Microbiologie

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V. Biofilms

= *a microbially derived sessile community characterized by cells that are irreversibly attached to a substratum or interface, are embedded in a matrix of extracellular polymeric substances that they have produced, and exhibit an altered phenotype with repect to growth rate and gene transcription*

Dolan & Costerton *Clinical Microbiology Reviews* (2002) 167–193

= city of microbes / forteresses bactériennes / joint venture

Watnick & Kolter Journal of Bacteriology (2000)
Klinger et al. La Recherche (2000)
Van Gemerden Marine Geology (1993)

= *the prevailing microbial lifestyle in most natural environments*

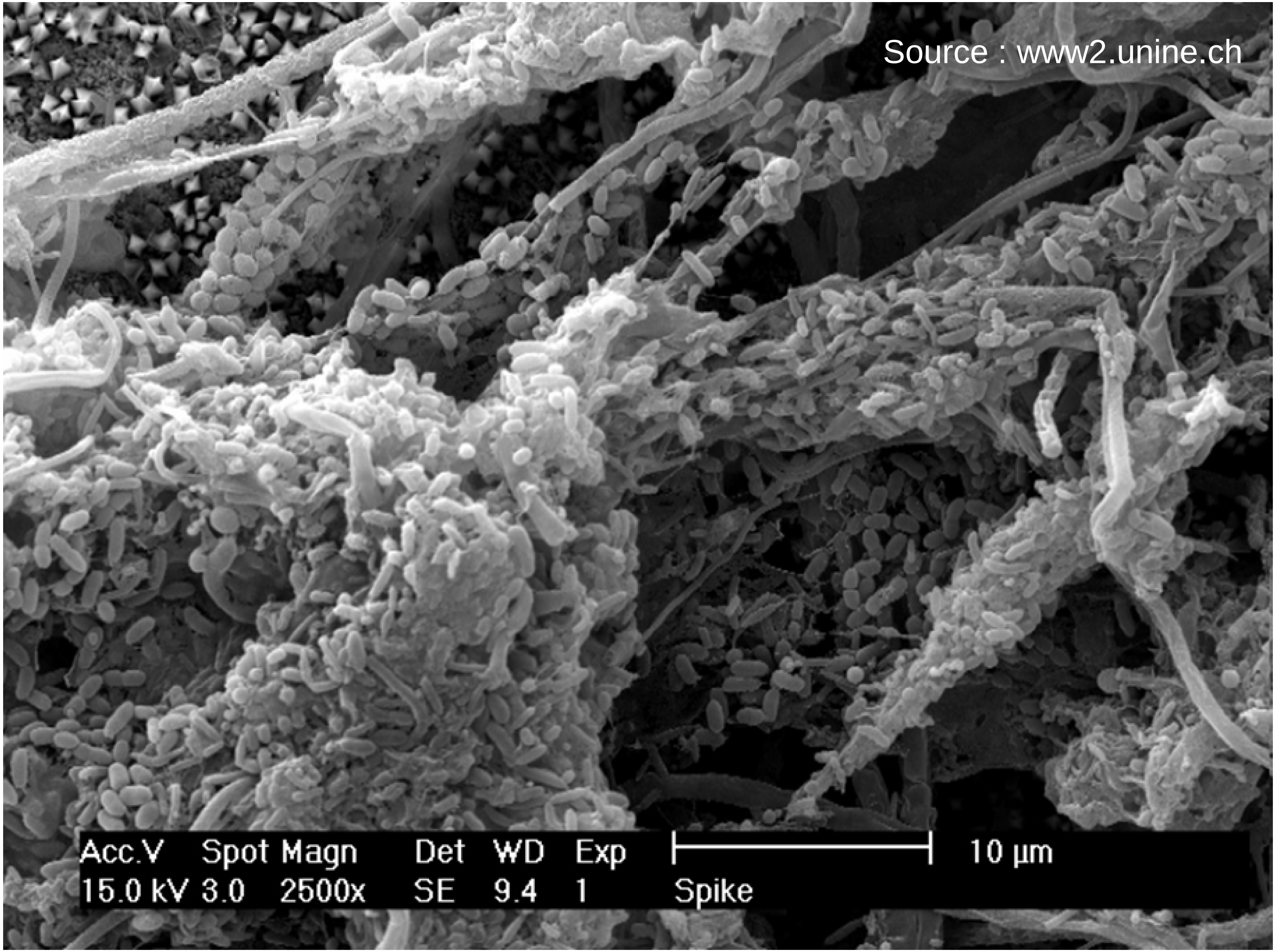
Watnick & Kolter Journal of Bacteriology (2000) 2675–2679

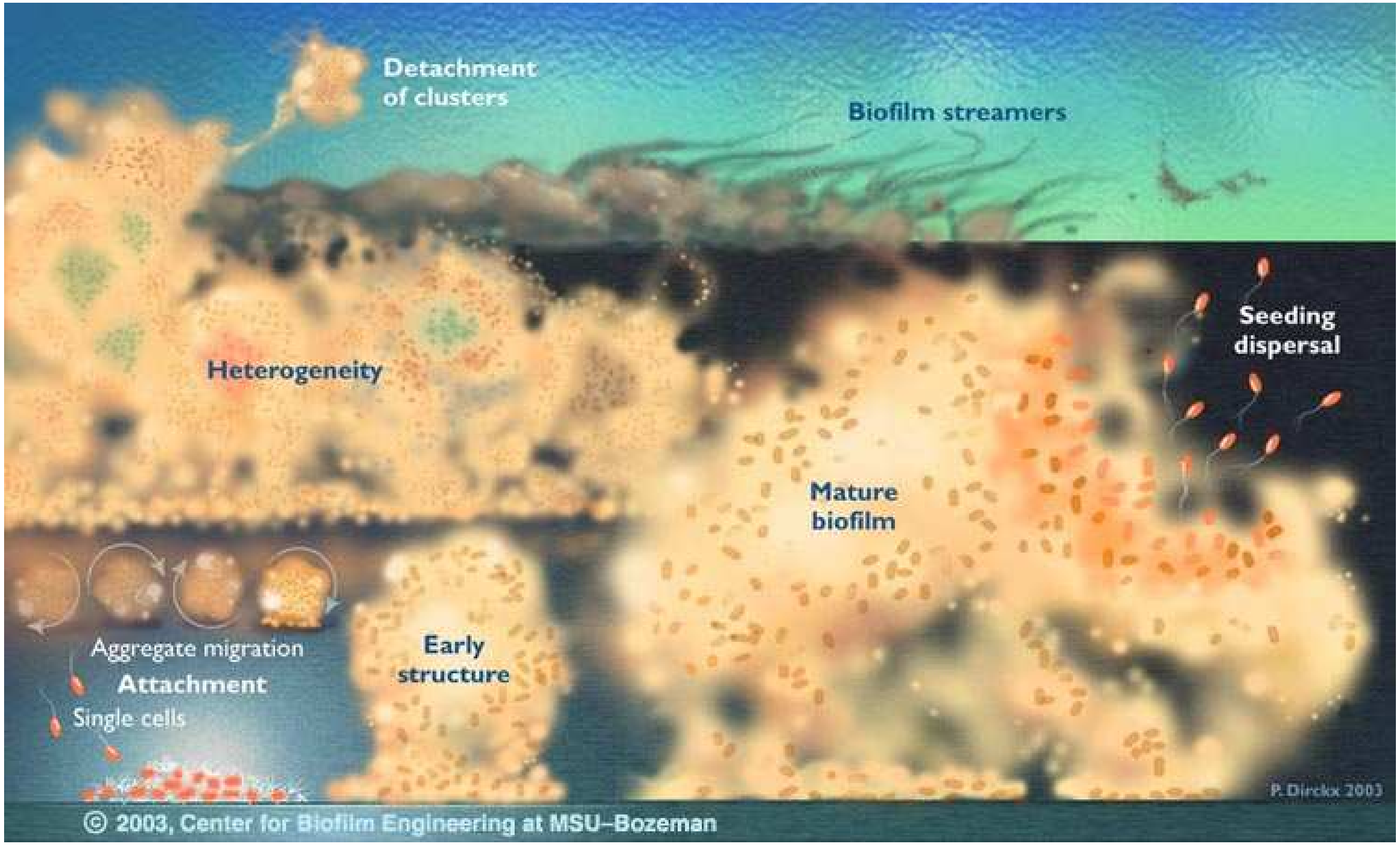
= une microbiologie (la vraie ?) des surfaces

BIOFILMS PNIR

IV. Biofilms

2. Formation, structuration de l'agrégat


Source : www2.unine.ch
Acc.V Spot Magn Det WD Exp
15.0 kV 3.0 2500x SE 9.4 1
10 µm
Spike


Detachment of clusters
Biofilm streamers
Seeding dispersal
Heterogeneity
Mature biofilm
Aggregate migration
Attachment
Single cells
Early structure
P. Dirckx 2003
© 2003, Center for Biofilm Engineering at MSU–Bozeman

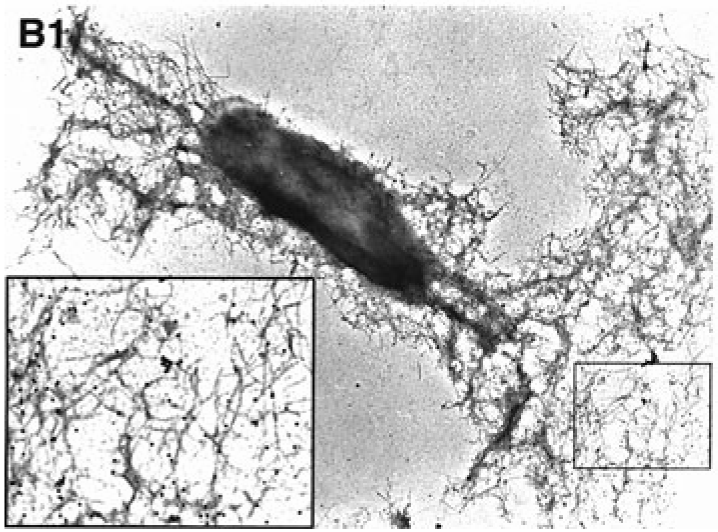
IV. Biofilms

3. L'adhésion cellulaire

Structures d'adhésion

Type d'Adhésine	Spécificité	Réversibilité	Nature	Interaction	Ligands
Passives	-	+	EPS, LPS Ac Teichoiques,	F.électrostatiques, I. Hydrophobes	Variables
Actives amorphes	+	-	Glycoprotéines	Liaisons prot-prot	Protéines
Actives filamenteuses	+	-	Fimbriae, curlis	Liaisons suc-prot	Sucres

Curlis – *E. coli*



***The EMBO Journal* (1997) 16, 5827–5836**

Escherichia coli MG1655.,

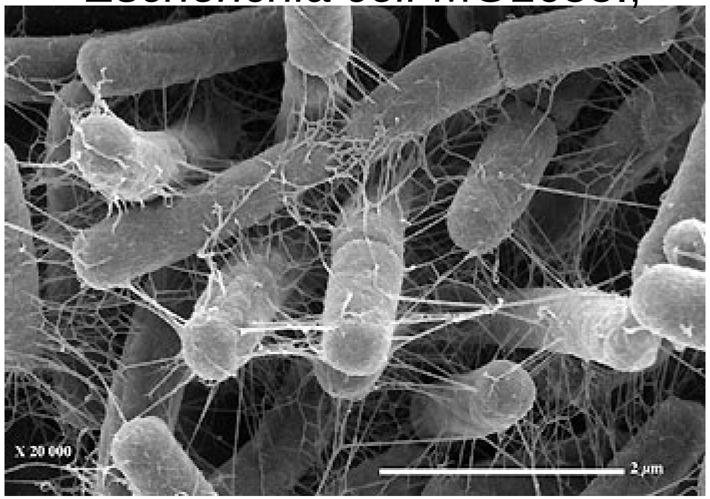


Photo Brigitte Arbeille *Laboratoire de Biologie Cellulaire et Microscopie Electronique, 37032 Tours Cedex*

Etapes de l’adhésion

1. Contact réversible avec la surface: *(secondes)*

   forces électrostatiques force de Van der Waals, nage

2. Attachement (quorum sensing) *(minutes)*

   expression des adhésines, synthèse des EPS

…et

1. Détachement (quorum sensing)

   « retour » au phénotoype planctonique

Phénotype « biofilms »

« 25 % du protéome est modifié chez *P. aeruginosa* lorsque les bactéries sont cultivées sous la forme de biofilm »

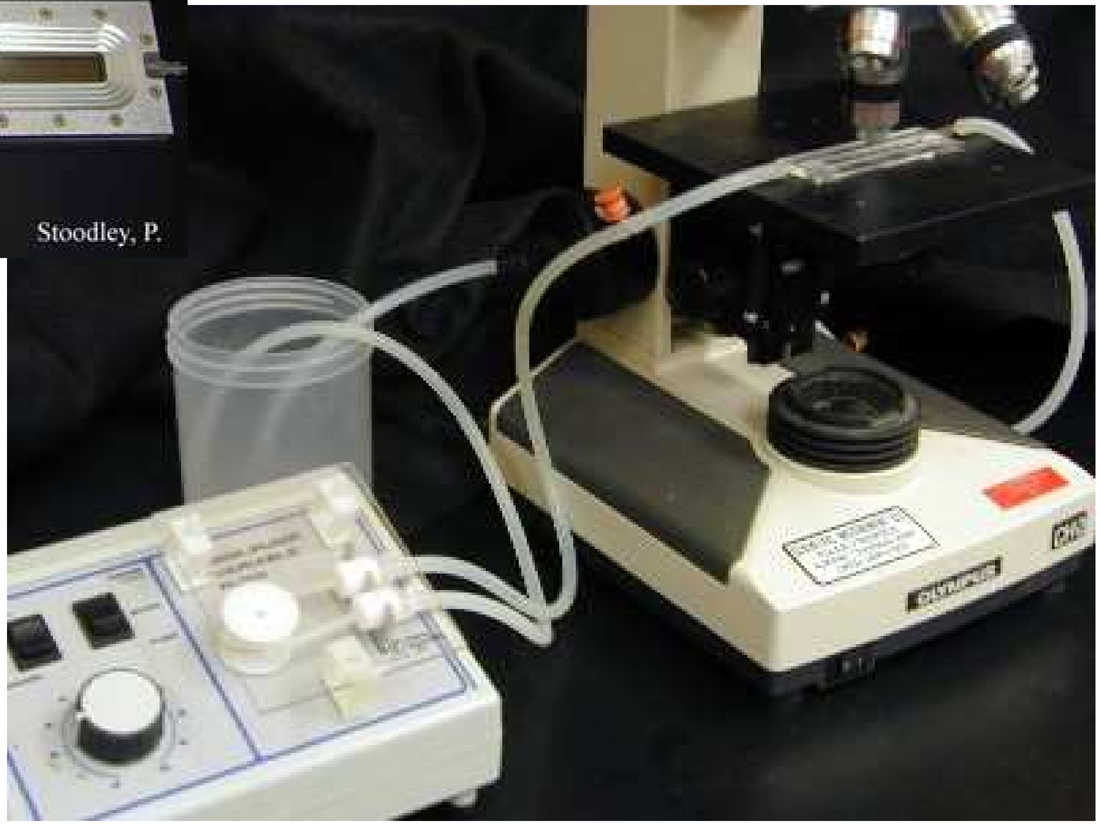
Jouenne et al. CNRS Infos, 2001

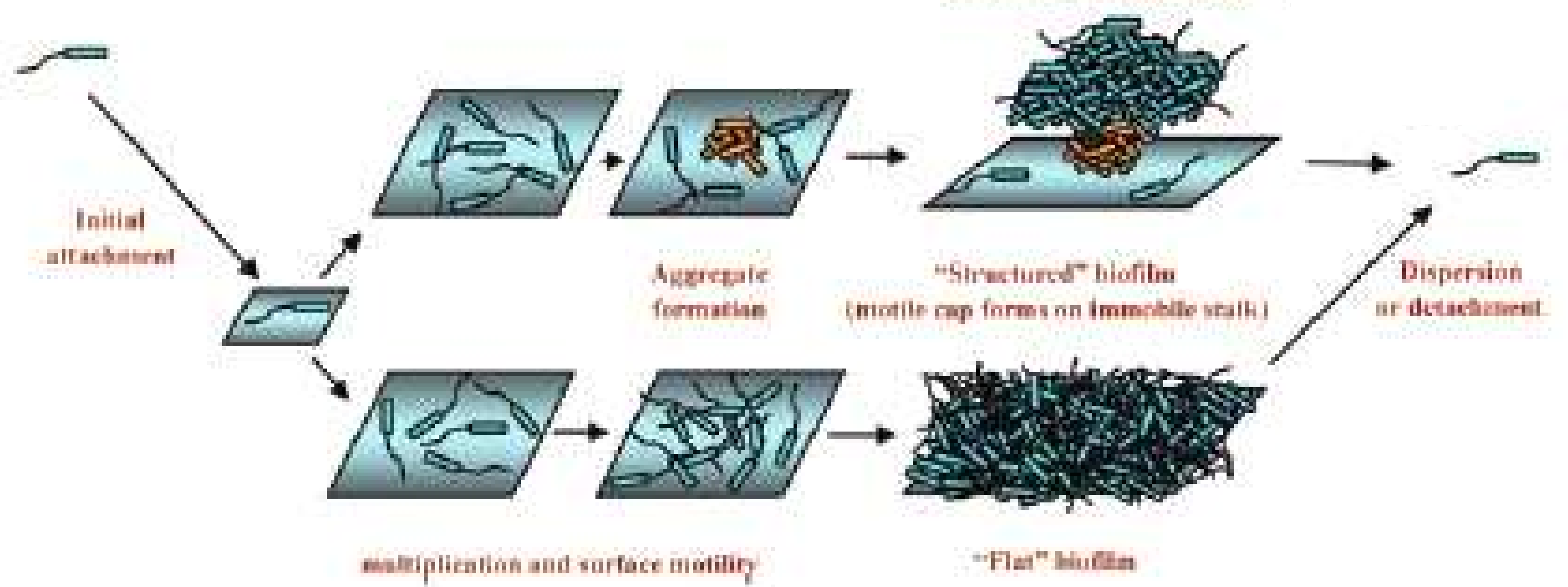
- Résistance accrue aux agents antimicrobiens
- Capacité d'adhésion
- …de connection

IV. Biofilms

3. Fonctionnement d'une population

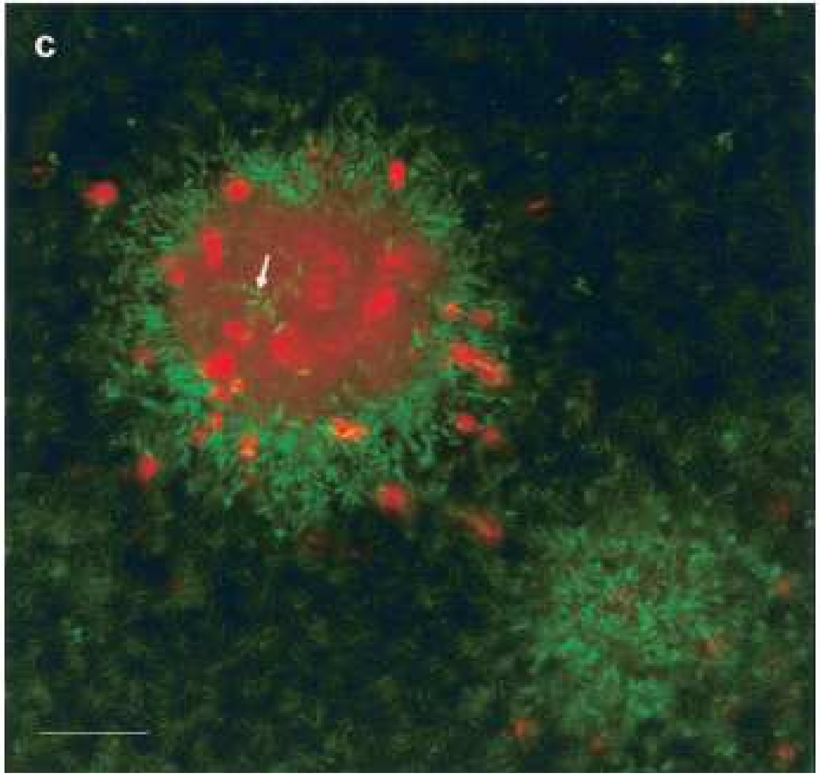
Flow cell



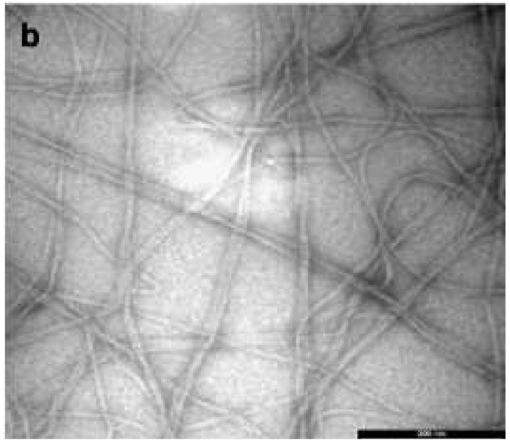


Klausen et al. *Molecular Microbiology* (2003) **50:**61–68

Webb et al. *Journal of Bacteriology* (2003) 185: 4585–4592



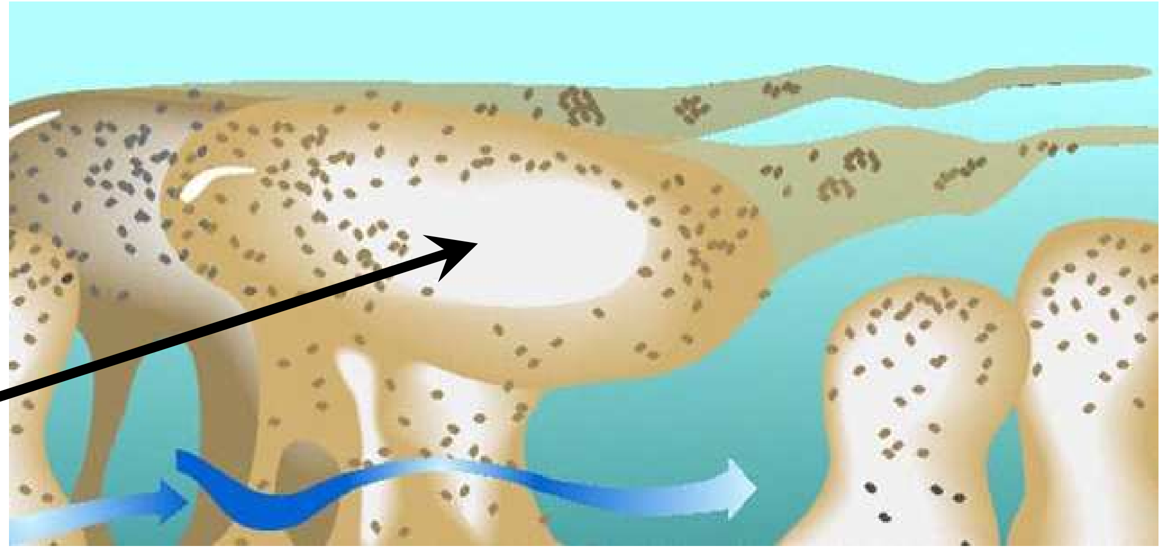
Pseudomonas aeruginosa : vue en microscopie confocale après coloration au SYTO 9 + PI d'une structure en champignon d'un biofilm de 7 jours développé en *flow cell*



Bacteriophage filamenteux

Pf1 - like

Vides



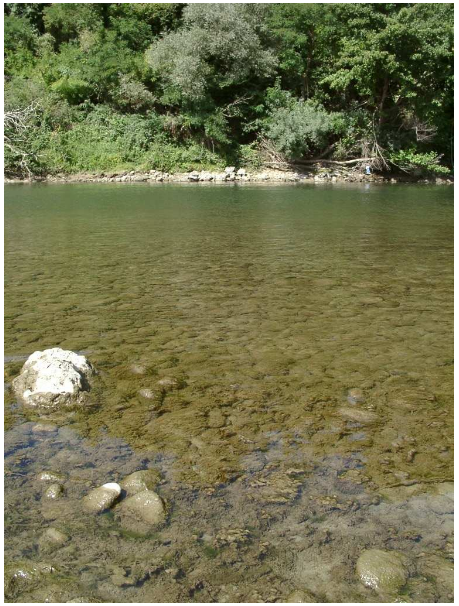
- plages de lyse de cellules induite par phage Pf1 like et/ou *Quorum sensing*
- lysats constituent des nutriments pour les autres cellules du biofilm (cf cannibalisme décrit chez *Bacillus*)
- lysats libèrent le DNA qui chez certains isolats constitue le principal « polymère » qui assure la cohésion du biofilm pourrait être le « rail » de circulation des cellules mobiles (pili IV ⇔ DNA)

IV. Biofilms

4. Fonctionnement des communautés

« *larger* » biofilms =

- Biofilms photosynthétiques
- Biofilms hétérotrophes
- Tapis (*mats*) microbiens
- Biodyctions
- Stromatolithes



Milieux :

Rivières, lacs, aquifères
Océans, salines
Sources hydrothermales

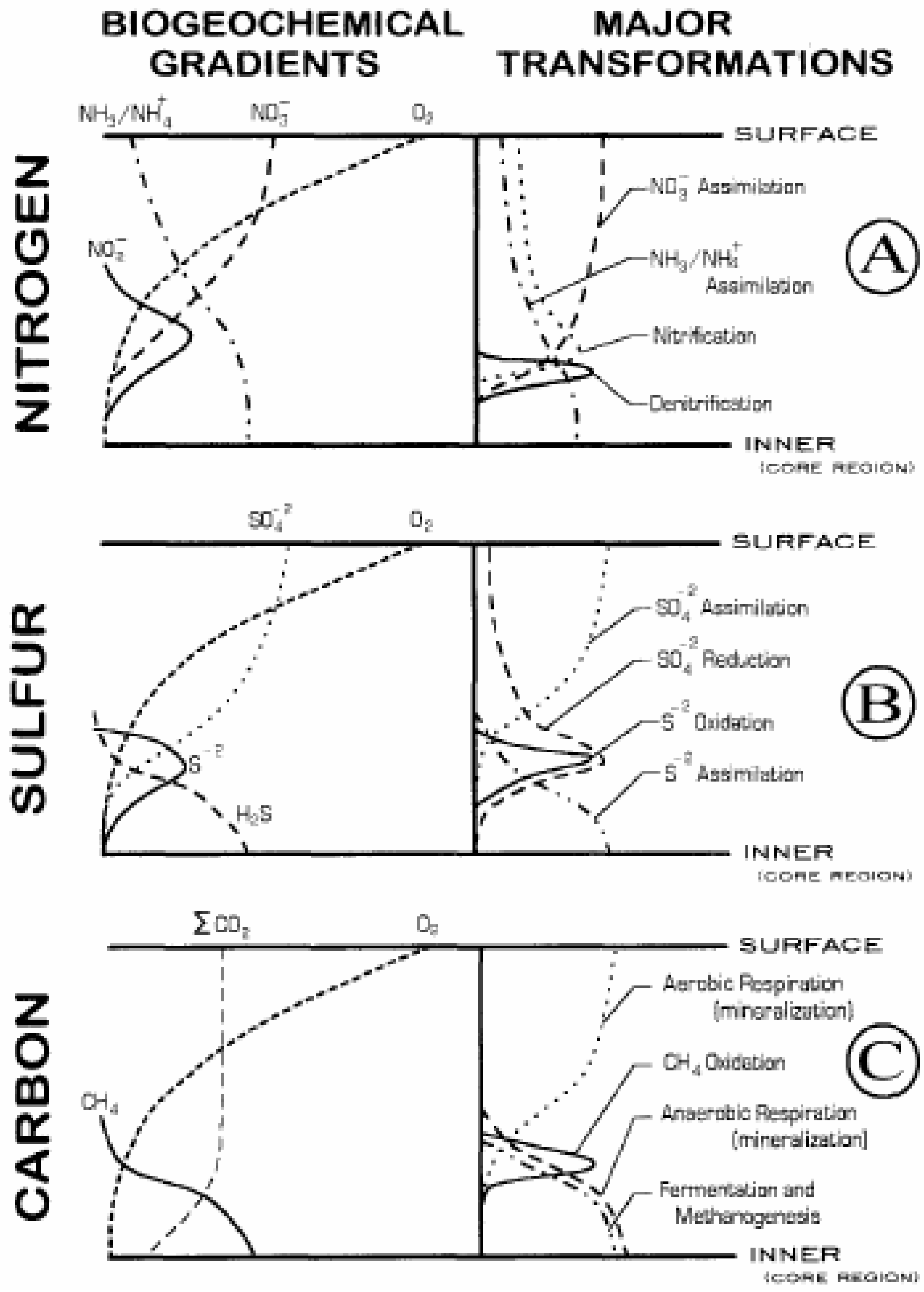
Supports :

Roches,
Sables, sédiments,
Bois, végétaux (feuilles ou racines)
Bioconstruction
Supports artificiels (coques de navires, piles de pont,…)

Diversité :

Procaryotes, eucaryotes,
Phototrophes, chimiotrophes
Aérobie, anaérobie du C, N, S

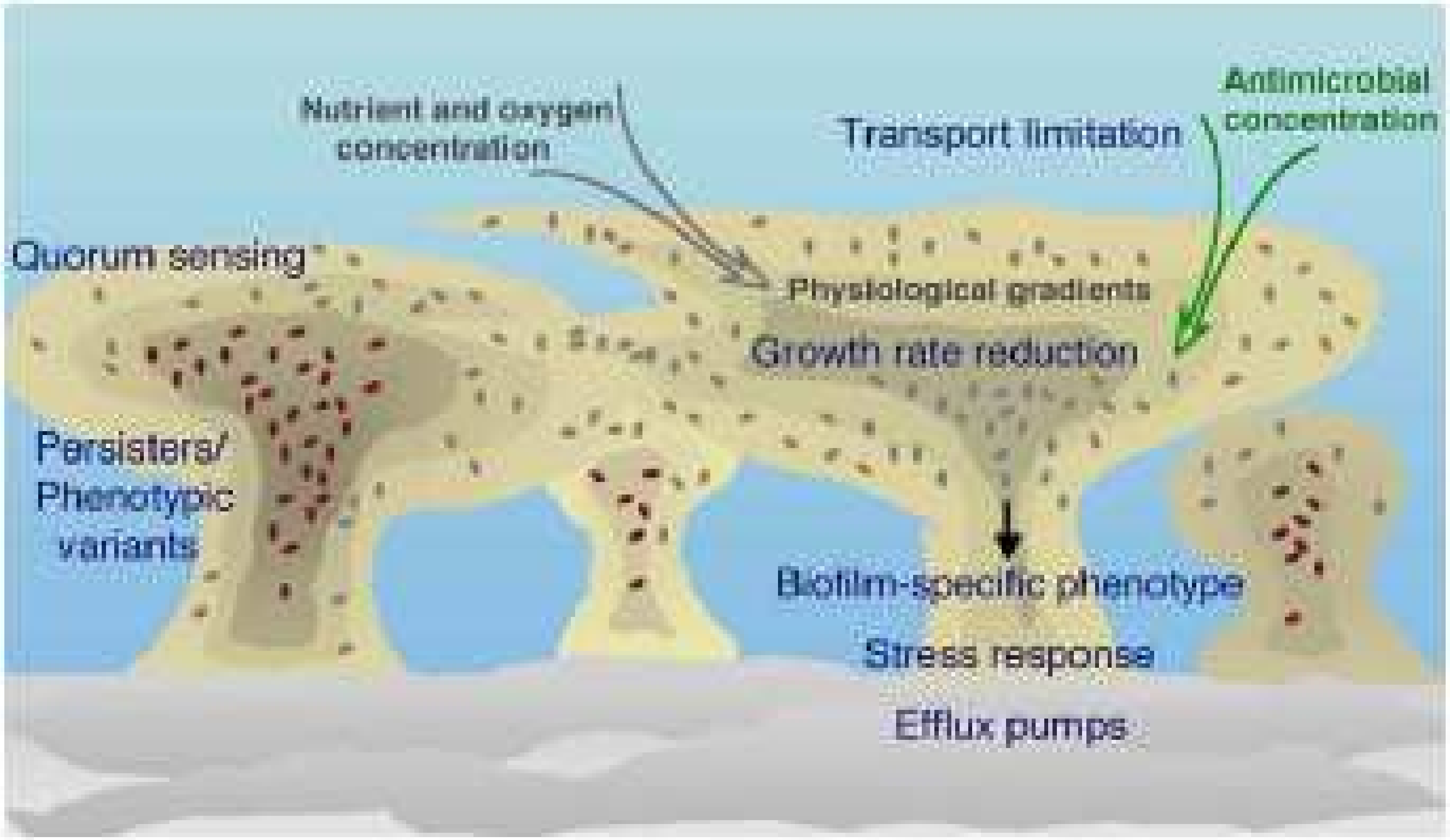
Micro-gradients



Paerl et Pickney
***Microbial Ecology* (1996) 31:225–247**

IV. Biofilms

5. Implications écologiques pour les microorganismes


Nutrient and oxygen concentration
Transport limitation
Antimicrobial concentration
Quorum sensing
Physiological gradients
Growth rate reduction
Persisters/ Phenotypic variants
Biofilm-specific phenotype
Stress response
Efflux pumps

JOURNAL OF BACTERIOLOGY, Nov. 2007, p. 7945–7947 Vol. 189, No. 22
0021-9193/07/$08.00+0 doi:10.1128/JB.00858-07

GUEST COMMENTARY

The EPS Matrix: The "House of Biofilm Cells"▽

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Biofilm Centre, University of Duisburg-Essen, Geibelstrasse 41, D-47057 Duisburg,[1] and Helmholtz Centre for Environmental Research—UFZ, Brueckstr. 3a, D-39114 Magdeburg,[2] Germany, and Wake Forest University, School of Medicine, Winston-Salem, North Carolina 27157[3]

EPS (ex slimes, glycocalyx)

= biopolymères d'origine microbienne dans lesquels les organismes du biofilm sont enveloppés

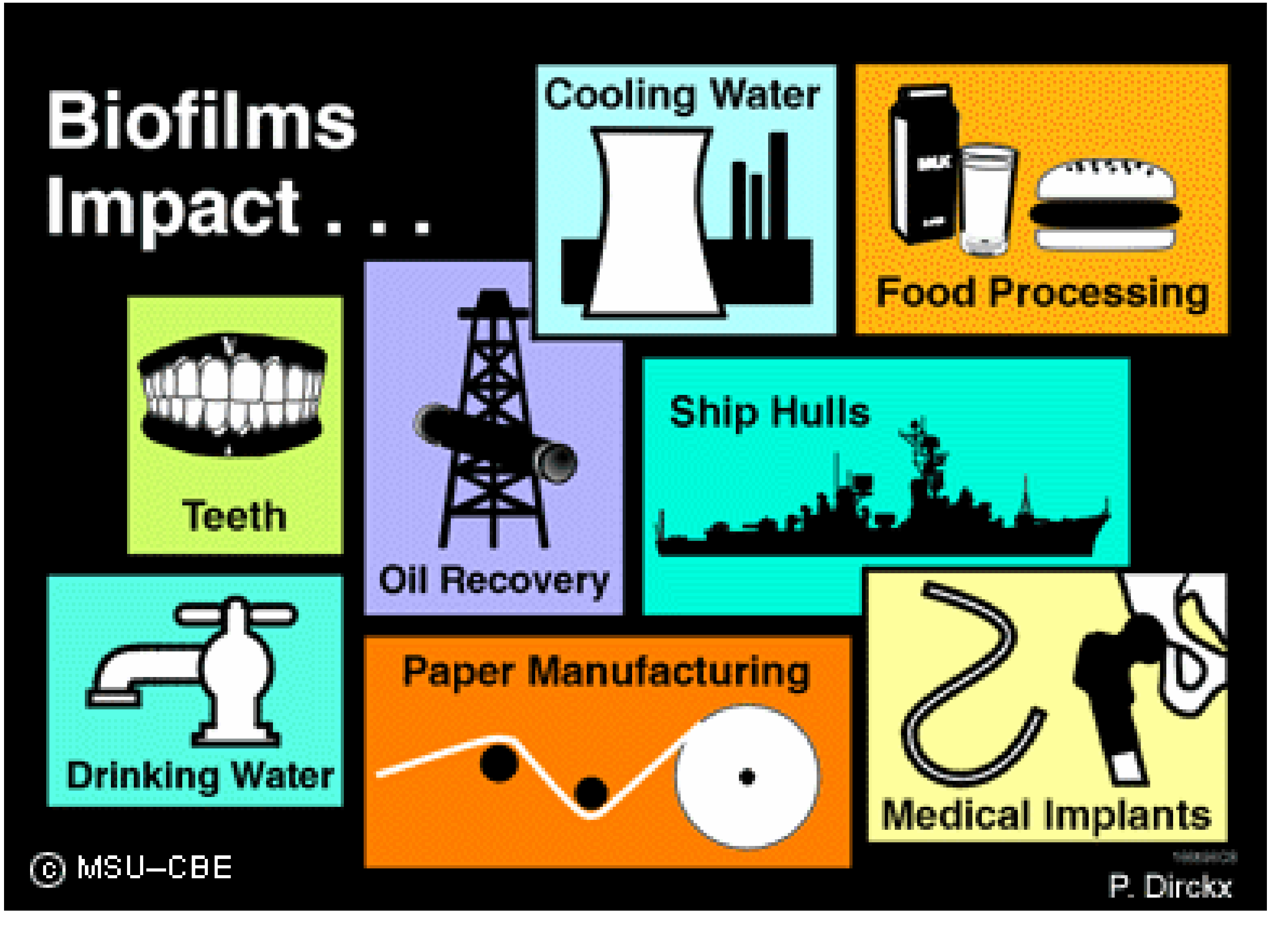
TABLE 1. EPS functionality[a]

Effect of EPS component	Nature of EPS component	Role in biofilm
Constructive	Neutral polysaccharides Amyloids	Structural component Structural component
Sorptive	Charged or hydrophobic polysaccharides	Ion exchange, sorption
Active	Extracellular enzymes	Polymer degradation
Surface-active	Amphiphilic Membrane vesicles	Interface interactions Export from cell, sorption
Informative	Lectins Nucleic acids	Specificity, recognition Genetic information, structure
Redox active	Bacterial refractory polymers	Electron donor or acceptor?
Nutritive	Various polymers	Source of C, N, P

Journal of Bacteriology (2007) 189:7945–7947

IV. Biofilms

6. Implications écologiques et environnementales pour les systèmes



Center for Biofilms Engeneering at MSU-Bozemann

Réservoirs à pathogènes

- *Pseudomonas aeruginosa*
- *Staphylococcus aureus*

- *Legionella pneumophila*

- *Pseudomonas syringae*
- *Ralstonia solanacearum*

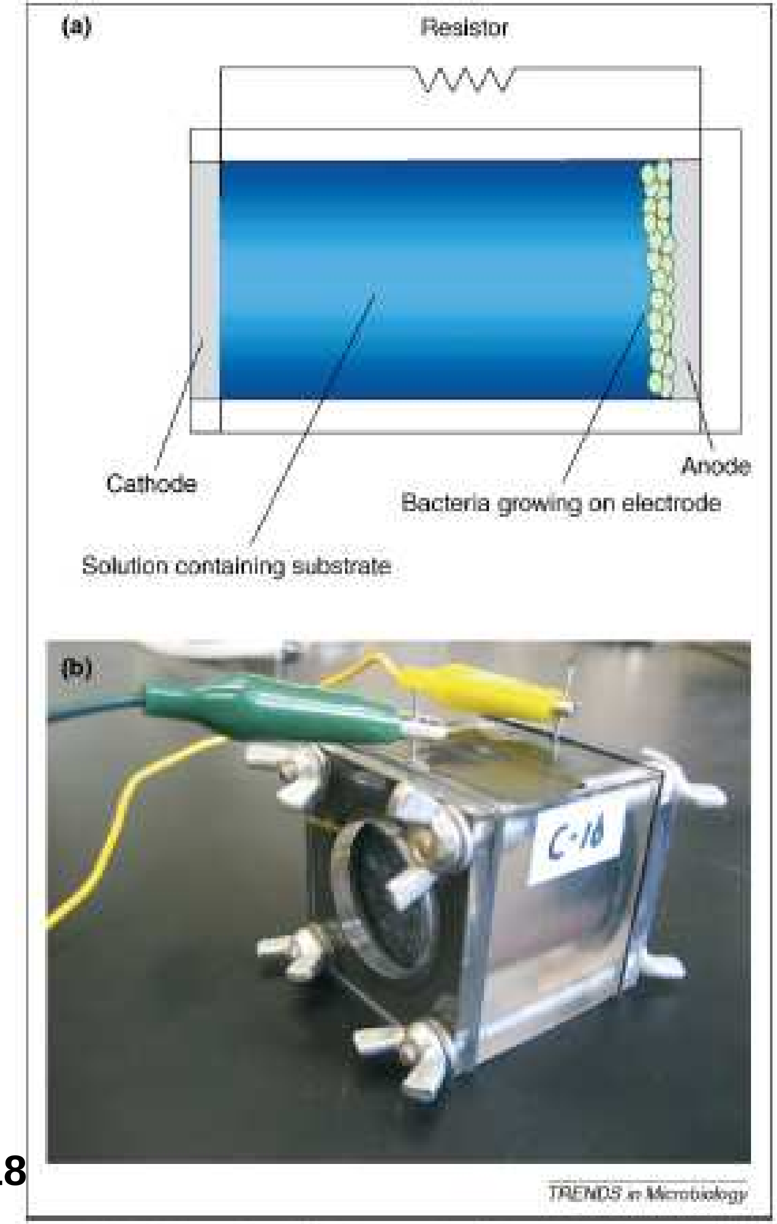
ioremediation of hydrocarbons using biofilms in bioreactors[a]

Pollutant	Reactor or experimental conditions	Organisms or culture	Overall efficiency of degradation	Refs
Chlorophenols				
2-Chlorophenol	Silicone tube membrane bioreactor	Anaerobic sludge from a swine wastewater treatment plant	>90%	[67,68]
4-Chlorophenol	Granular activated-carbon biofilm reactor	Bacterial consortium from rhizosphere of *Phragmites australis*	70–100%	[69,70]
2,4-Dichlorophenol	Rotating perforated tube biofilm reactor	*Pseudomonas putida*	~100%	[49]
2,4,6-Trichlorophenol	Fluidized bed biofilm reactor	*Pseudomonas* sp., *Rhodococcus* sp.	~100%	[50]
2,3,4,6-Tetrachlorophenol	Fluidized bed biofilm reactor	*Pseudomonas* sp., *Rhodococcus* sp.	~100%	[50]
Pentachlorophenol	Fluidized bed biofilm reactor	*Pseudomonas* sp., *Rhodococcus* sp.	~100%	[50]
Pyrene, phenanthrene	Biofilm grown directly on liquid medium	*Polaromonas* sp., *Sphingomonas* sp., *Alcaligenes* sp., *Caulobacter* and *Variovorax* sp.	~50% (pyrene); ~98% (phenanthrene)	[71]
o-Cresol, naphthalene, phenol, 1,2,3-trimethylbenzene	Biofilm grown in NAPLs	*Pseudomonas fluorescens*	Not determined	[72]
n-Alkanes	Rotating biological contactors	*Prototheca zopfii*	~65%	[73]
Carbon tetrachloride	Continuous flow fixed biofilm reactor	*Providencia stuartii*, *Pseudomonas cepacia*	~100%	[74]
Toluene	Hollow-fibre membrane biofilter reactor; continuously fed biodrum reactor	Secondary sludge from wastewater treatment plant; various aerobic and anaerobic bacteria	~84%; 65%	[75,76]
Azo dyes				
Acid Orange 10, 14	Laboratory-scale rotating drum biofilm reactor	*Methylosinus trichosporium*	~60%	[77]
Everzol Turquoise Blue G	Laboratory-scale activated sludge unit	*Coriolus versicolor*	~82%	[78]
Herbicides				
MCPP; 2,4-D	Granular activated-carbon biofilm reactor	Mixed culture of herbicide-degrading bacteria	MCPP (partial); 2,4-D (complete)	[79]

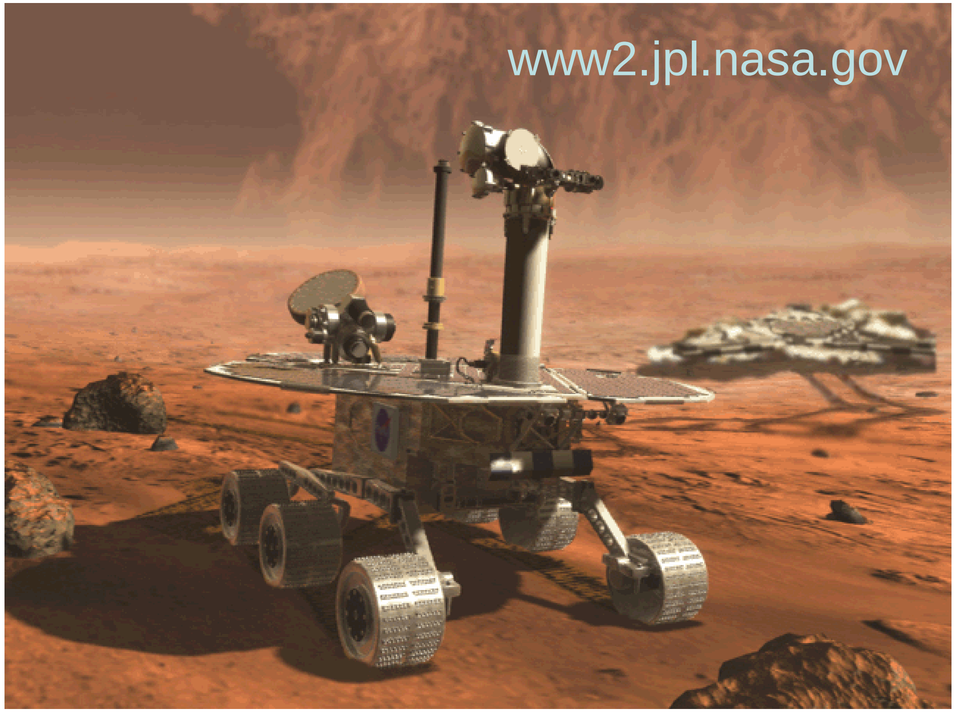
[a]Abbreviations: 2,4-D, 2,4-Dichlorophenoxyacetic acid; MCPP, 2-(2-methyl-4-chlorophenoxy) propionic acid.

TRENDS in Microbiology (2006) 14:389-397

Microbial fuel cells



TRENDS in Microbiology (2006) 14:512-518



de l’histoire de la vie sur Terre à l’exobiologie….