The use of structural nano and micro-filtration membrane as a confine bioreactor for microbial growth and extracellular digestive enzymes secretion

By
Ofir Menashe

4th International Conference on Nanotek and Expo
San Francisco, December 2014.

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

The term of structural membrane

Structural membrane: It is a semi preamble membrane that can be designed and constructed according to defined need (macro-encapsulation structures).

The aim of the lecture is to provide applicable tools for the method preparation of structural semi permeable membrane.

Agenda

Part A – Introduction: Confine environment and utilities in wastewater treatment process

Part B – Structural membrane characterization and mechanism

Part C – Biocompatibility and the effect of confine environment on the secretion of extracellular enzymes.

Part D - Summary

Original design of structural membrane

Structural membrane design utilities:

It was design to provide a confined* environment to support microorganism growth, in order to allowing a successful culture implementation within host bioreactor of wastewater treatment plant.

To induced a successful bio-augmentation treatment approach.

Bio-augmentation treatment approach: is the use of external selective microorganism culture to induce a specific biological or biochemical process.

*A *confined* environment is a space which is substantially enclosed (though not always entirely).

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

The needs for exogenous bacterial culture implementation in wastewater treatment facilities

Bio-augmentation treatment approach is use to reduce specific contaminants concentration into safe environmental level.

Bio-augmentation can elevate the biological stabilization process over time , thus elevating the treatment yield..

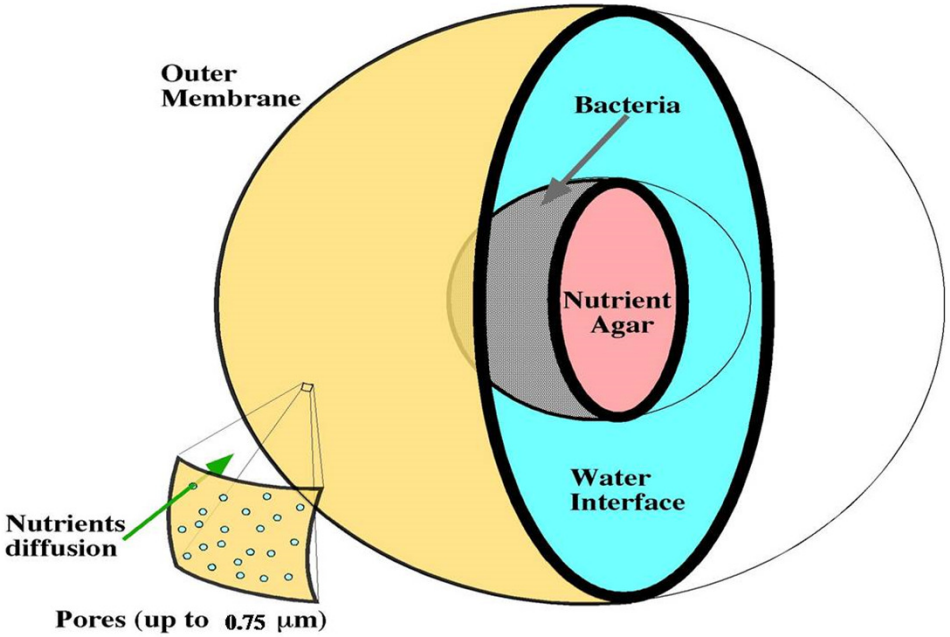
Bio-augmentation can accelerate the bio-digestion process, thus elevating the treatment yield.

The most successful cases of bio-augmentation occur in confined systems, such as bioreactors in which the conditions can be controlled to favor survival and prolonged activity of the exogenous microbial population

Consequently :

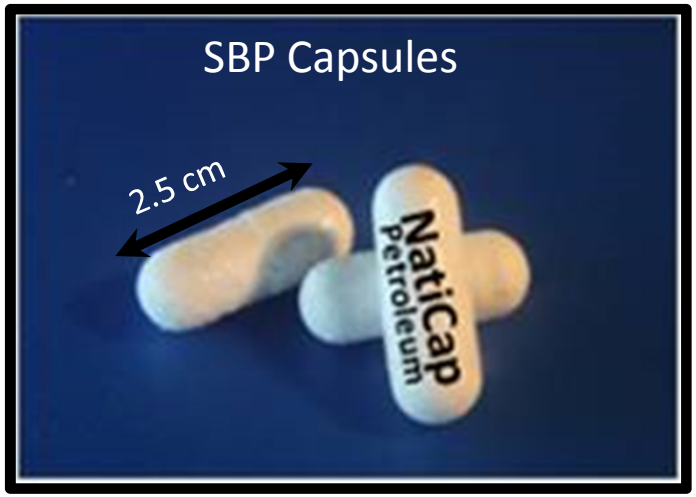
Elevate the probability for adaptation and prosperity

Sample for a particle that can defined as a confine environment: The SBP capsule



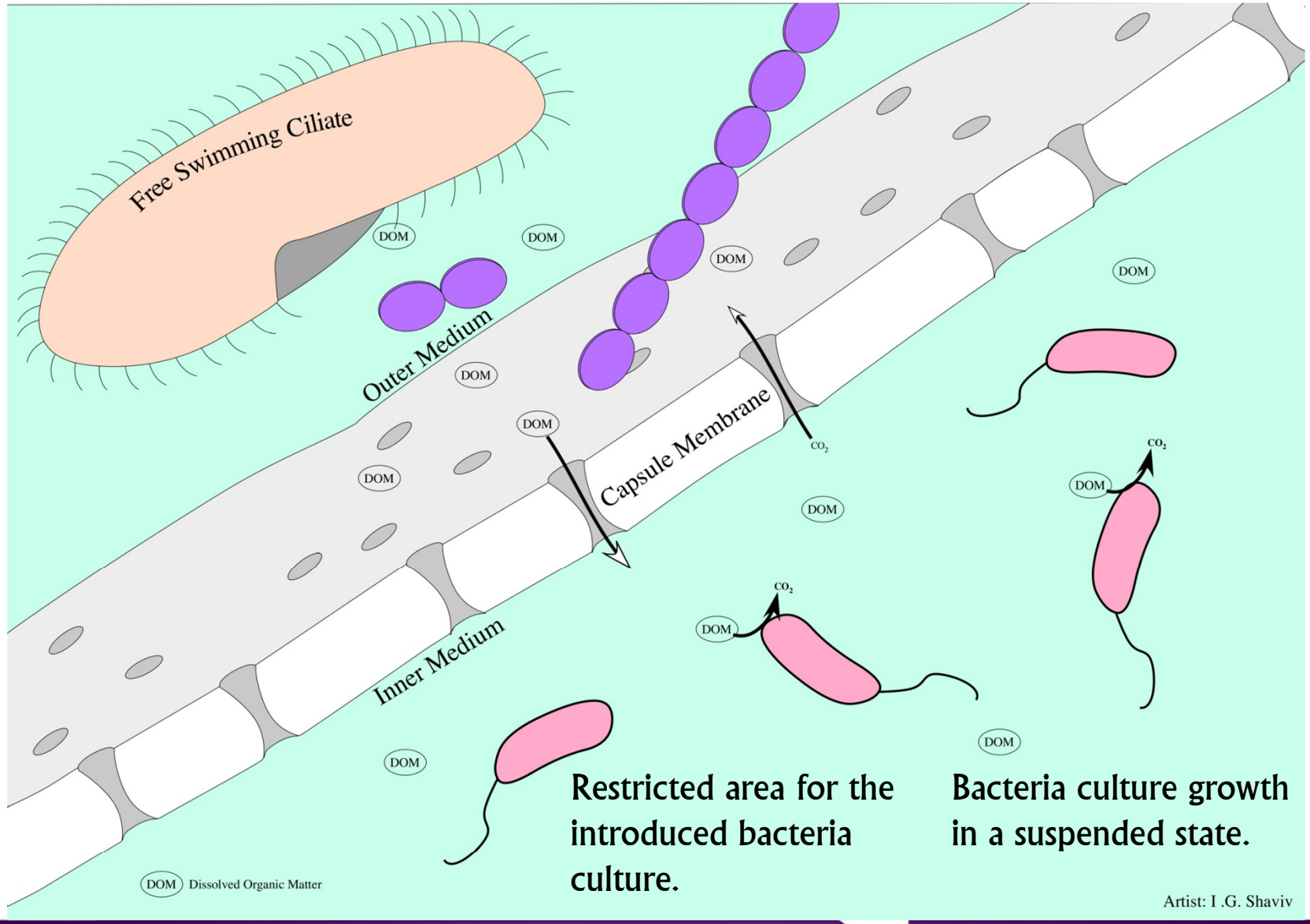
SBP capsule outline design

Aimed to protect the introduced culture , and provide favorable micro-cosmos conditions – Confine environment.



The constructed particle: Small Bioreactor Platform (SBP) technology

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School



Confine environment (SBP capsule)

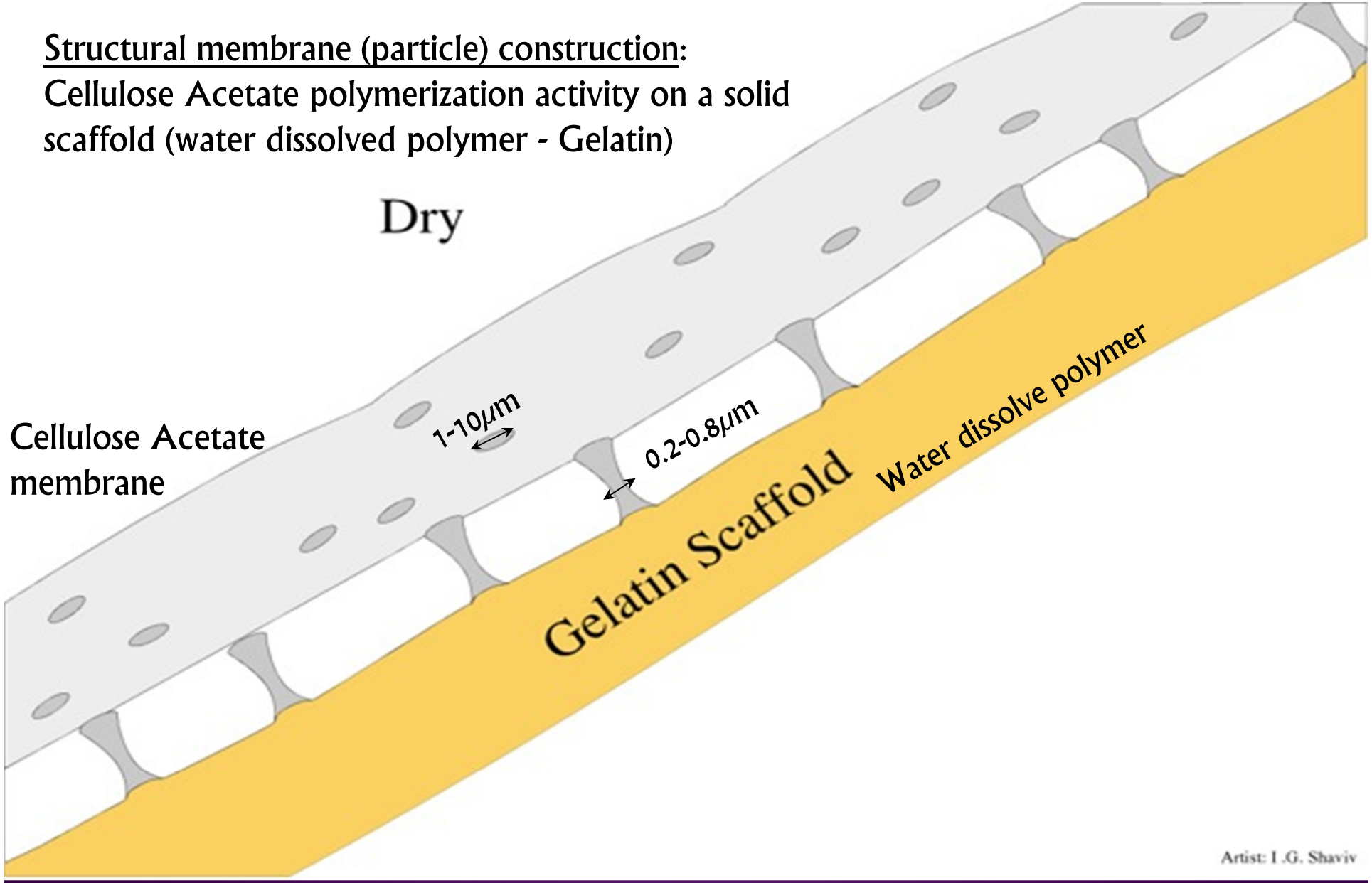
KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

Part B

Structural membrane characterization and mechanism

- ✓Structural membrane structure and forming
- ✓Structural membrane activation and viability
- ✓Structural membrane characterization

Structural membrane (particle) construction:
Cellulose Acetate polymerization activity on a solid scaffold (water dissolved polymer - Gelatin)

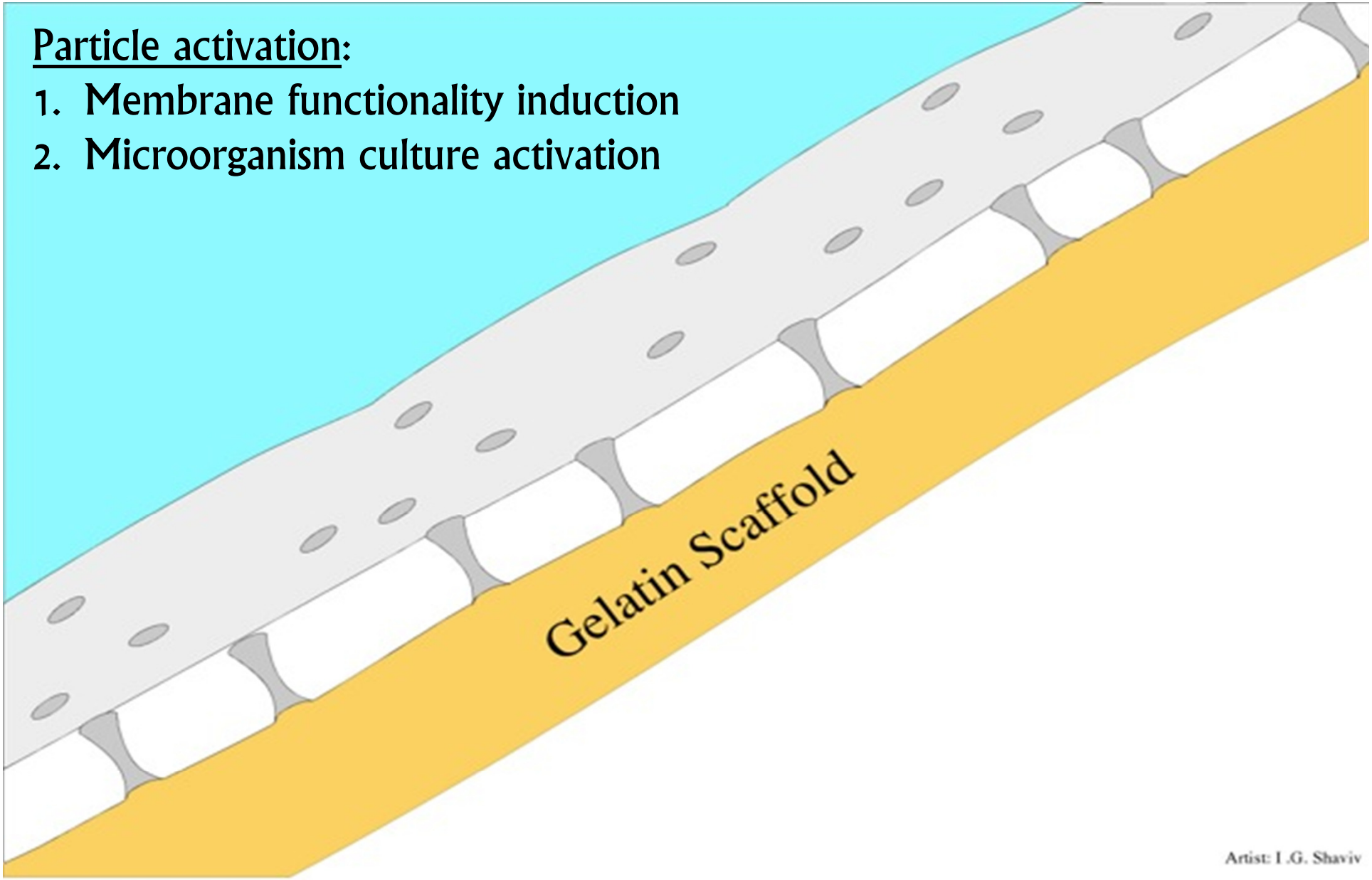


Stage number 1:
Inactivated SBP Capsule

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

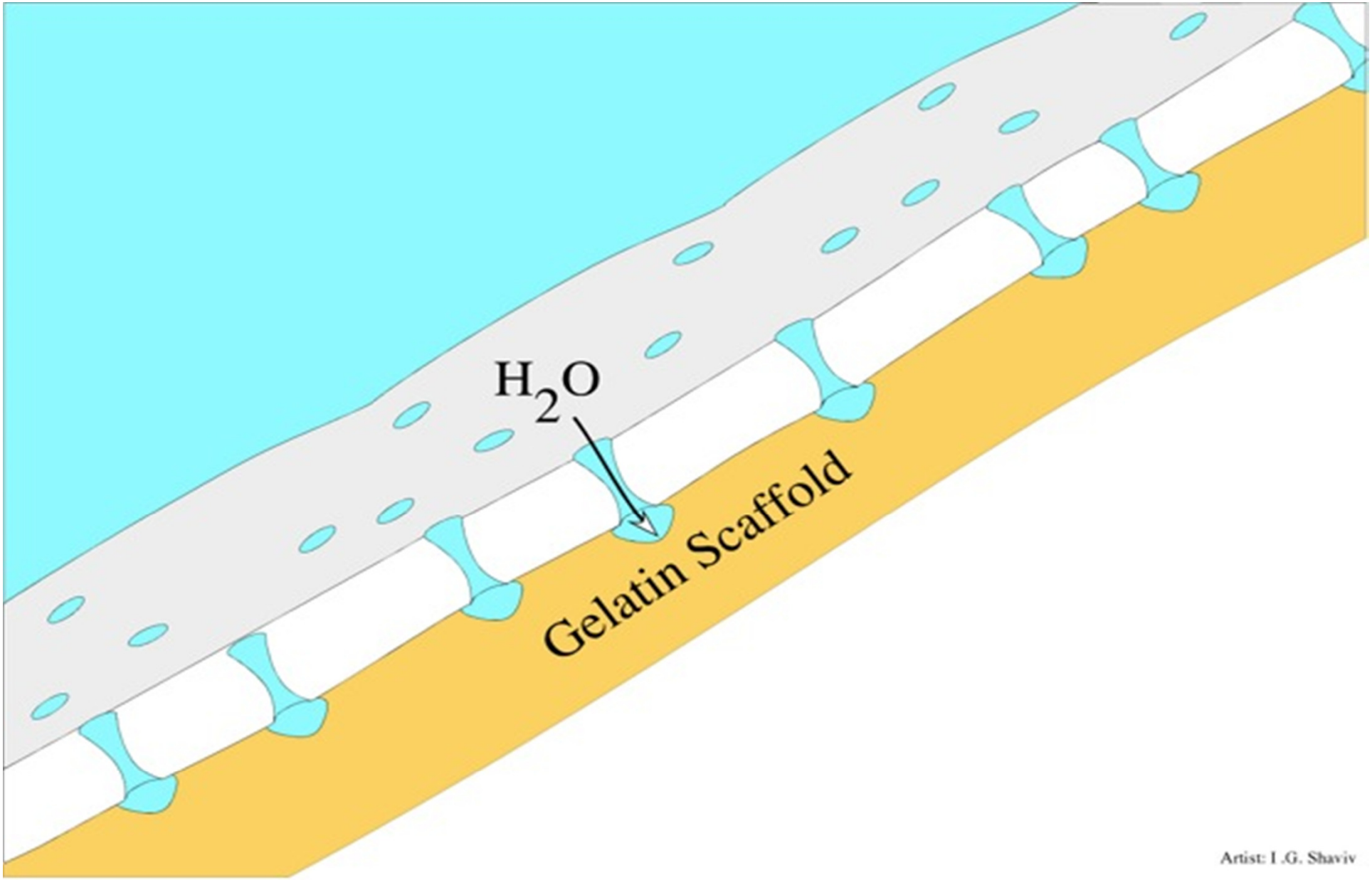
Particle activation:

1. Membrane functionality induction
2. Microorganism culture activation



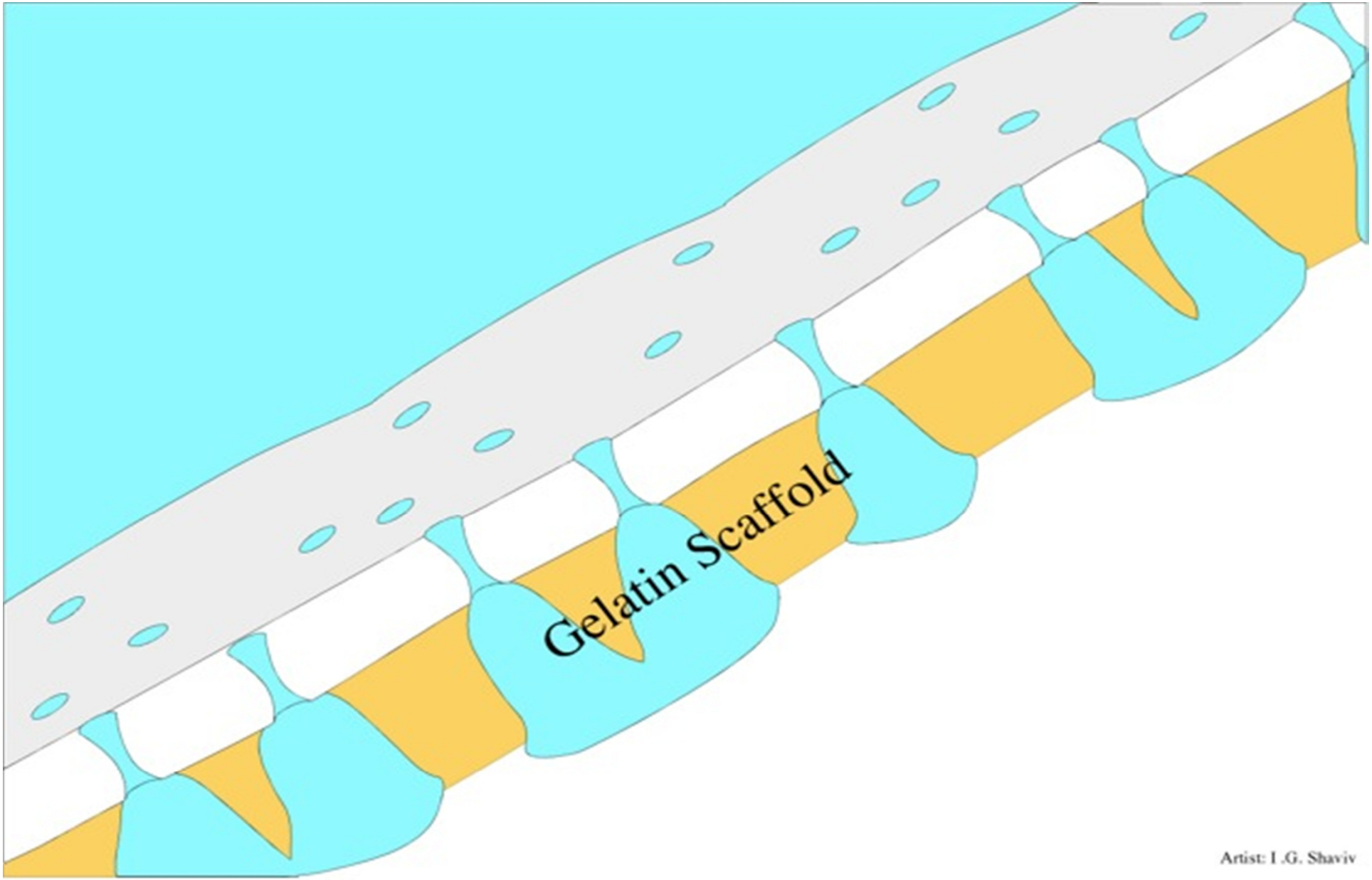
Stage number 2: Activation by the exposure to aquatic medium

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School



Stage number 3: Water (medium) penetration through the pores of the membrane

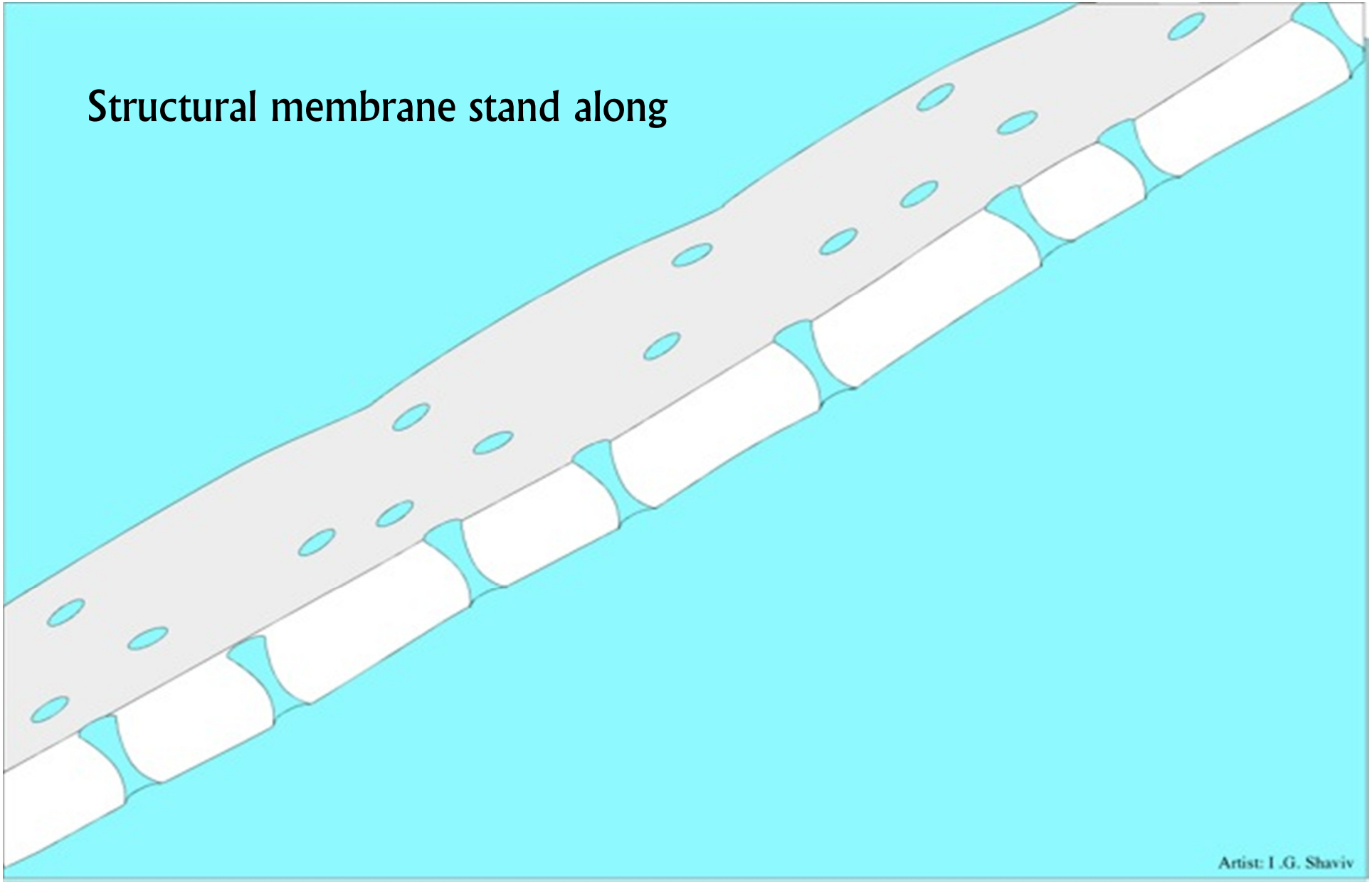
KINNERET
College on the Sea of Galilee
Achi Racov Engineering School



Stage number 3: The introduced water molecules are dissolving the Gelatin scaffold

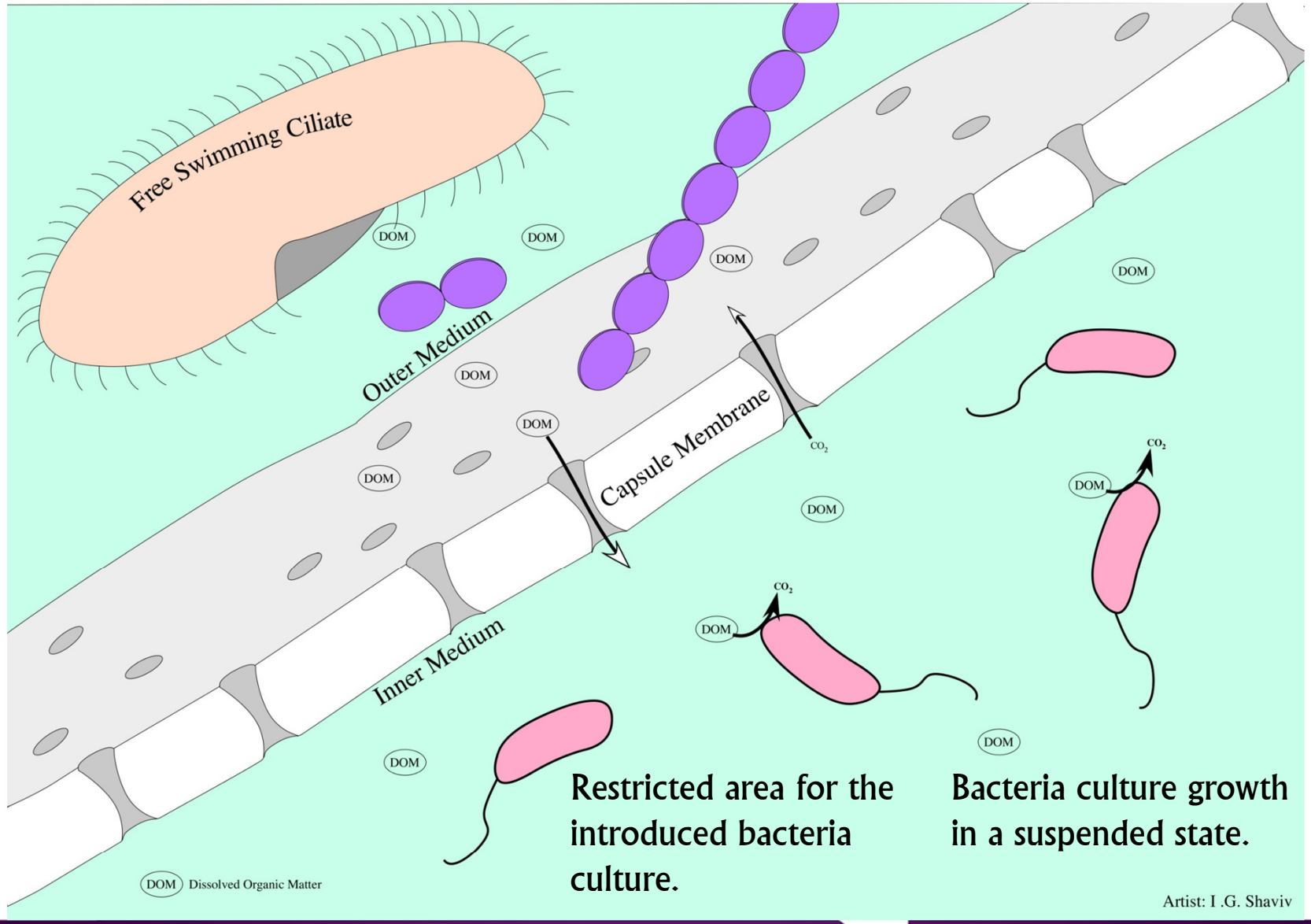
KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

Structural membrane stand along



Stage number 4: The presence of microfiltration membrane (Activated particle)

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

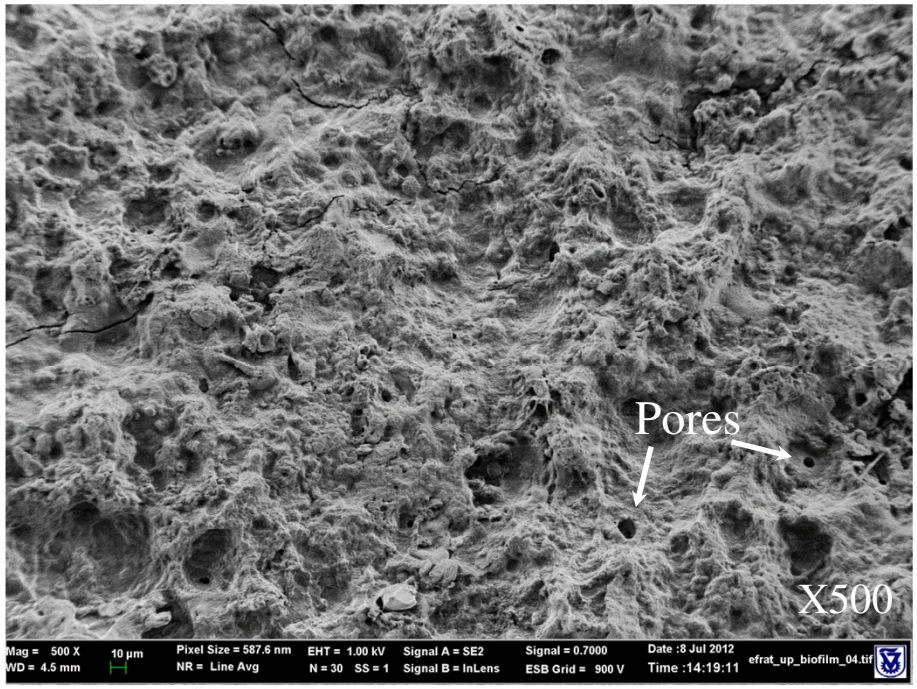


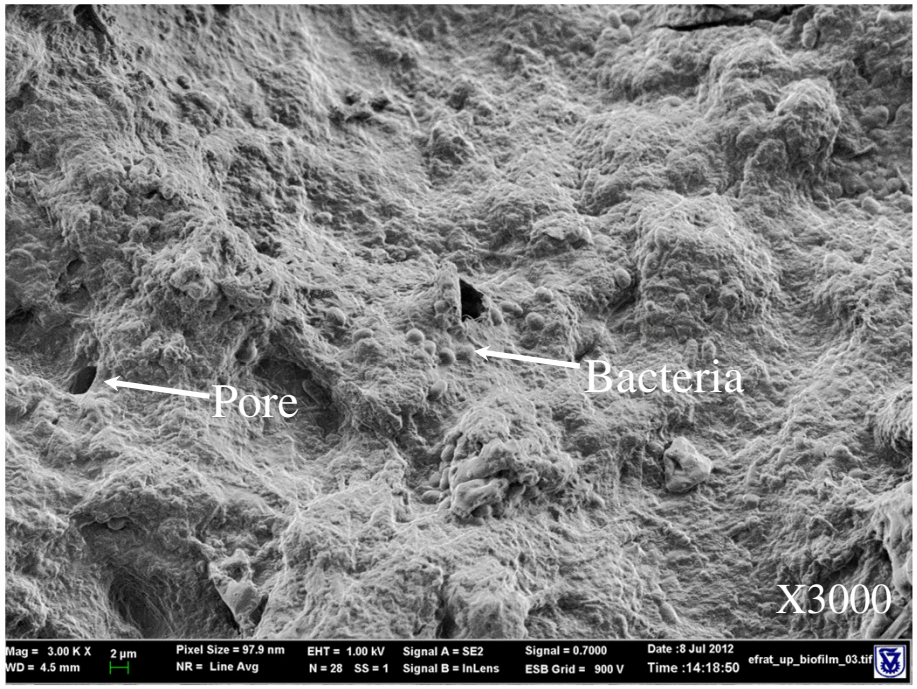
Functional SBP capsule within a wastewater treatment plant bioreactor medium (mix liquor)

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

Membrane characterization after long term incubation within microorganisms saturated environment (fouling membrane)

SBP capsule membrane surface – SEM (scanning electron microscope)





* SEM and pore size analysis made by Prof. Dosoretz, Technion – Israel Institute of Technology

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

Structural membrane characterization

Membrane pore size (determined by latex beds study)

After activation (saline, disinfection environment): 0.8 μm

After a month incubation within a sanitary medium: 0.2 μm

Membrane width

Membrane width: 500μm-800μm (average 650μm)

Increasing membrane width will reduced the membrane pore size.

Average time of membrane stability (particle prolong)

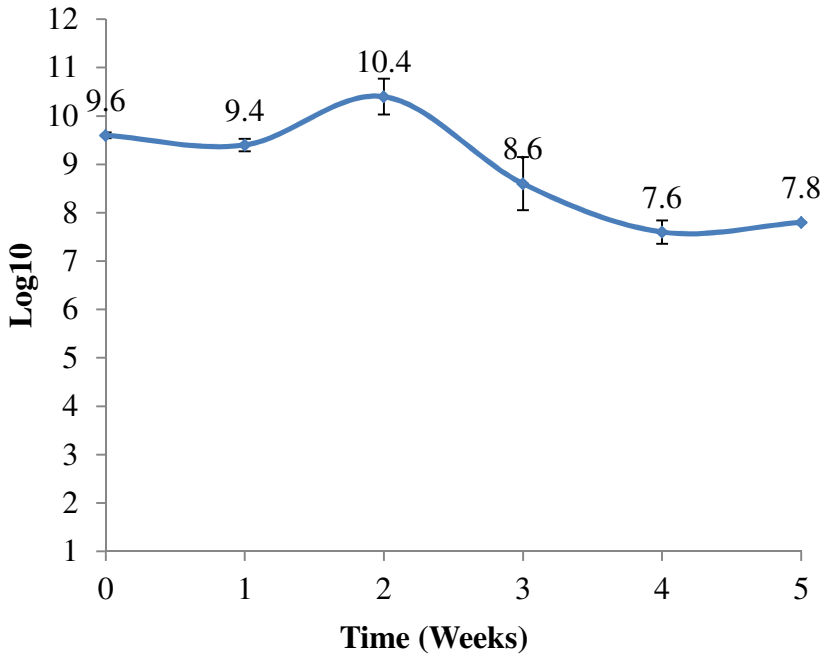
Over 2 months within wastewater

Part C

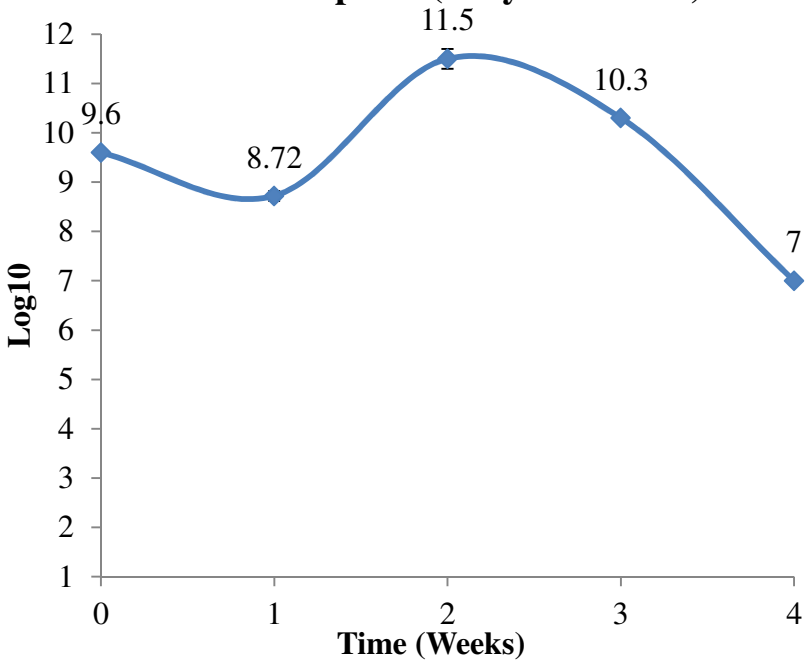
Biocompatibility and the effect of confine environment on the secretion of extracellular enzymes.

Bio- compatibility study of the structural membrane to the host microbial culture

Viable counts (log10 CFU) inside the activated capsule (Cellulose Acetate)



Viable counts (log10 CFU) inside the activated capsule (Ethyl Cellulose)



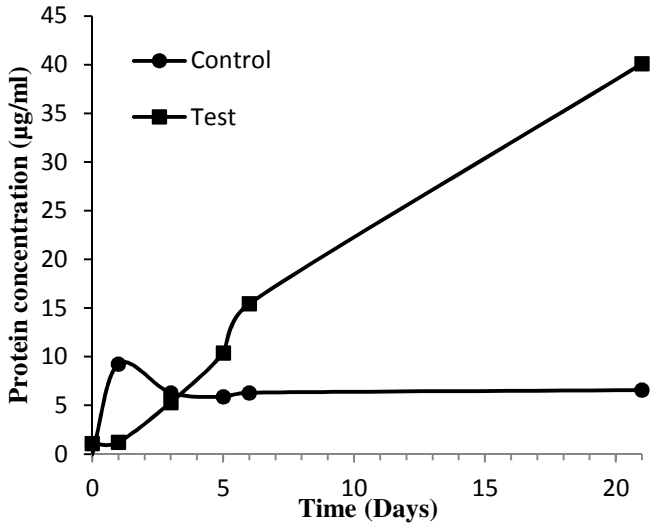
Extracellular protein secretion

Control system – suspended microbial blend

Test system – SBP encapsulated microbial blend

Incubation medium: saline and substrate bland of 0.25% Glycerol and 0.25% Canola oil.

Extracellular protein concentration



The control system presents a constant protein concentration over time (average 5.7±3 μg/ml), while the test system present a continuous increase of extracellular protein concentration over time (R^2= 0.98).

Summary

The use of structural membrane to construct a particle (SBP capsule) that can provide a confine environment for the introduced microorganisms culture.

The postulated particle significant reduced natural selection forces (grazing, shear forces), resulting in culture long term prosperity (over 2 months).

The postulated particle allowing us to enjoy the benefit of the bio-augmentation treatment approach.

Confine environment can induce extracellular proteins (enzymes?) over expression, suggesting the benefit of bio-chemical process amplification.

Structural semi-permeable membrane - other utilities?

KINNERET
College on the Sea of Galilee
Achi Racov Engineering School

Thank you


KINNERET
College on the Sea of Galilee
Achi Racov Engineering School