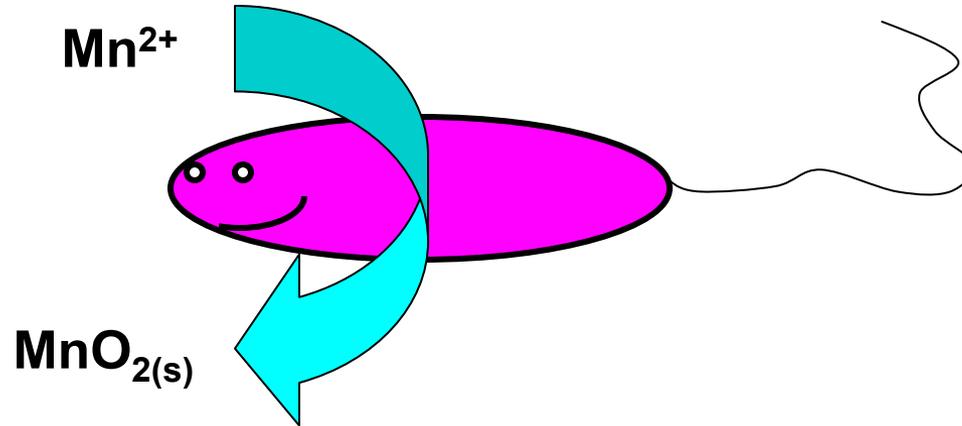


Microbiology of Manganese Oxidation



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Colorado School of Mines

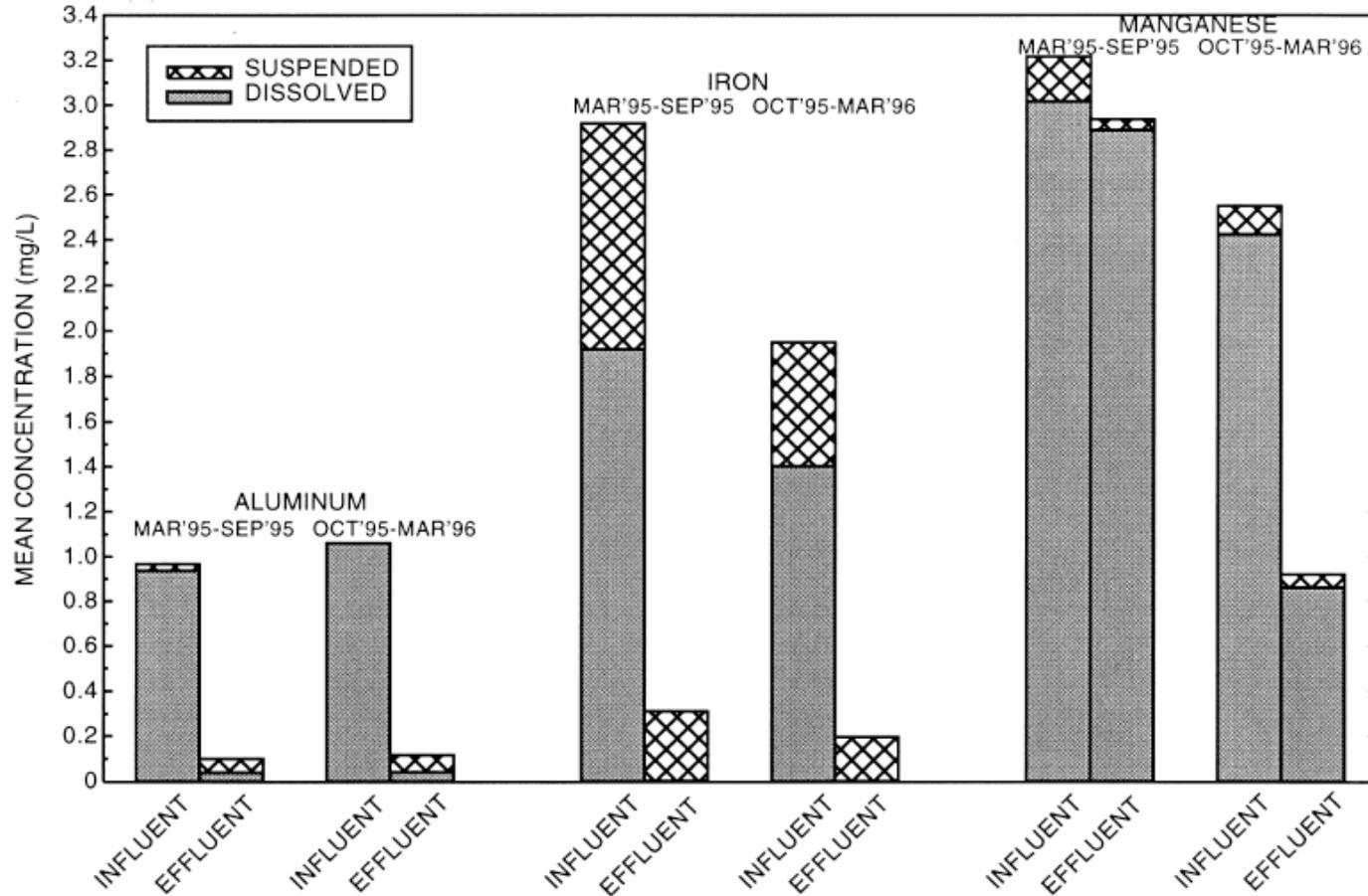
Appalachian Region Technology Transfer
2005 Mine Water Treatment Conference
August 17, 2005



Manganese impacted water

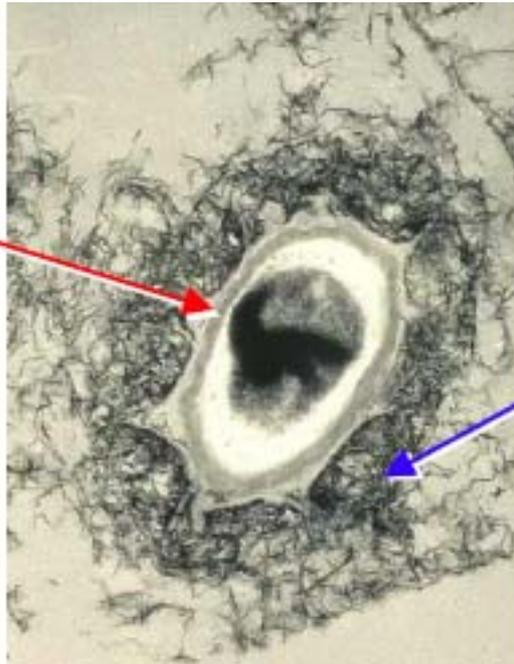


Manganese removal in limestone beds



Biogenic manganese oxidation

Mn(II) oxidizing bacteria



Biogenic Mn-oxides

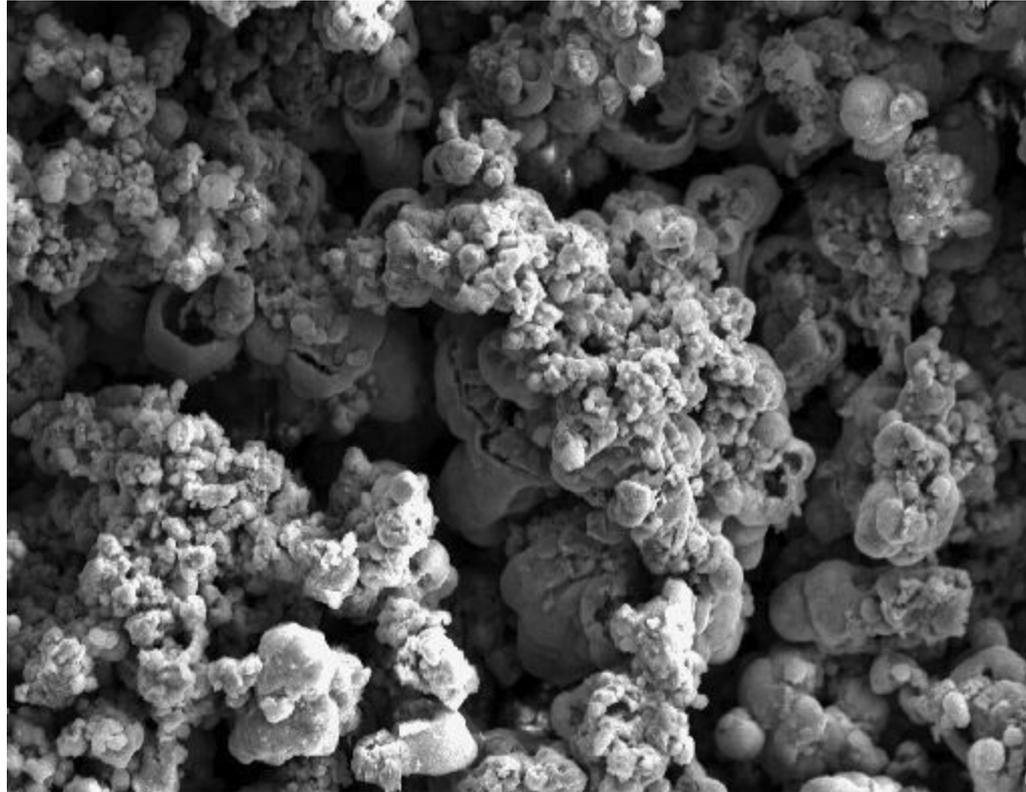
<http://www.nsf.gov/mps/che/nuggets/tebo.pdf>

Leptothrix discophora



http://soils1.cses.vt.edu/ch/biol_4684/Microbes/Leptothrix.html

Manganese nodules



Provided by Charles Cravotta

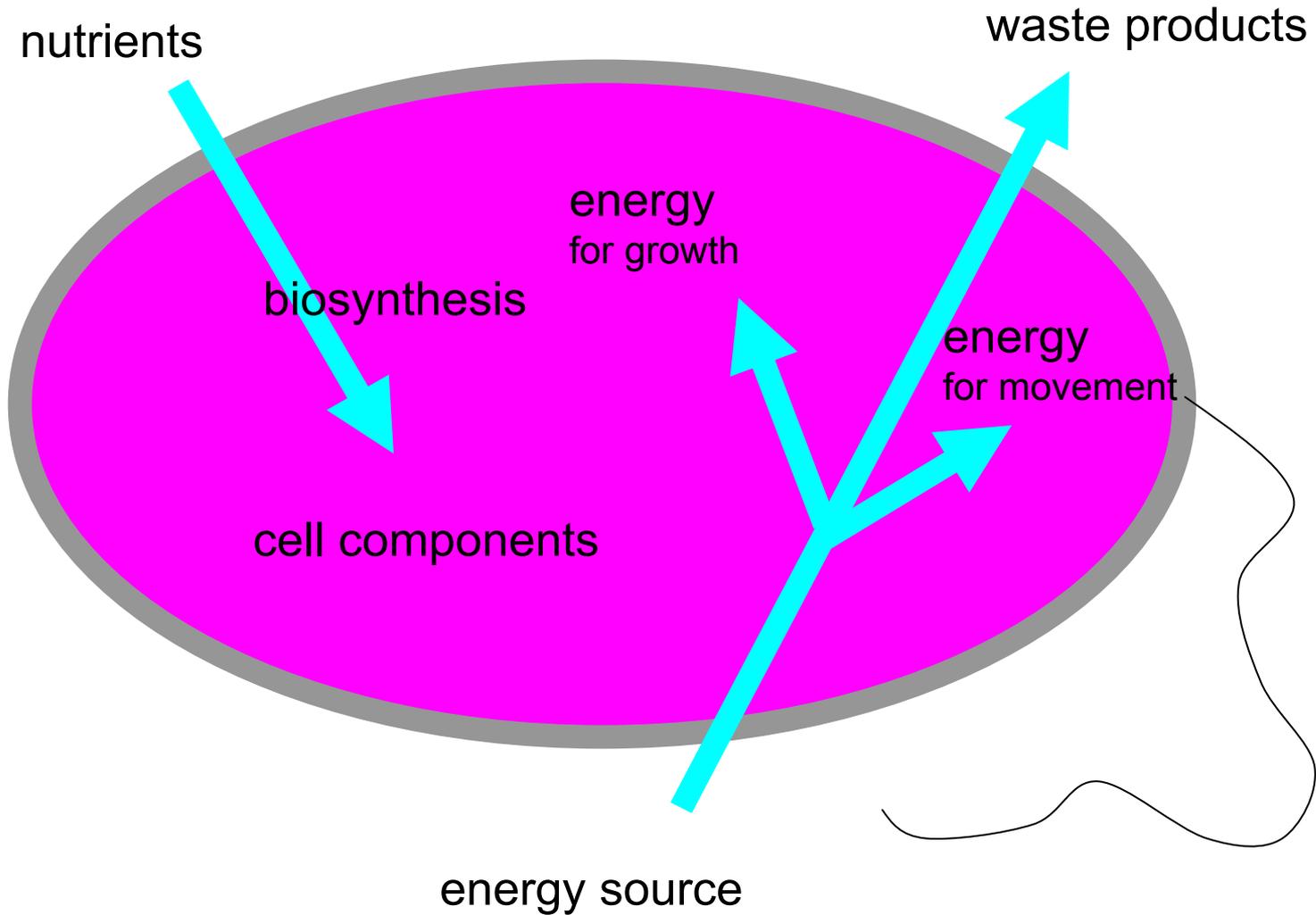
Questions

To what extent do bacteria contribute to manganese oxidation in limestone beds?

What are the environmental requirements to promote manganese oxidation in limestone beds?

What is an appropriate model for the bacterial component of manganese oxidation?

Microbial reactions



Microbial requirements

growth materials

nutrients and carbon

electron donor

electron acceptor

appropriate conditions

Microbially facilitated processes

oxidation/reduction reactions

direct

energy

fortuitous

indirect

nutrient requirement

detoxification

Synergism

Algae

Fungi

Organic producing ecosystem (e.g., wetland)

Reasons for bacteria to oxidize manganese

Energy for growth

Mn(IV) reaction with from humic and fulvic acids to release organic nutrients

Response to low carbon stress

Response to toxic metals

Bind organic substrates to bacterial surface

Modeling

Stoichiometry

Kinetics

Carbon requirement

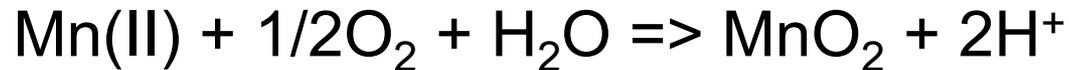
Autotrophic - CO₂

Heterotrophic - organic carbon

Mixotrophic - can use both

Stoichiometry

Manganese oxidation

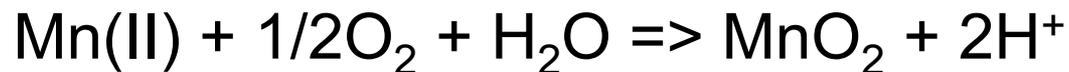
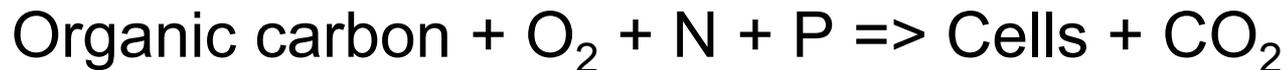


Possible microbial stoichiometries (unbalanced)

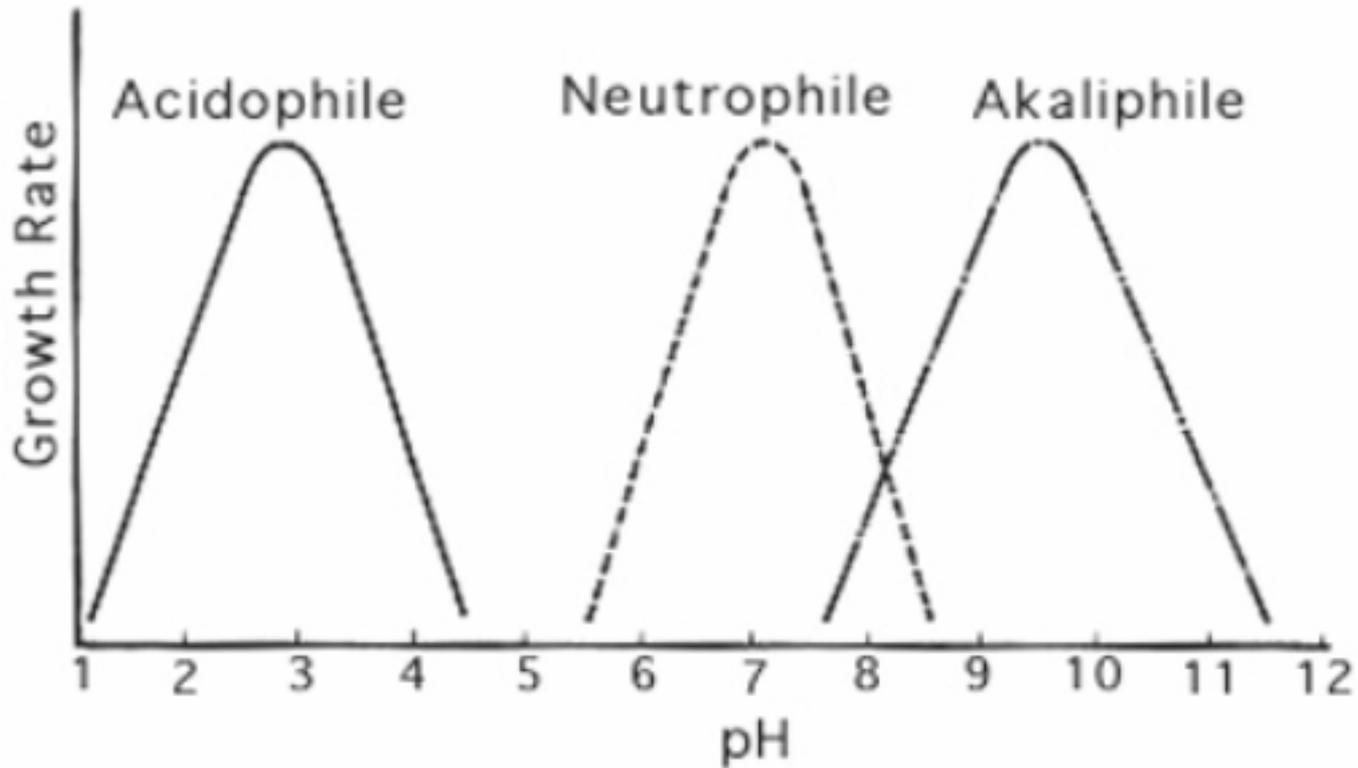
Autotrophic



Heterotrophic

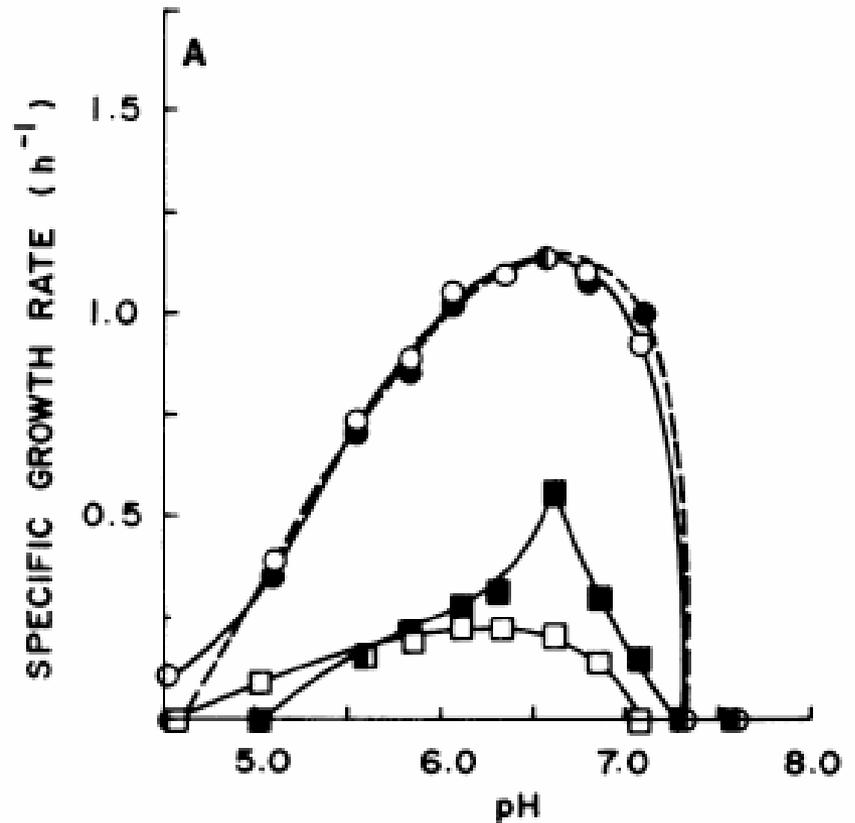
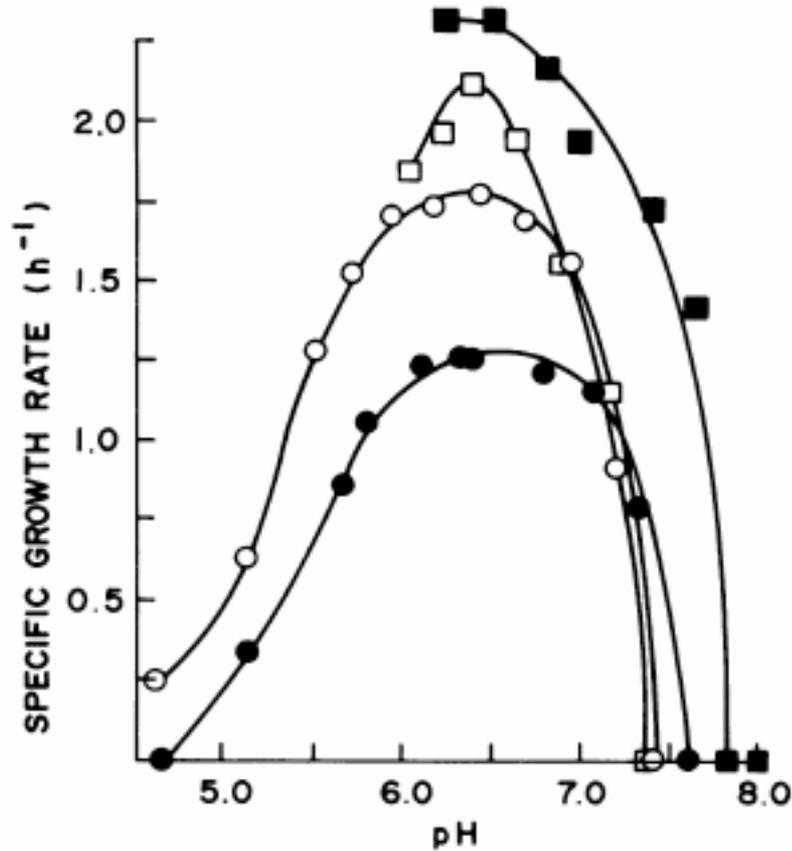


Theoretical pH effects



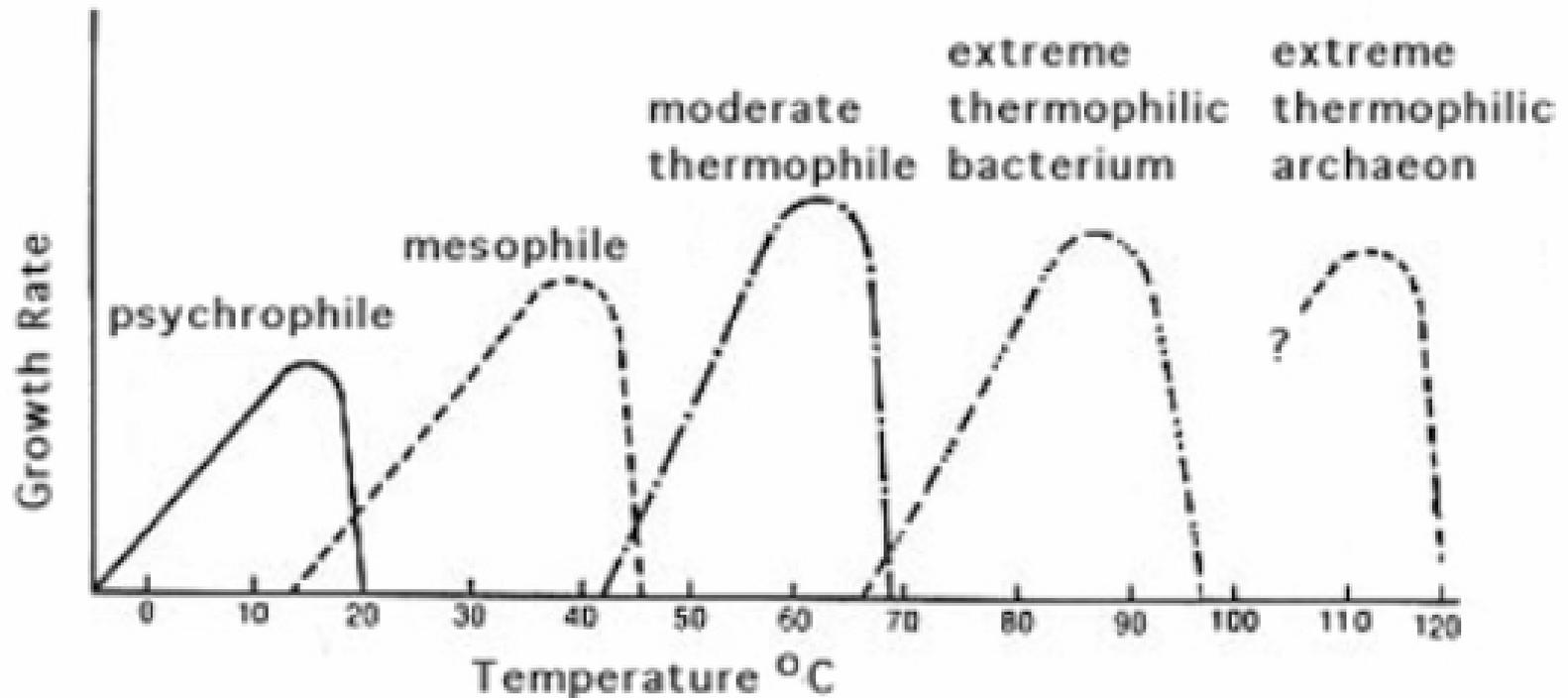
Todar 2004 Online Textbook of Bacteriology

Typical pH effects data



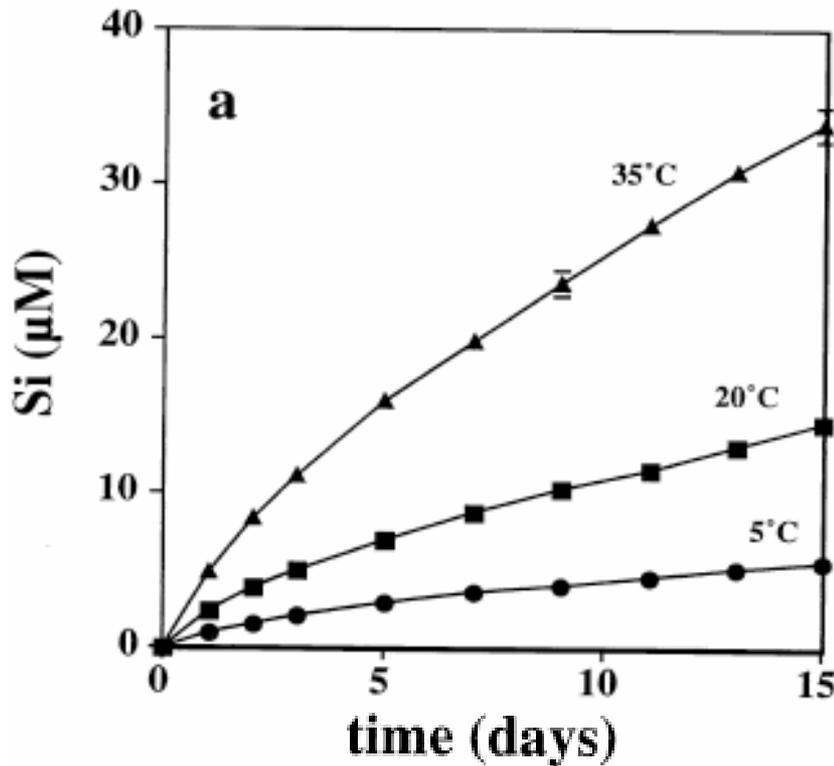
Therion et al. 1982

Theoretical temperature effects

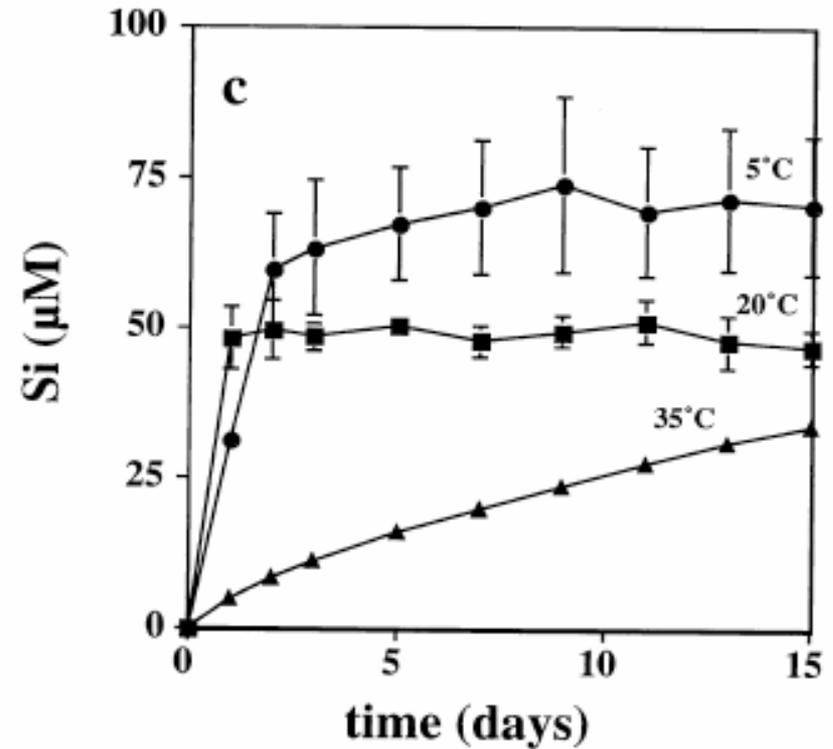


Todar 2004 Online Textbook of Bacteriology

Typical temperature effects data



abiotic feldspar dissolution



*microbially facilitated
feldspar dissolution*

Welch and Ullman 1999

Possible kinetic model

$$\frac{d[Mn(II)]}{dt} = k_0[Mn(II)][O_2] + k_1[Mn(II)][MnO_2] + \text{microbial term}$$

Microbial term (heterotrophic, no energy from Mn(II) oxidation)

$$\frac{d[Mn(II)]}{dt} = k_3 \frac{[Mn(II)]}{K_{Mn} + [Mn(II)]} \frac{[O_2]}{K_{O_2} + [O_2]} [X_{Mn}]$$

$$\frac{d[X_{Mn}]}{dt} = k_4 \frac{[S]}{K_S + [S]} \frac{[O_2]}{K_{O_2} + [O_2]} [X_{Mn}]$$

Summary

To what extent do bacteria contribute to manganese oxidation in limestone beds?

Variable, difficult to establish

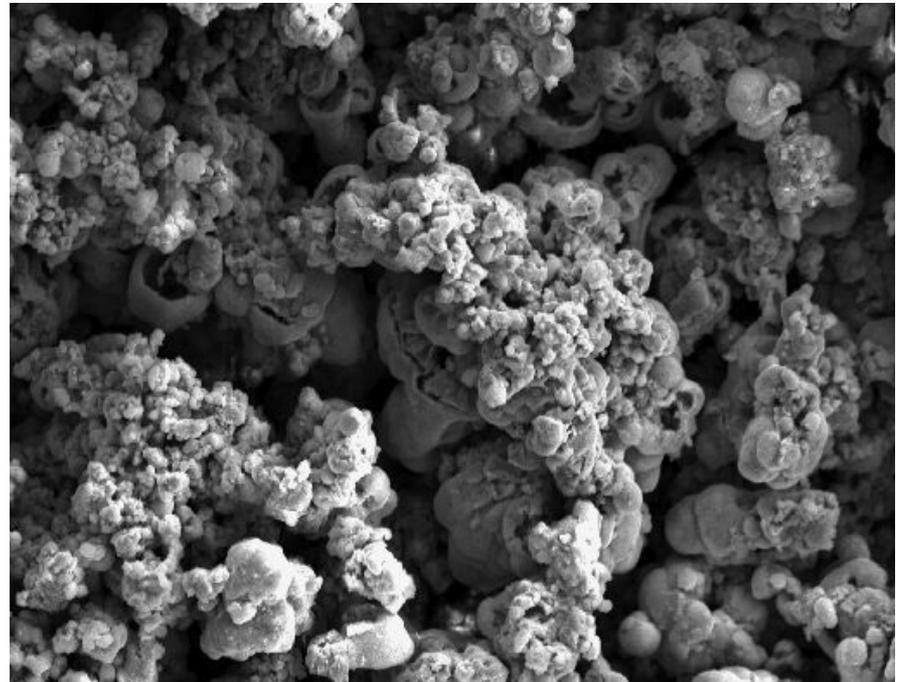
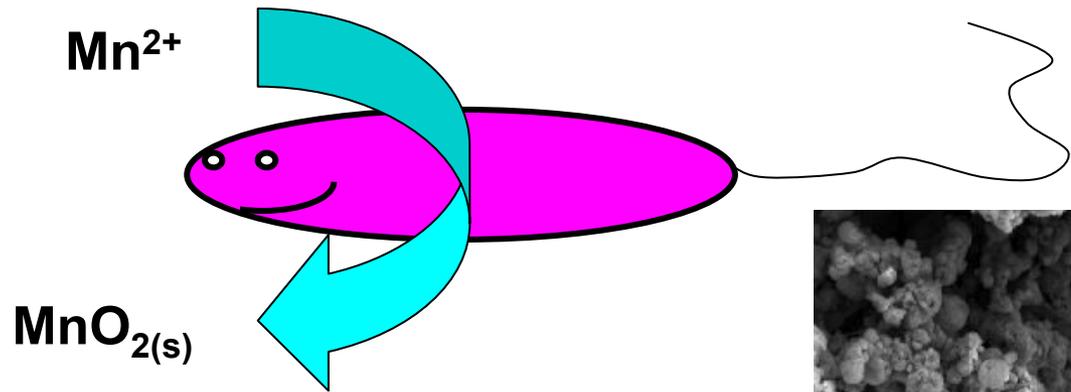
What are the environmental requirements to promote manganese oxidation in limestone beds?

Importance of individual requirements not clear

What is an appropriate model for the bacterial component of manganese oxidation?

Model proposed for heterotrophic manganese oxidation

More work is need in understanding
microbial contribution



Acknowledgements

Thomas Wildeman (CSM)

Bradley Tebo (Scripps)

Brian Parks (MSE)

John Spear (CSM)

Brent Means (OSM)

Charles Cravotta (USGS)

Amy Pruden (CSU)

Karen Johnson (Durham)