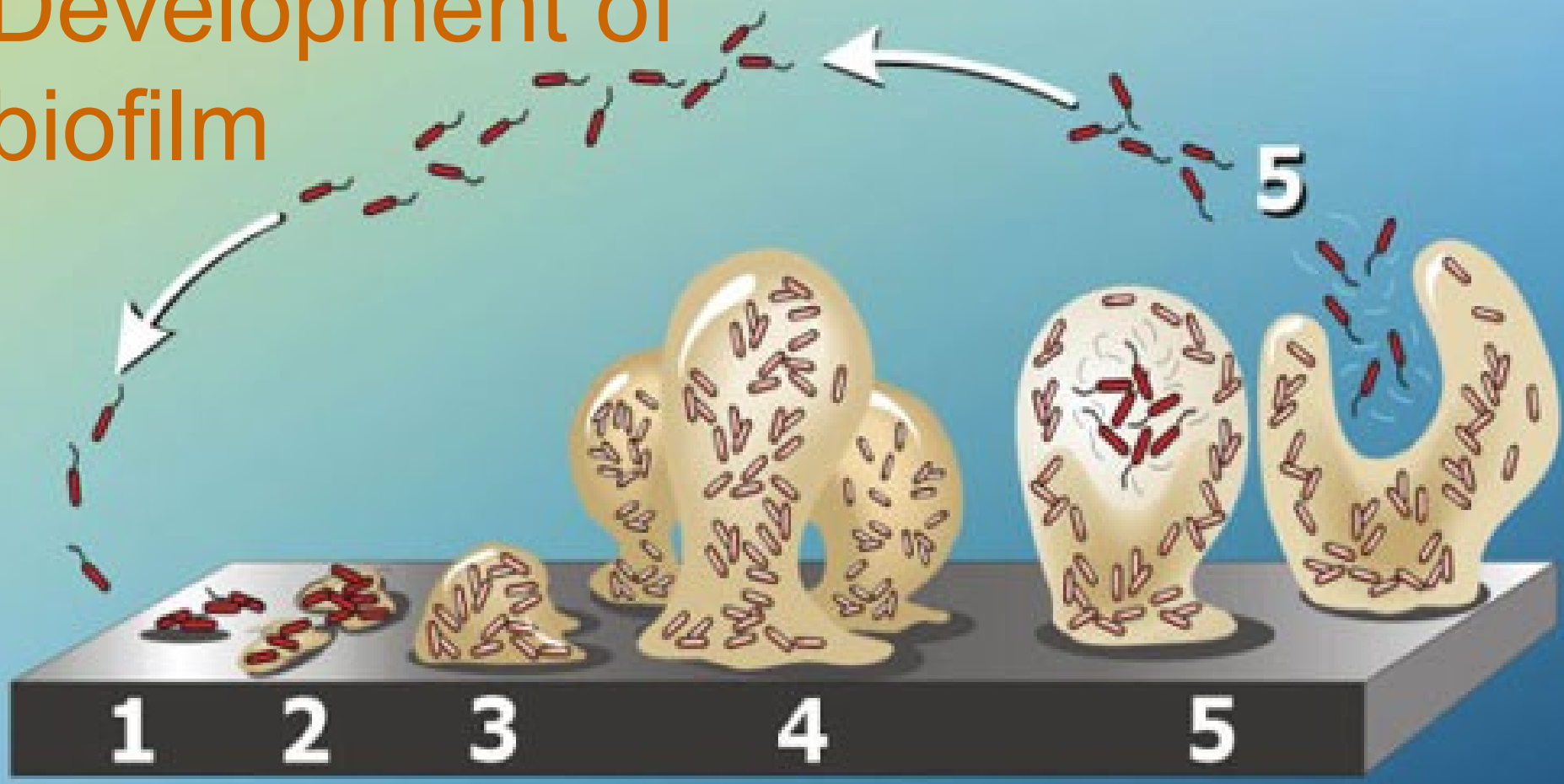
A channell

Catheter

Polysaccharides



Development of biofilm



Biofilm development, another picture

webs.wichita.edu

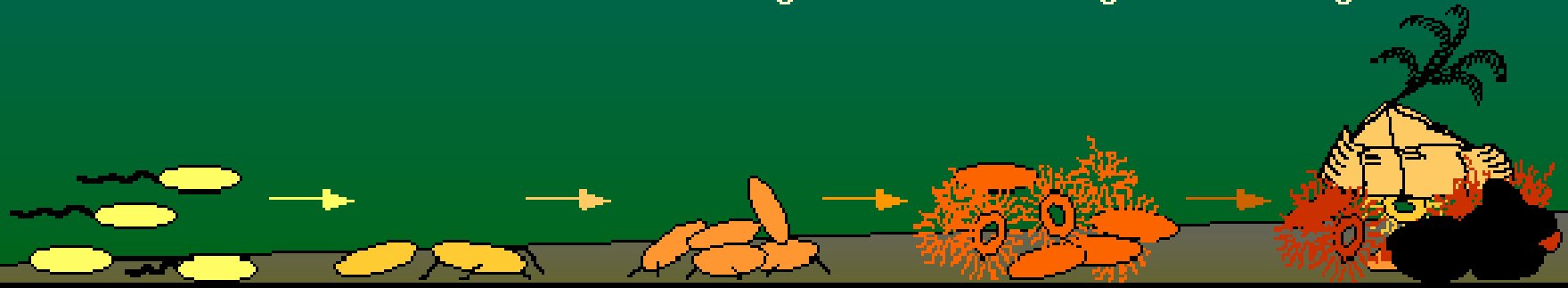
REVERSIBLE
ADSORPTION
OF BACTERIA
(sec.)

IRREVERSIBLE
ATTACHMENT
OF BACTERIA
(sec.-min.)

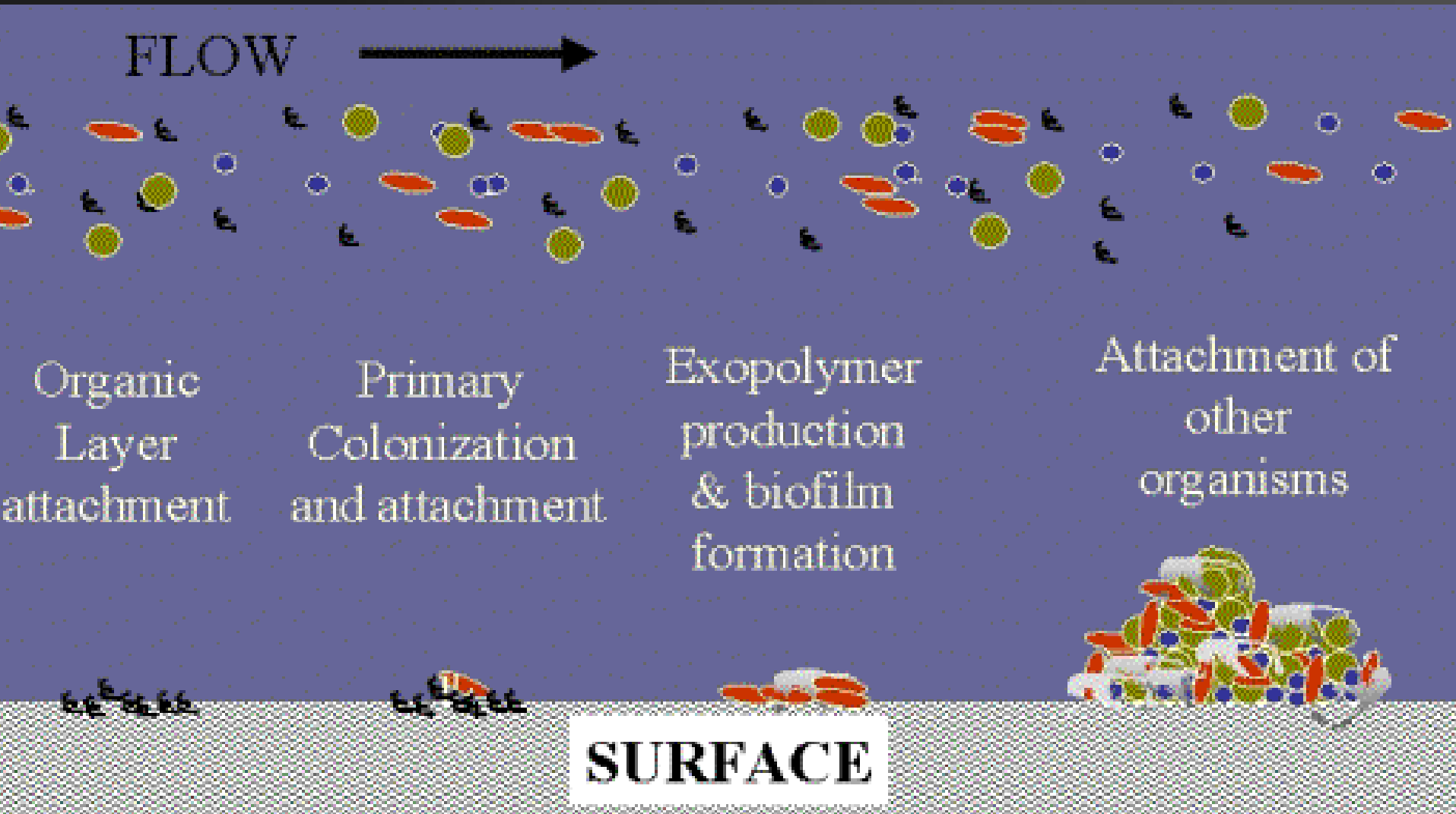
GROWTH &
DIVISION
OF
BACTERIA
(hrs.-days)

EXOPOLYMER
PRODUCTION
& BIOFILM
FORMATION
(hrs.-days)

ATTACHMENT
OF OTHER
ORGANISMS TO
BIOFILM
(days-months)



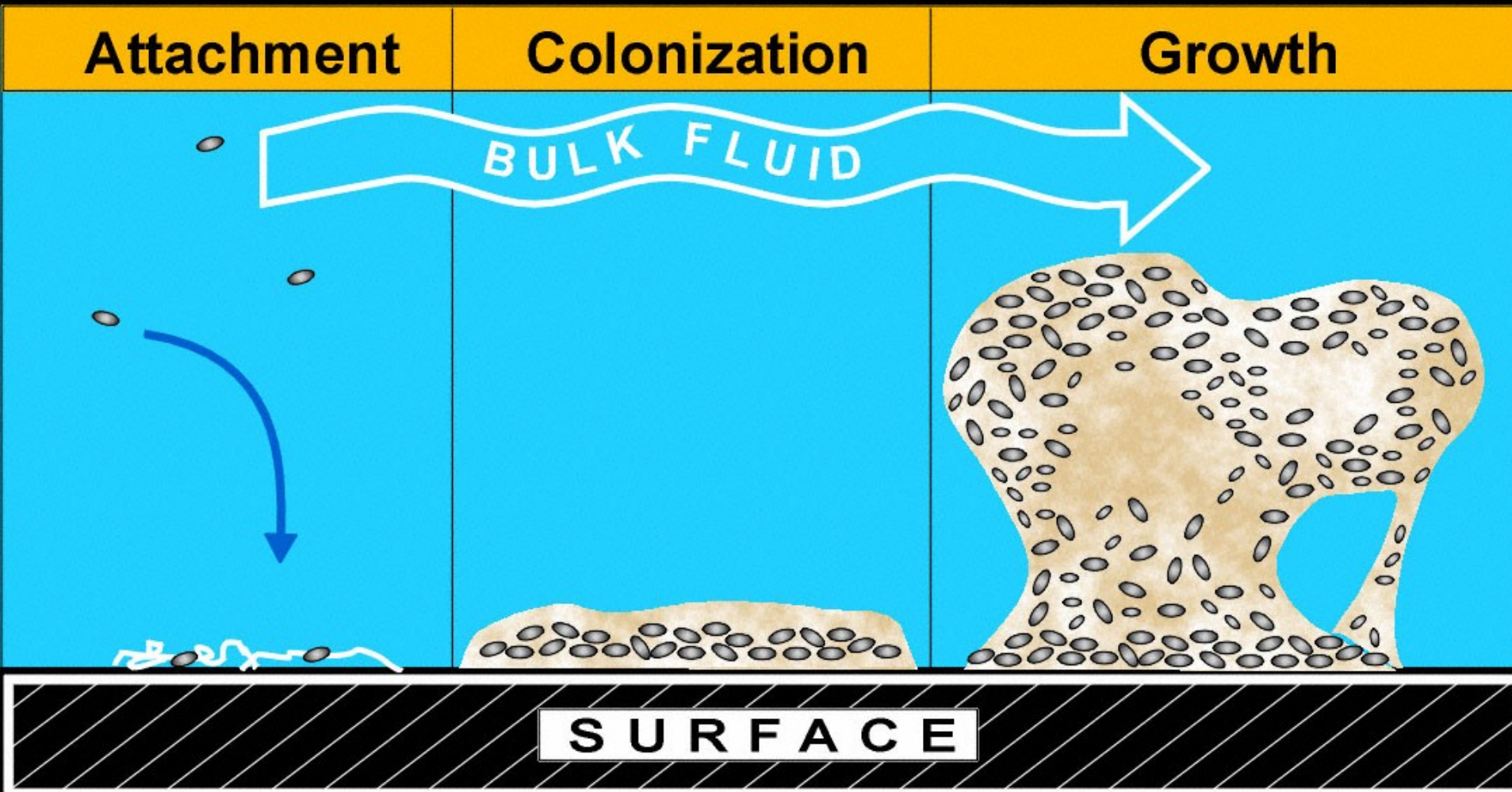
Biofilm development



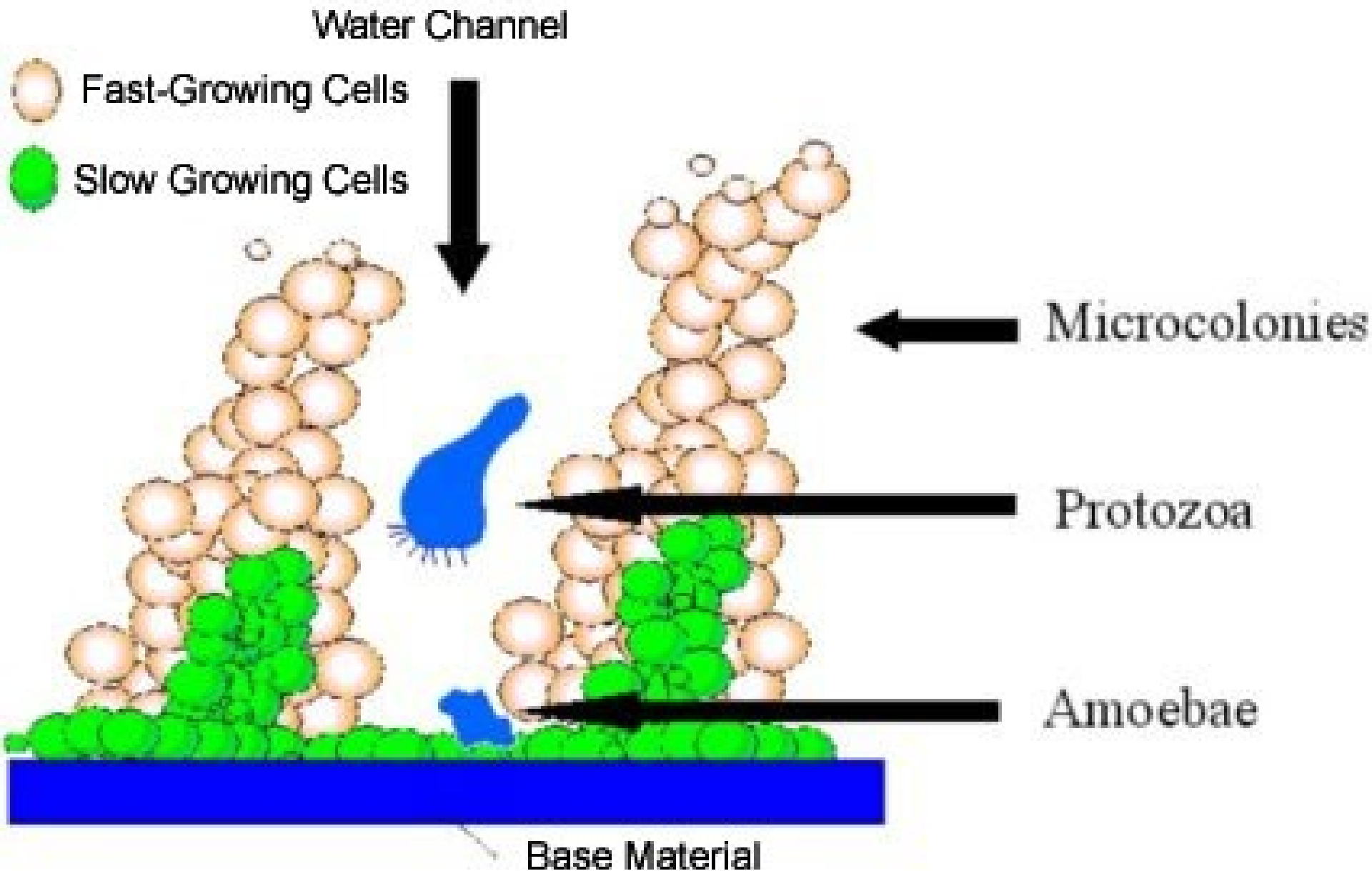
Biofilm formation, another picture

www.uweb.engr.washington.edu

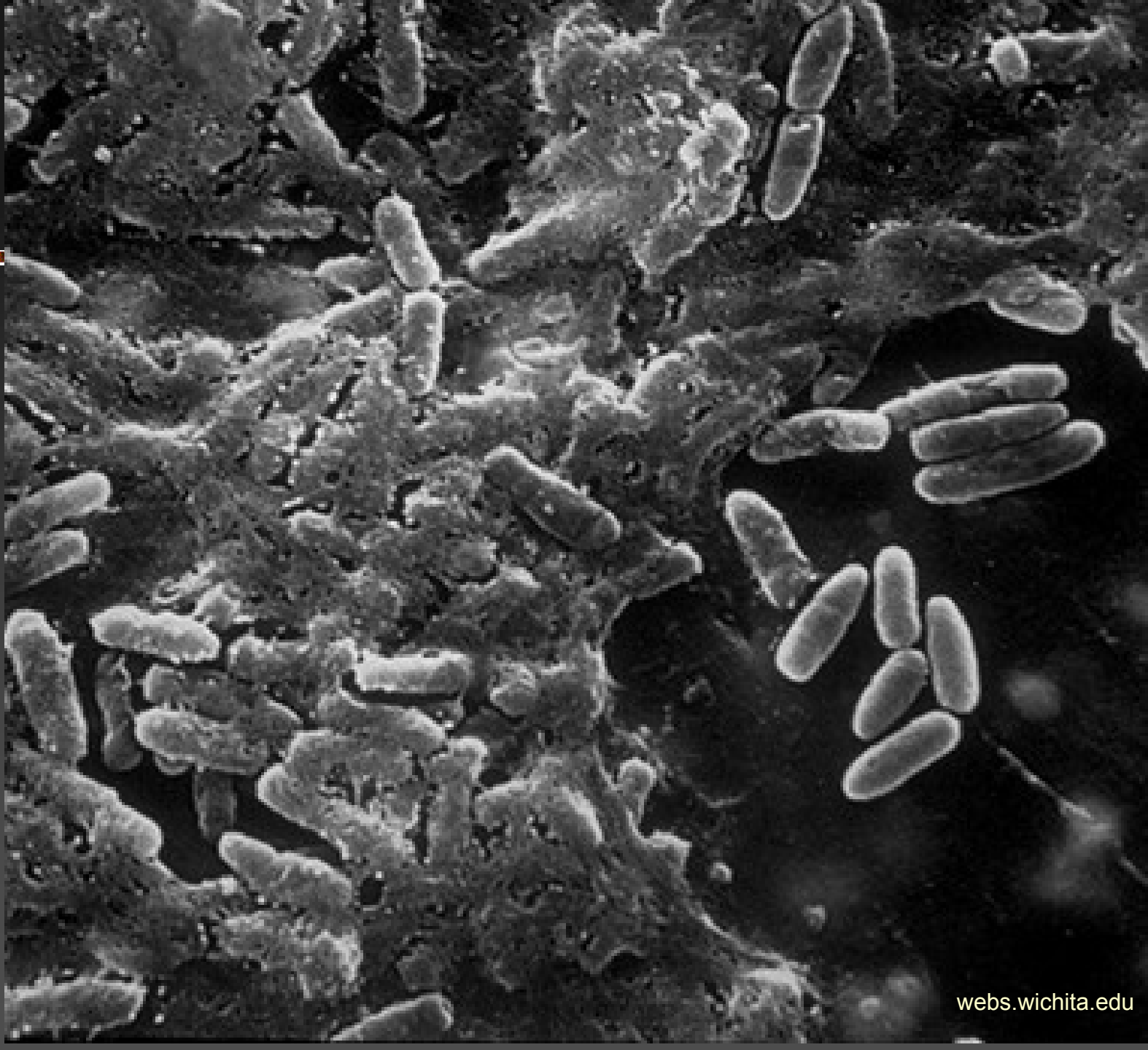
Biofilm formation:



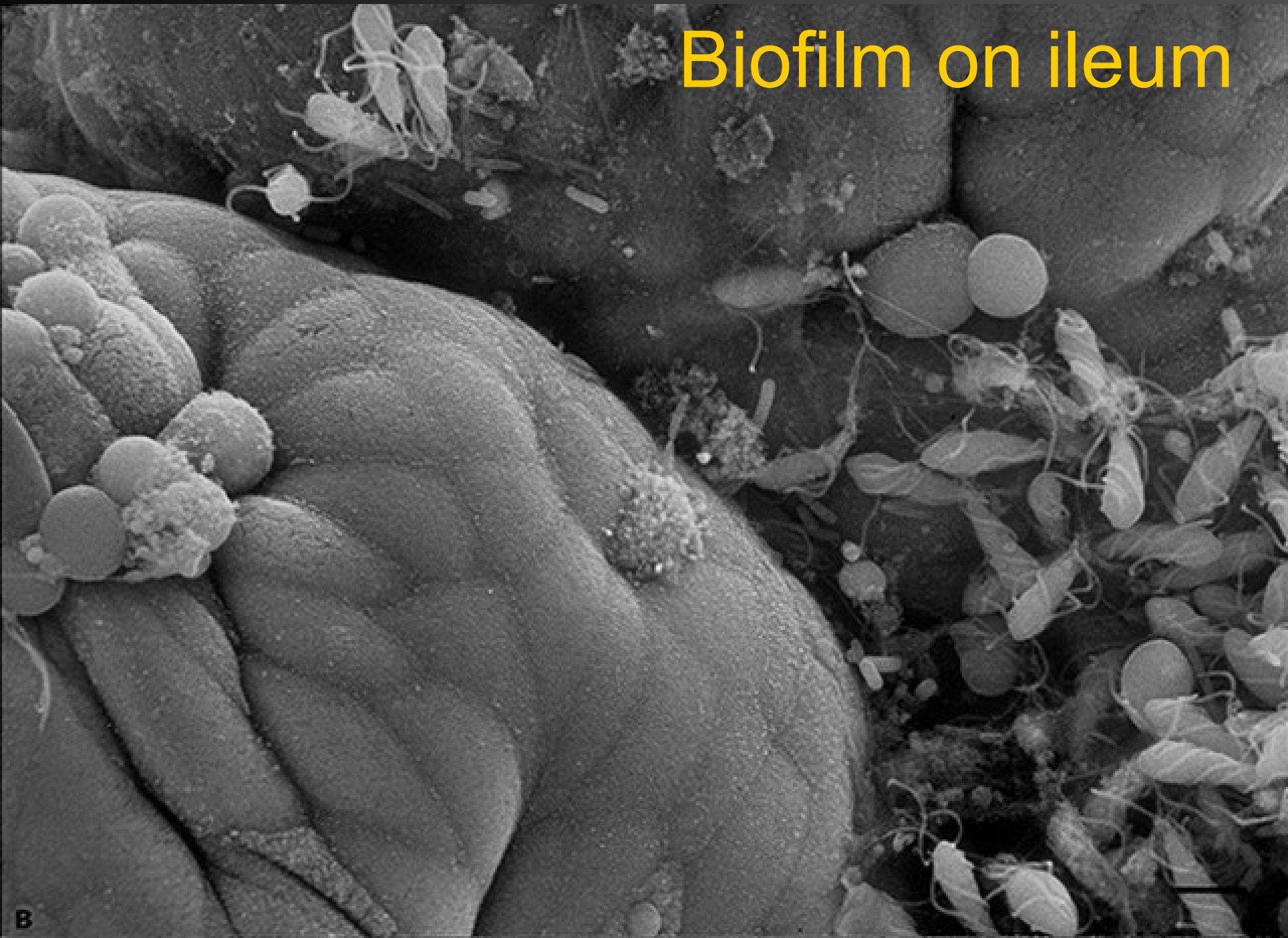
Biofilm in a river



Catheter biofilm



Biofilm on ileum

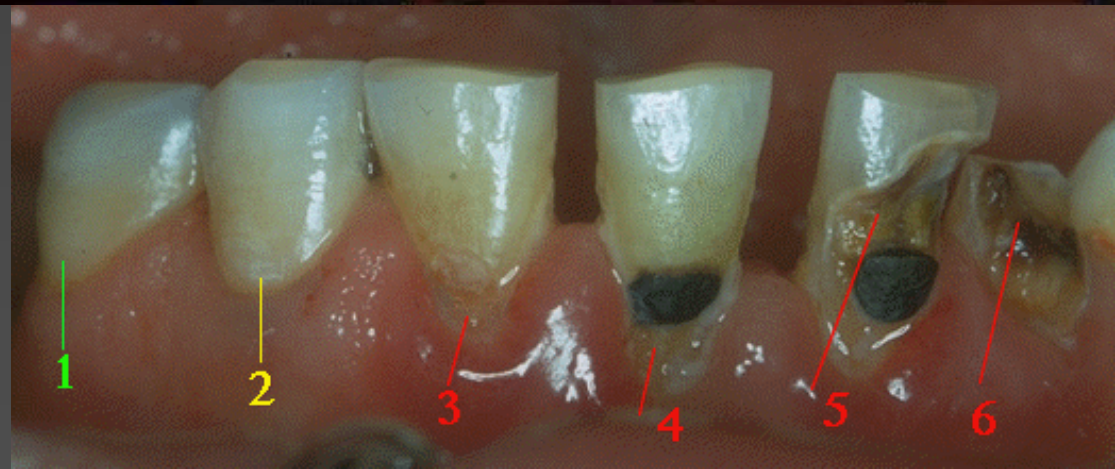
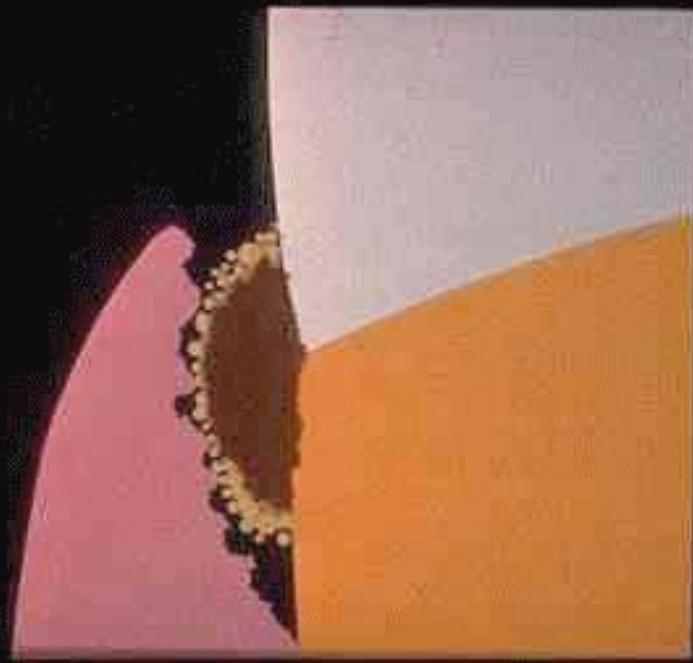
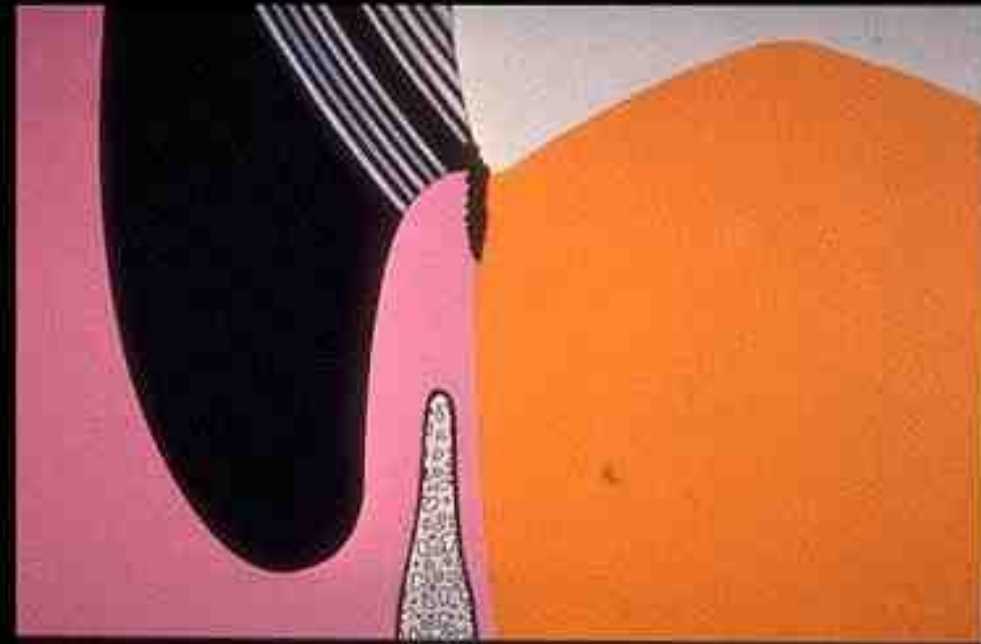


A Prosthetic biofilm

webs.wichita.edu



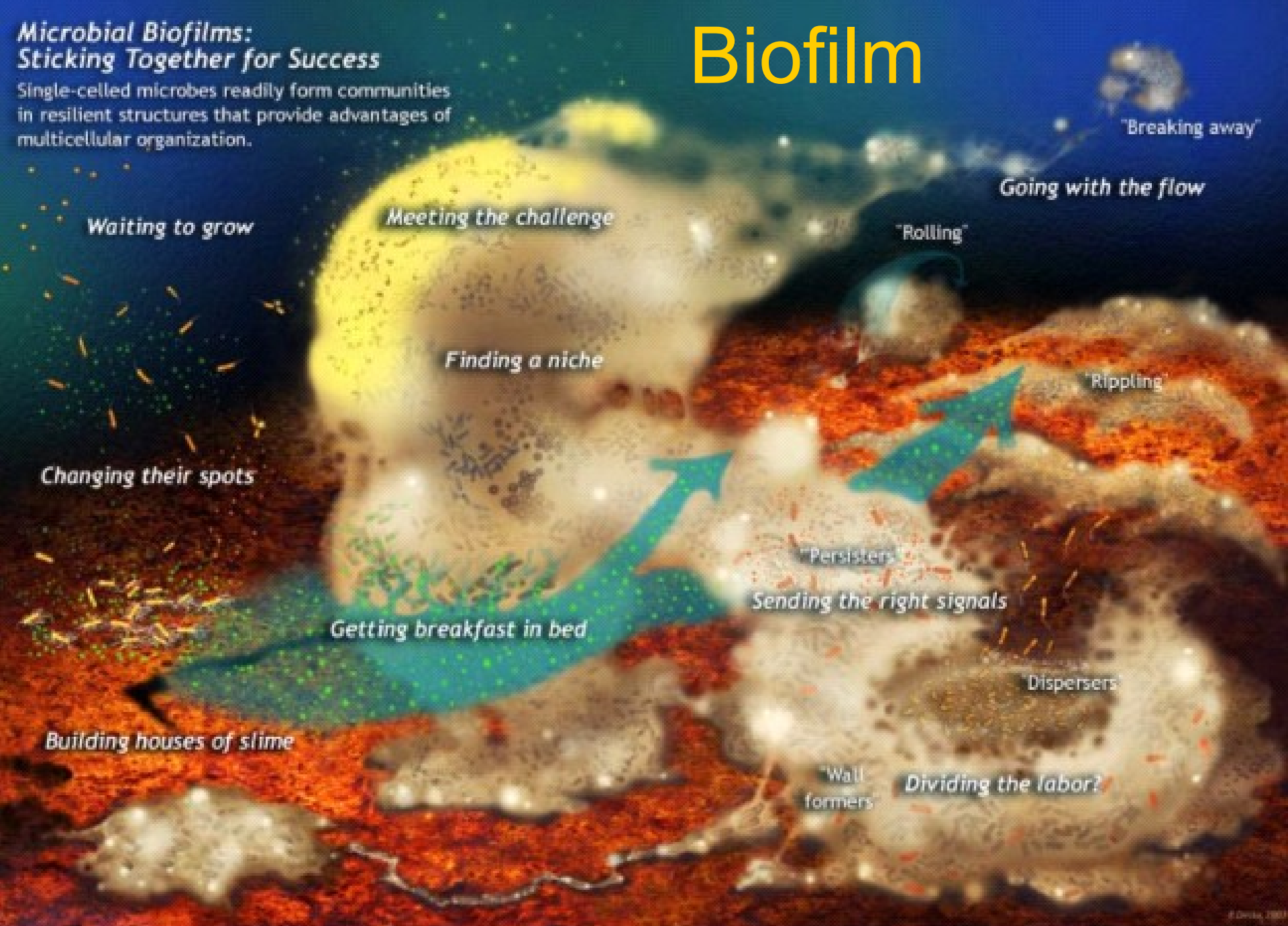
Biofilm missed by a toothbrush may lead to a caries formation



Biofilm

Microbial Biofilms: Sticking Together for Success

Single-celled microbes readily form communities in resilient structures that provide advantages of multicellular organization.



Waiting to grow

Meeting the challenge

Finding a niche

Changing their spots

Getting breakfast in bed

Building houses of slime

"Rolling"

Going with the flow

"Breaking away"

"Rippling"

"Persists"

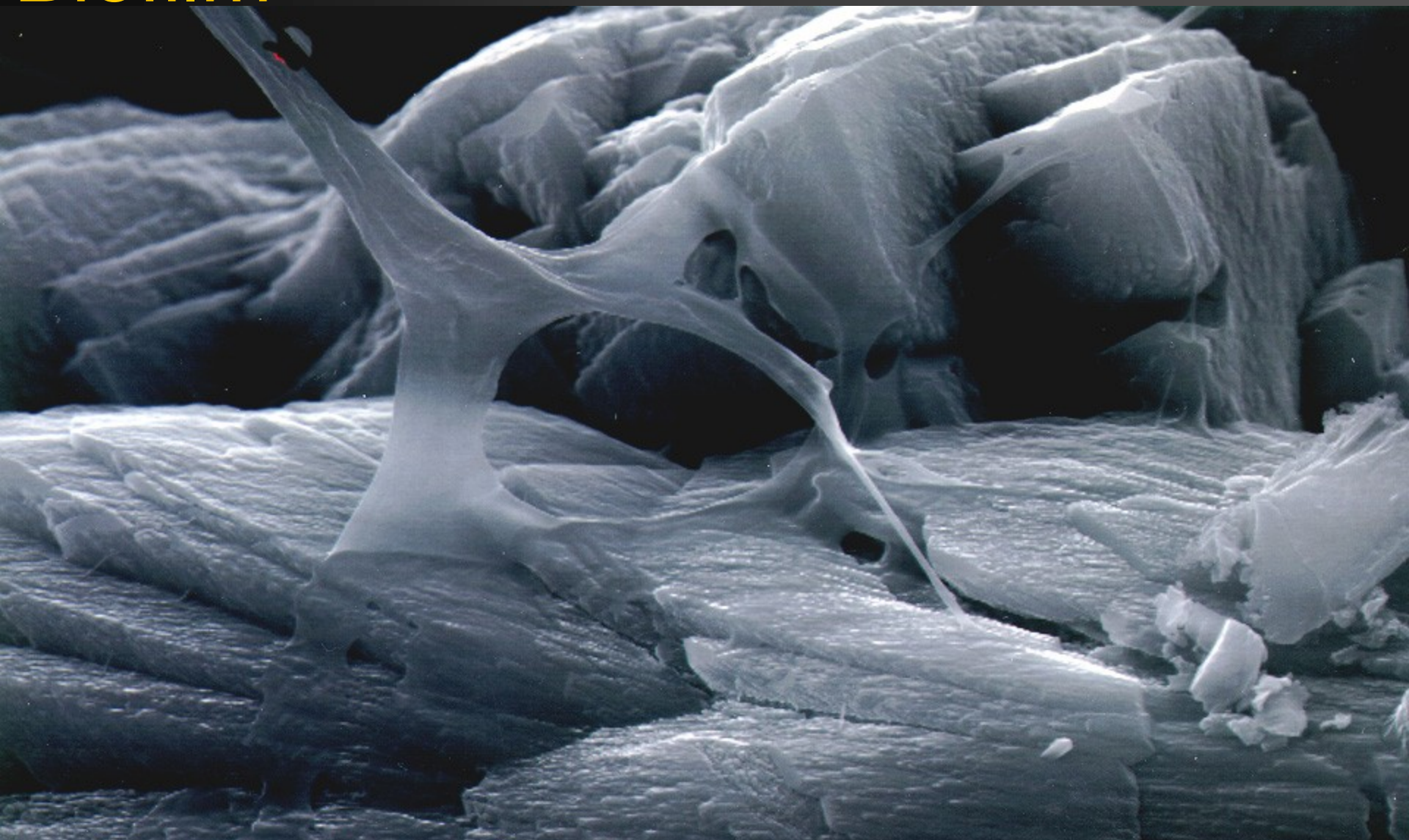
Sending the right signals

Dispersers

"Wall formers"

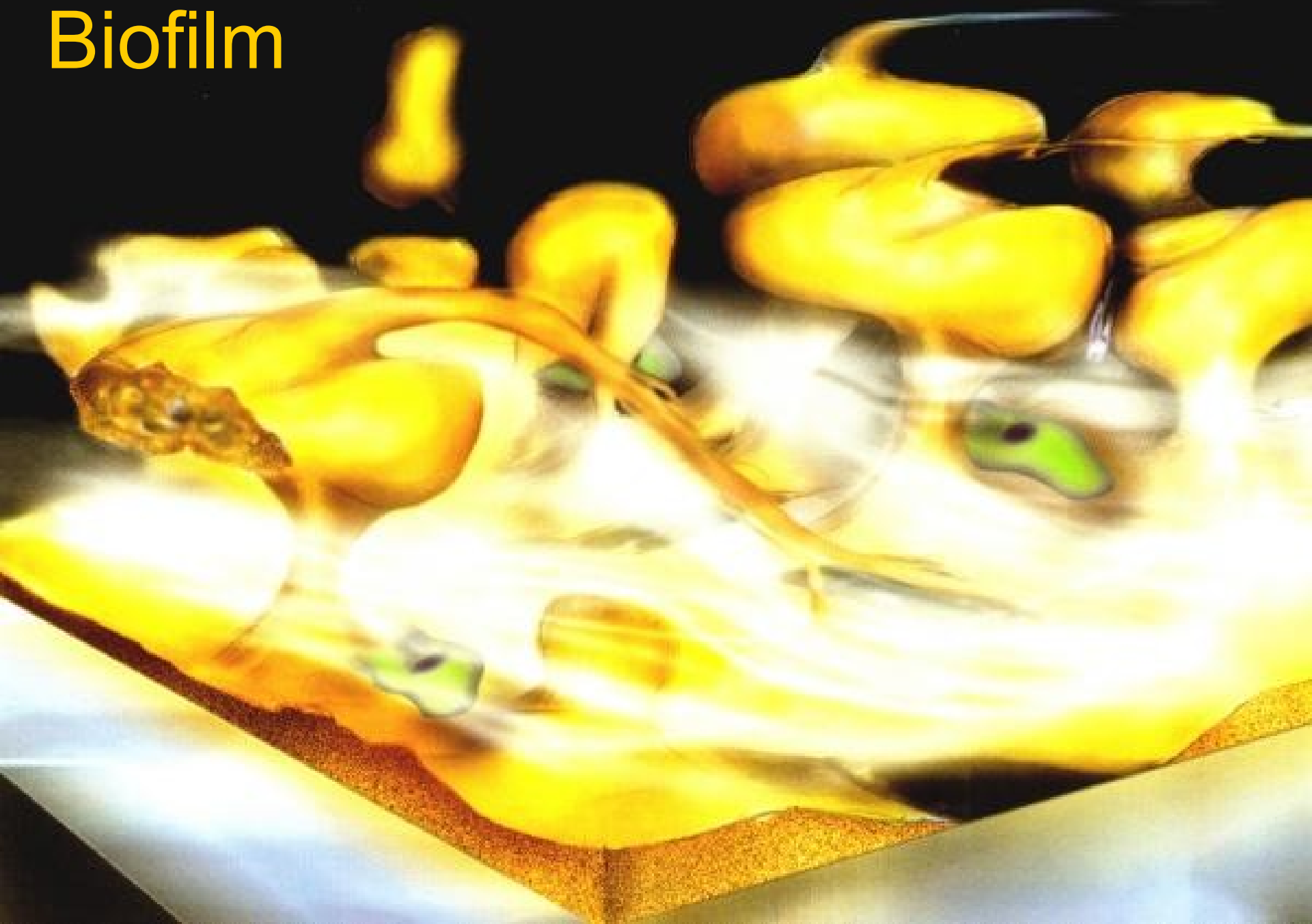
Dividing the labor?

Biofilm



Acc.V - Exp |-----| 5 μ m
25.0 kV 5076 Travertine ZF#5 Unetched Area 2

Biofilm



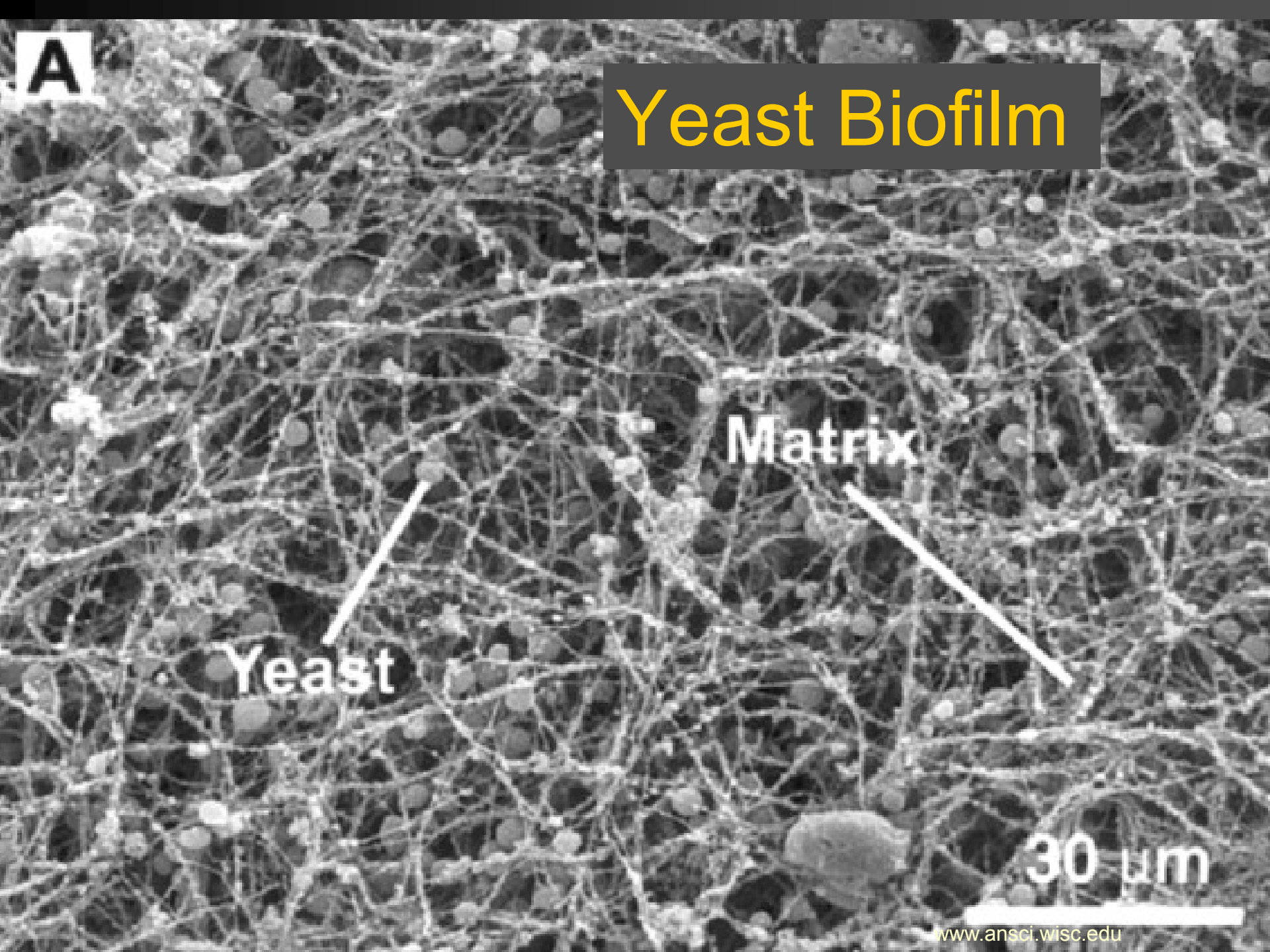
A

Yeast Biofilm

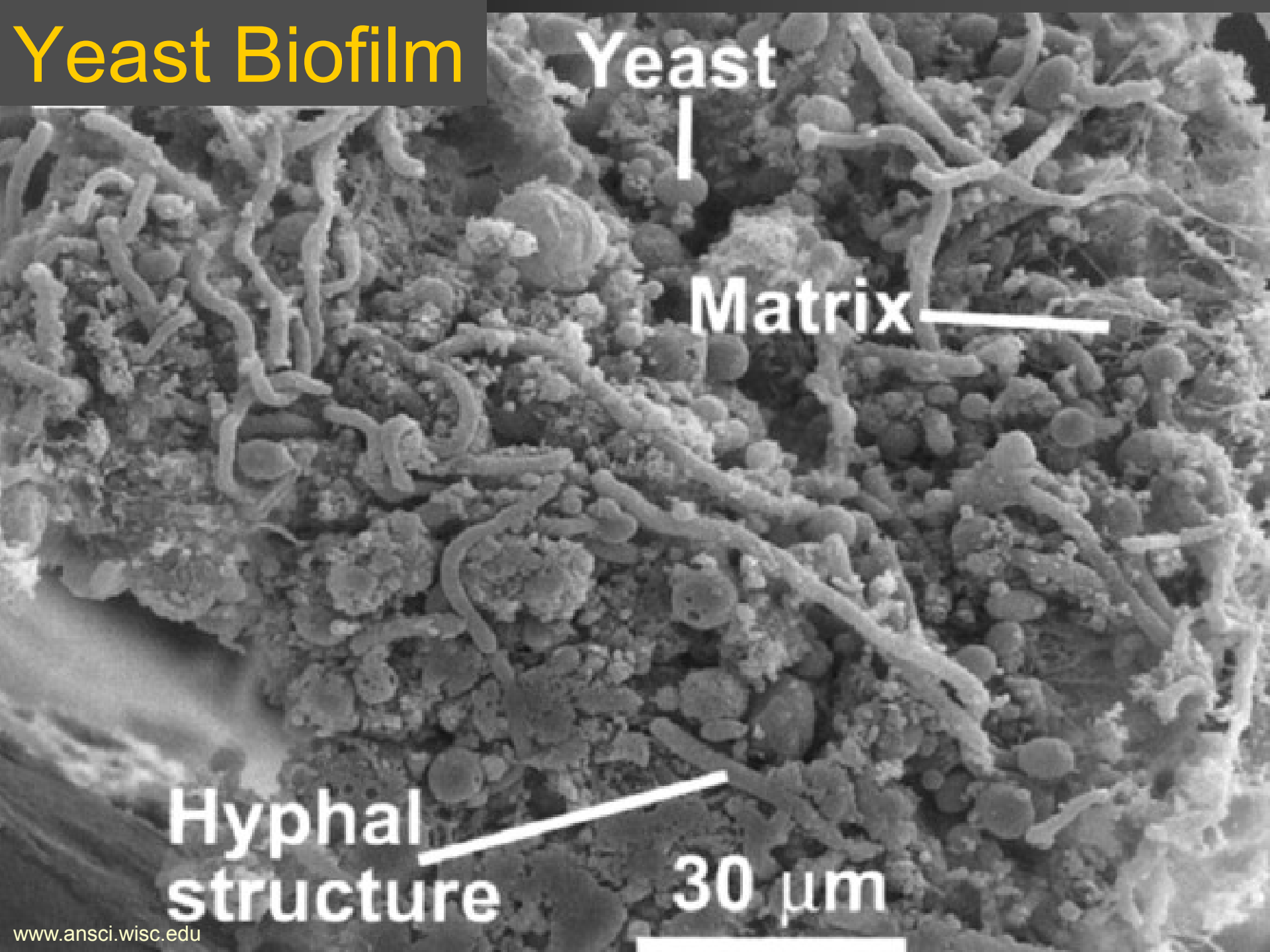
Yeast

Matrix

30 μ m



Yeast Biofilm



Yeast

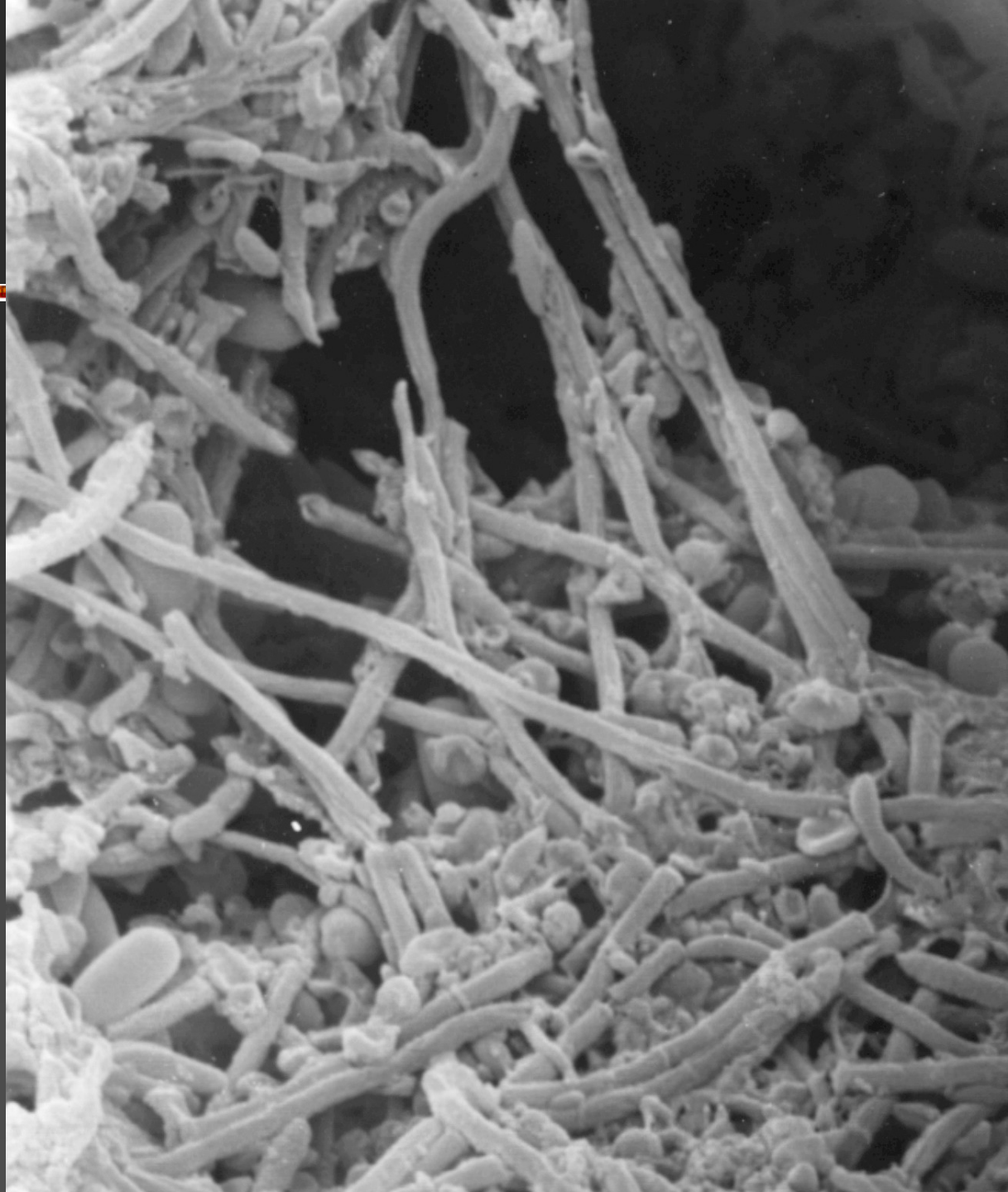
Matrix

Hyphal
structure

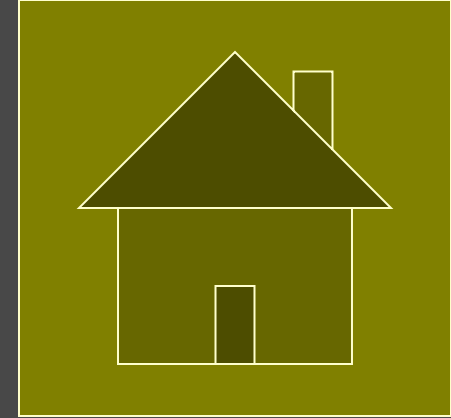
30 μm

Biofilm

commtechlab.msu.edu



The End



This slideshow was prepared in cooperation of ing. Veronika Holá, MUDr. Lenka Černožorská, PhD., and MUDr. Ondřej Zahradníček

(Student K. C. 3 years ago forgot to bring her index, so she got the credit in the evening in a pub 😊)



Photo: Archive of O. Z.