USC *Geobiology* *Astrobiology* CENTER for LIFE DETECTION JPL

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SHEWANELLA and Genomes to Life !! THE FUTURE!!

WHERE ARE WE GOING?

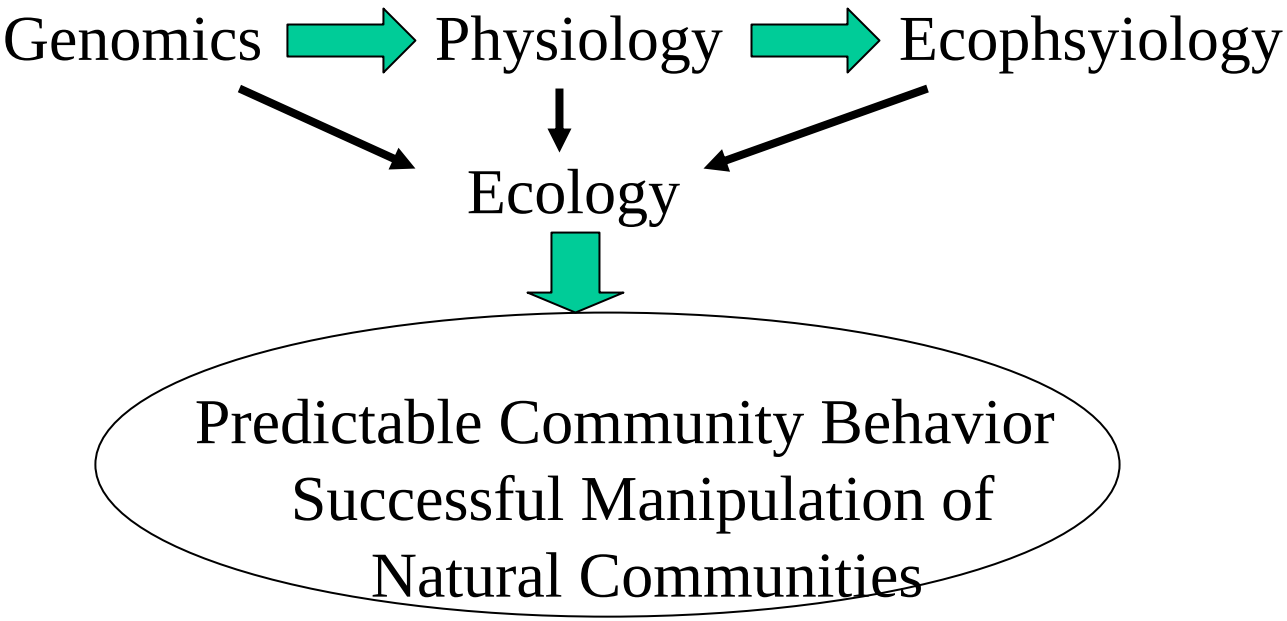
HOW WILL WE GET THERE?

WHAT ARE THE CHALLENGES AND TRAPS?

Genomes to Life: Shewanella and the future !!

Genomes & Genomics: For sake of this discussion, I include

Genome composition, gene expression, & metabolism



Shewanella in the future:

Short Term: Genomic/Proteomic/Metabolic Connections

Linkage of physiology to genomic information

Mid Term: Ecophysiology

Questions regarding regulation of MR-1

How does the cell”work”?

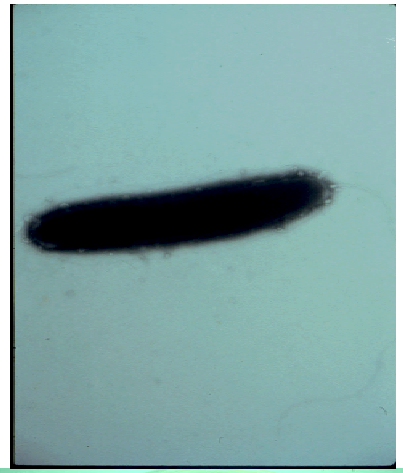
Linkage of laboratory to microcosm and field data

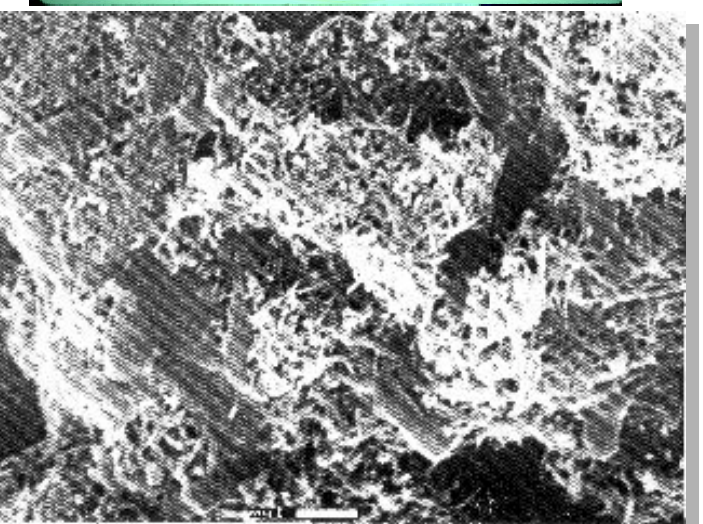
Long Term: Community structure and activities

Genetic variability and use of genomic approaches

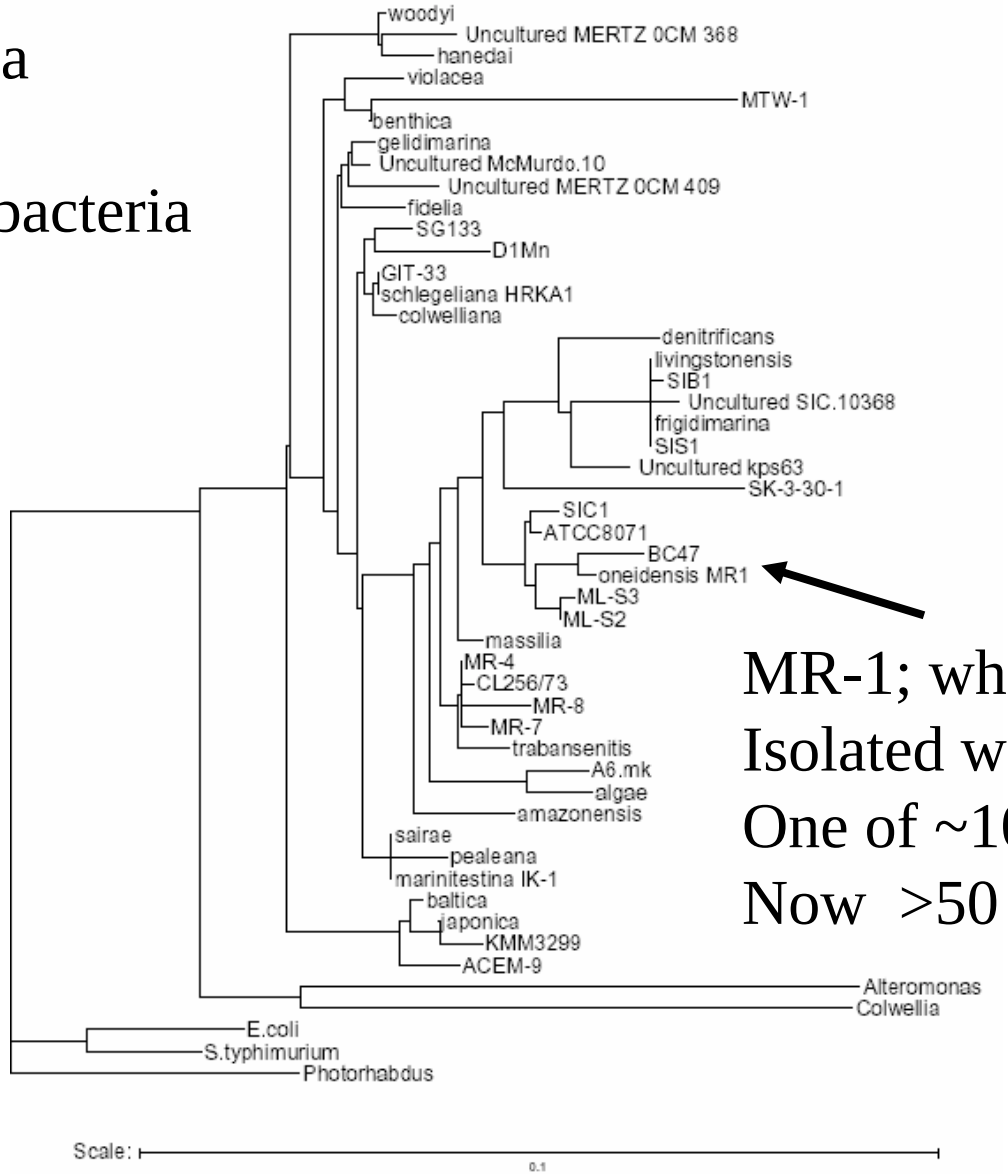
Predictable community ecology

The “old view” of *Shewanella oneidensis*



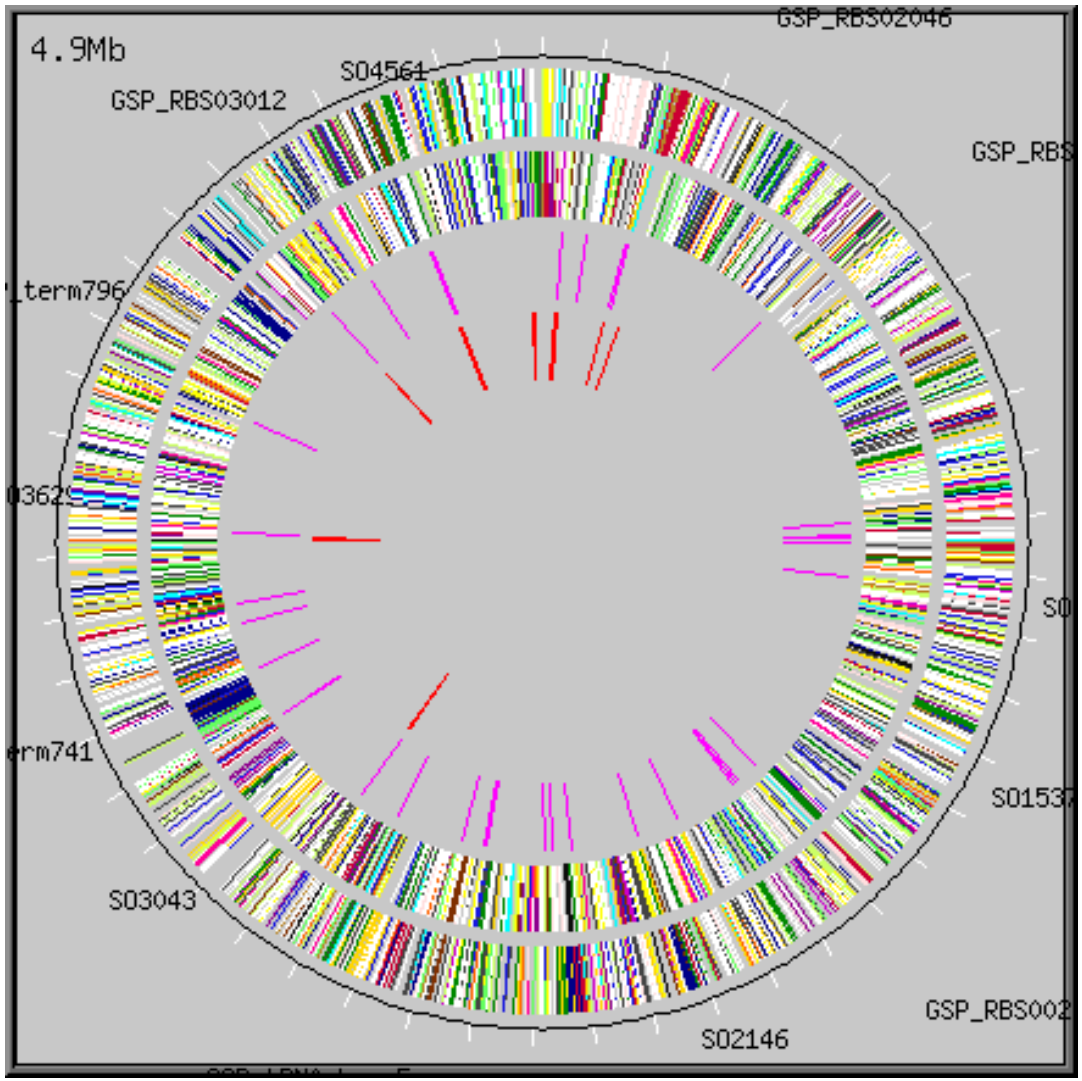


Gamma
Purple
proteobacteria



MR-1; when
Isolated was
One of ~10,
Now >50 !

The “new view” of *Shewanella*



Now MR-1 is again one of 1, although a strain of *S. benthica* is almost finished by a Japanese group (JAMSTEC)

Excitement of the “new view”:

May be able to use this information to dissect specific aspects of both ecology and evolution:

Ecology:

Involved in many different redox processes
Aerobic and anaerobic niches
Metal cycling connected with carbon cycling
Potential for dealing with many toxic metals and radionuclides

Can we understand *Shewanella* well enough to begin to use it?

what it does
how it does it
how it regulates
how it interacts with other organisms

All of this well enough to make predictions that work.

Dangers of the “new view”

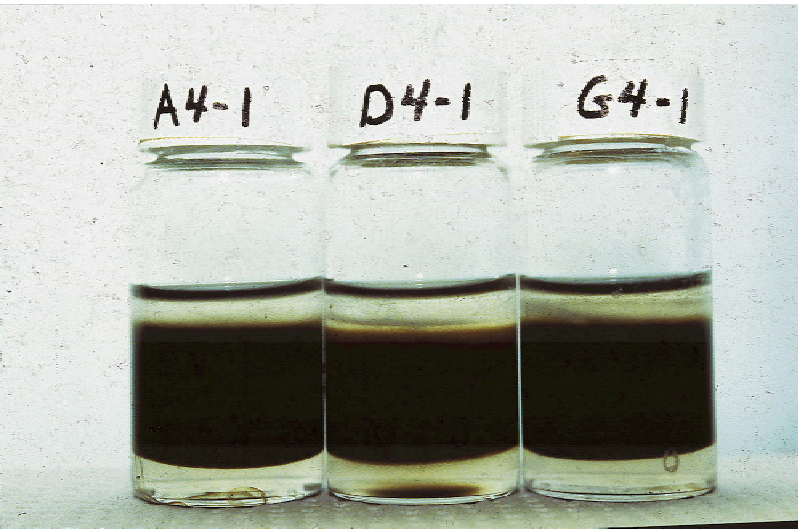
1. We forget that it is what it does that counts, rather than what its potential is; clearly it is capable of doing many different things – which will it do, and when?

2. We forget that surface attachment may be vital for expression of some of its functions.

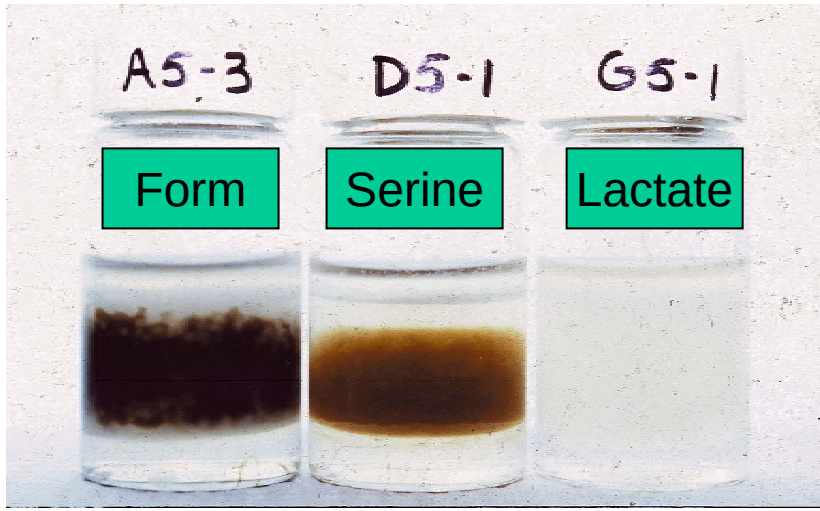
3. We forget that it seldom lives alone

4. We forget that there are many species of this genus, and that they may exhibit fundamental differences.

Starting Cultures

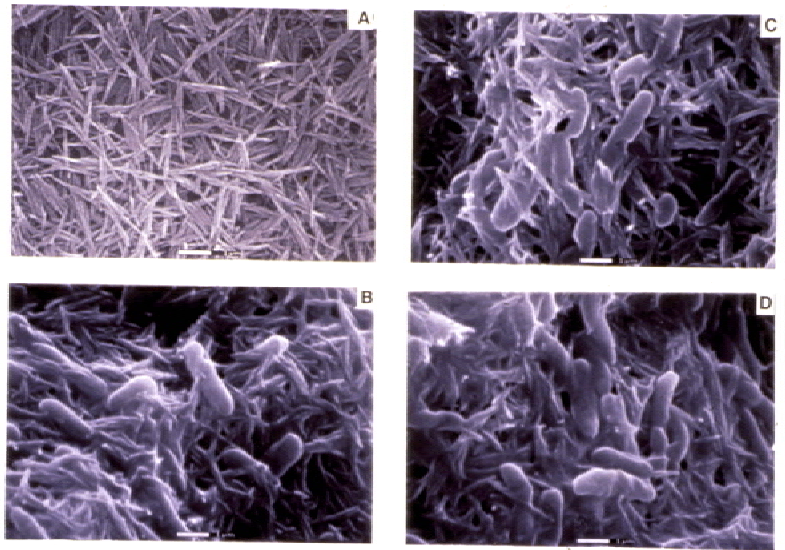


Five Days Incubation

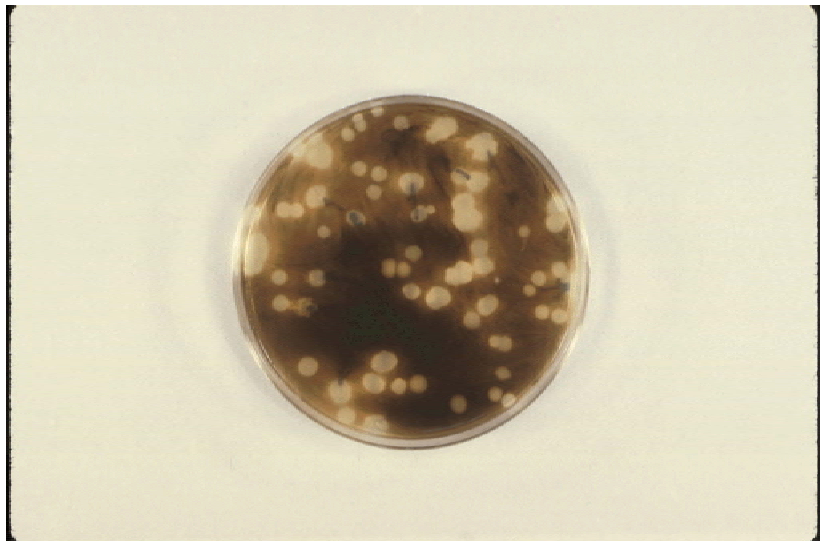


IT'S WHAT IT DOES THAT COUNTS !!

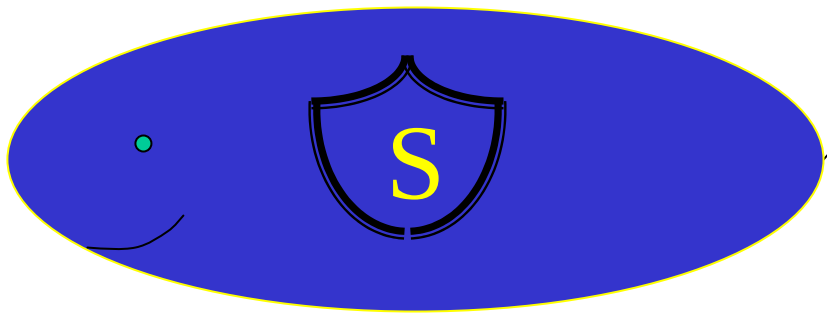
Pure Culture on MnO_2



Breathing Mn oxide!



Shewanella oneidensis – MR-1



Formate

Lactate

Pyruvate

Amino Acids

H_2

Mine waste
Black Sea
Oneida Lake
Green Bay

Panama Basin
Mississippi Delta
North Sea Redox Interfaces

O_2

NO_3^-, NO_2^-

Mn(IV)

Mn(III)

Fe (III)

Fumarate

DMSO

TMAO

S^o

$S_2O_3^{2-}$

U(VI)

Cr(VI), Tc, As, Se, I,

With this kind of versatility, what will it really do?

This kind of insight helps us frame the questions that we know we need to answer.

Need constant feedback from Federation for this!

Start with sets of Conditions:

1. Nutrient limitation (C,P,N,S)
2. Electron donors (hydrogen, formate, lactate, serine)
3. Electron acceptors (O_2,NO_x,metals, etc.)

Process measurement

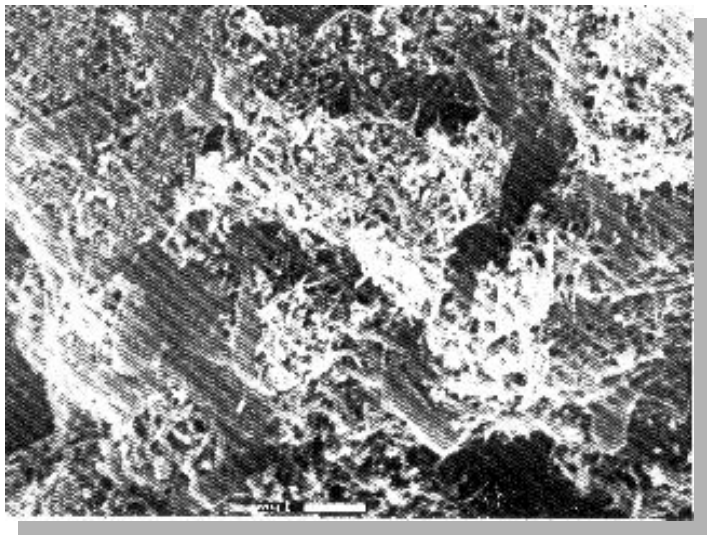
- Oxygen metabolism
- Nitrate uptake
- Metal reduction
- Growth rate (DNA,RNA,protein synthesis)
- Specific synthesis of cytochromes

FOR EXAMPLE !!

Table 1: Molar Growth Yields and Products Excreted by *Shewanella* growing anaerobically with TMAO as electron acceptor

Substrate	Growth Yield[a]	Gen. Time (h)	CO_2[b]	Acetate[b]	Alanine[b]	NH_3[b]	% C Recov.
Serine	17.5	12	2.8	0.0	0.11	0.9	104
Cysteine	17.5	12	2.7	0.0	0.10	1.1	98
Lactate	11.5	7	2.0	0.42	0.06	0.3	100
Formate	5.0	13	nd	0.0	0.0	0.2	nd

[a]Molar growth yield as μg dry weight/μmole of substrate oxidized
[b]Product excreted is expressed μmol/μmole of substrate oxidized



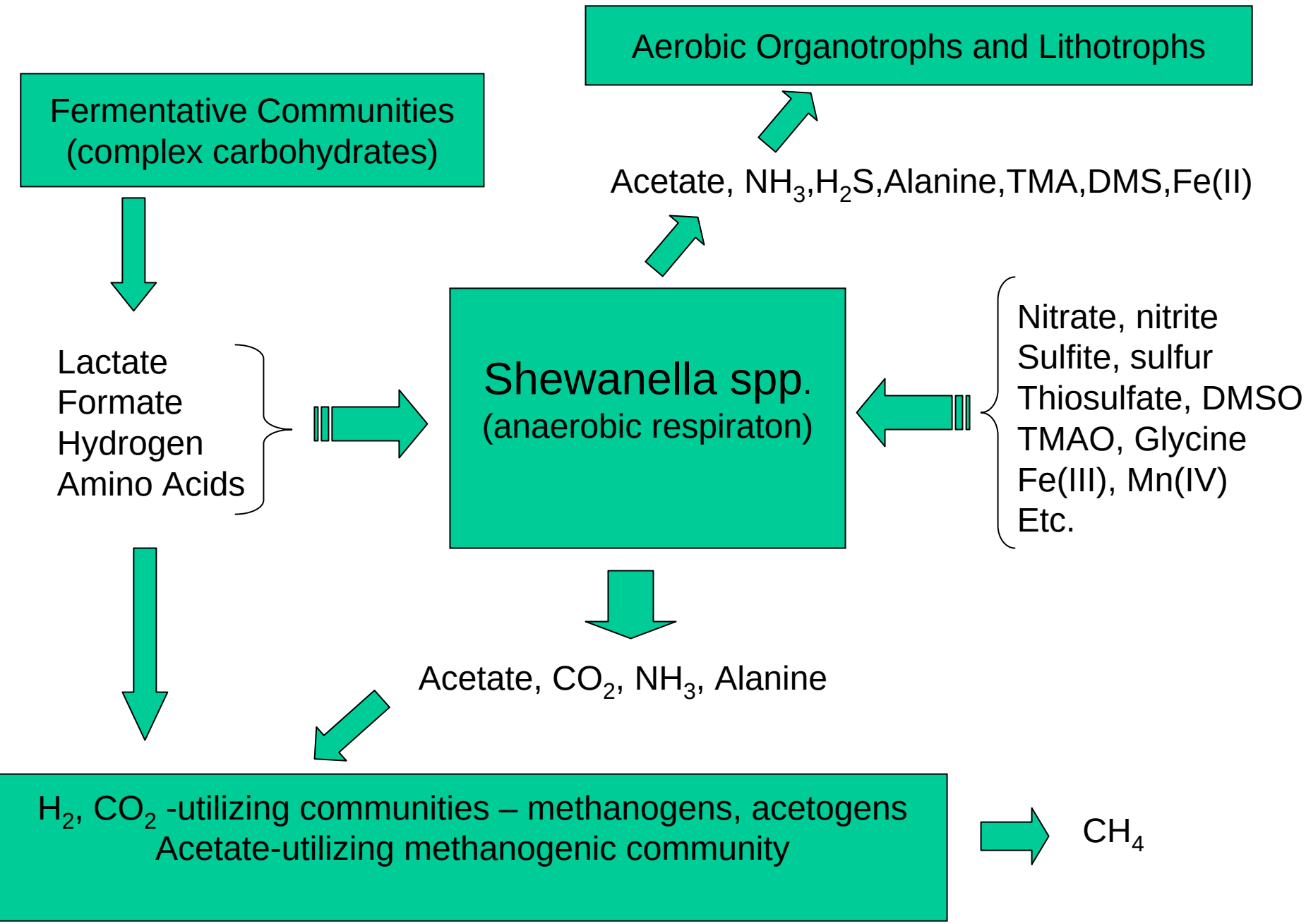
Surface attachment may be crucial to activities:

Studies of effect of attachment on genomic expression

Complex interactions of *Shewanella* with surfaces

- Gene modulation via and during surface attachment
- Importance of attachment for key reactions

Will require close collaboration between physiology and genomics



***Shewanella* does not live alone !!**

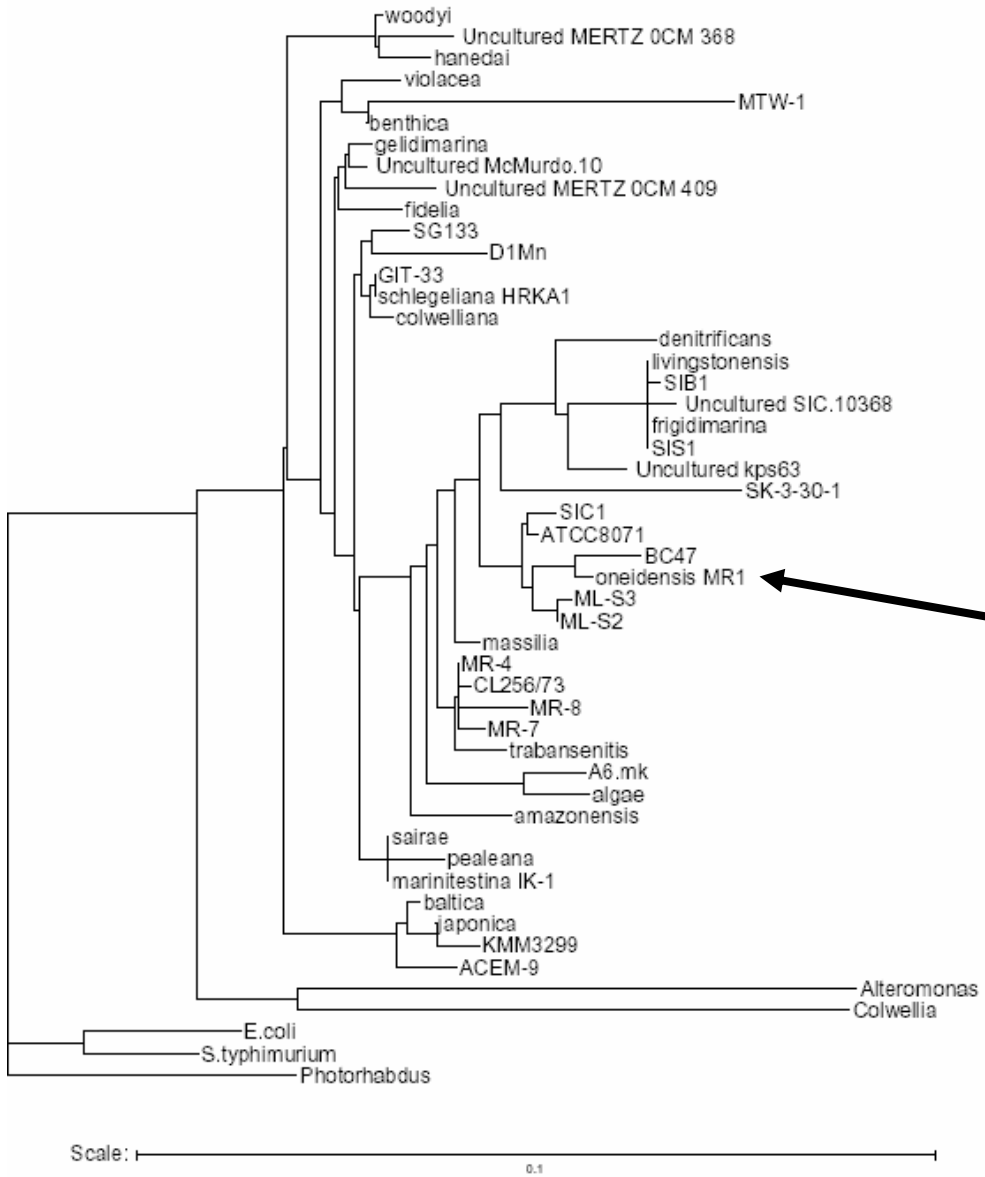
Shewanella (and probably all other bacteria!)
SELDOM ARE FOUND ALONE!!

Consider natural partners: need environmental data

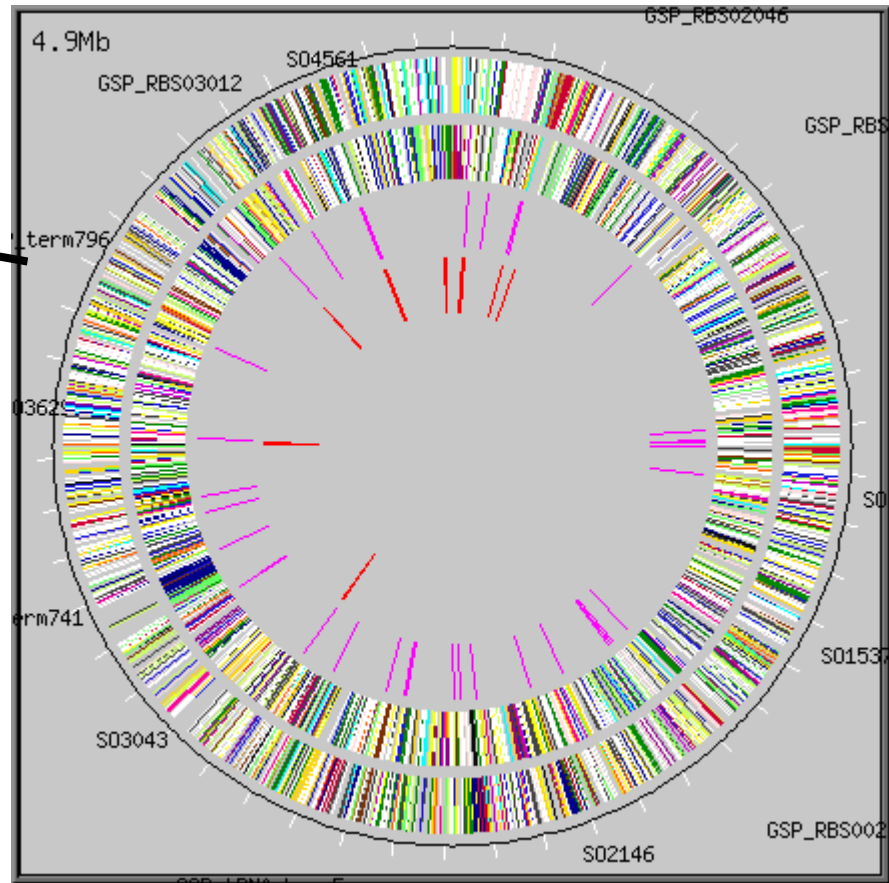
Do genomics with and without associated organisms

Expression of key activities
May want to use mixed cultures for remediation

Genomic indicators in response to other cultures
May lead to insights regarding regulation
Cell-cell communication
Metabolite removal or supply



MR-1 is one of many shewanellae



Now see a large diversity of shewanellae:

Get some sense of genomic variability of Shewanella group

Choose several strains for sequencing

Choose with care and some insight

Goal should be to assess the viability of genomic approach for "real world" work

SUMMARY AND CLOSING THOUGHTS:

1. Immediate future is well defined:
   chemostats and nutrient limitation
   definition of cell regulation
   relationship between genome, proteome, and physiology
      metabolome – need fluxes not numbers!
2. Next steps will involve interactions with envioronment
3. More difficult endeavors will include:
   community interactions
   diversity within the group
   models of community interactions – predictive ecology
4. Perhaps most important single thing now will be a close link between molecular scientists and those doing physiology. We need to make sure we are asking the right questions!!

SF Team

- **Argonne National Lab**
  - **Carol Giometti**
  - Sandra Tollaksen
  - Gyorgy Babnigg
- **BIATECH**
  - **Eugene Kolker**
  - Alex Picone
  - Sam Purvine
  - Brian Tjaden
  - Tim Cherny
  - Alex Nesvizhskii (ISB)
  - Andy Keller (ISB)
  - Serg Stoliar (UW)
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  - Xuedan Liu
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