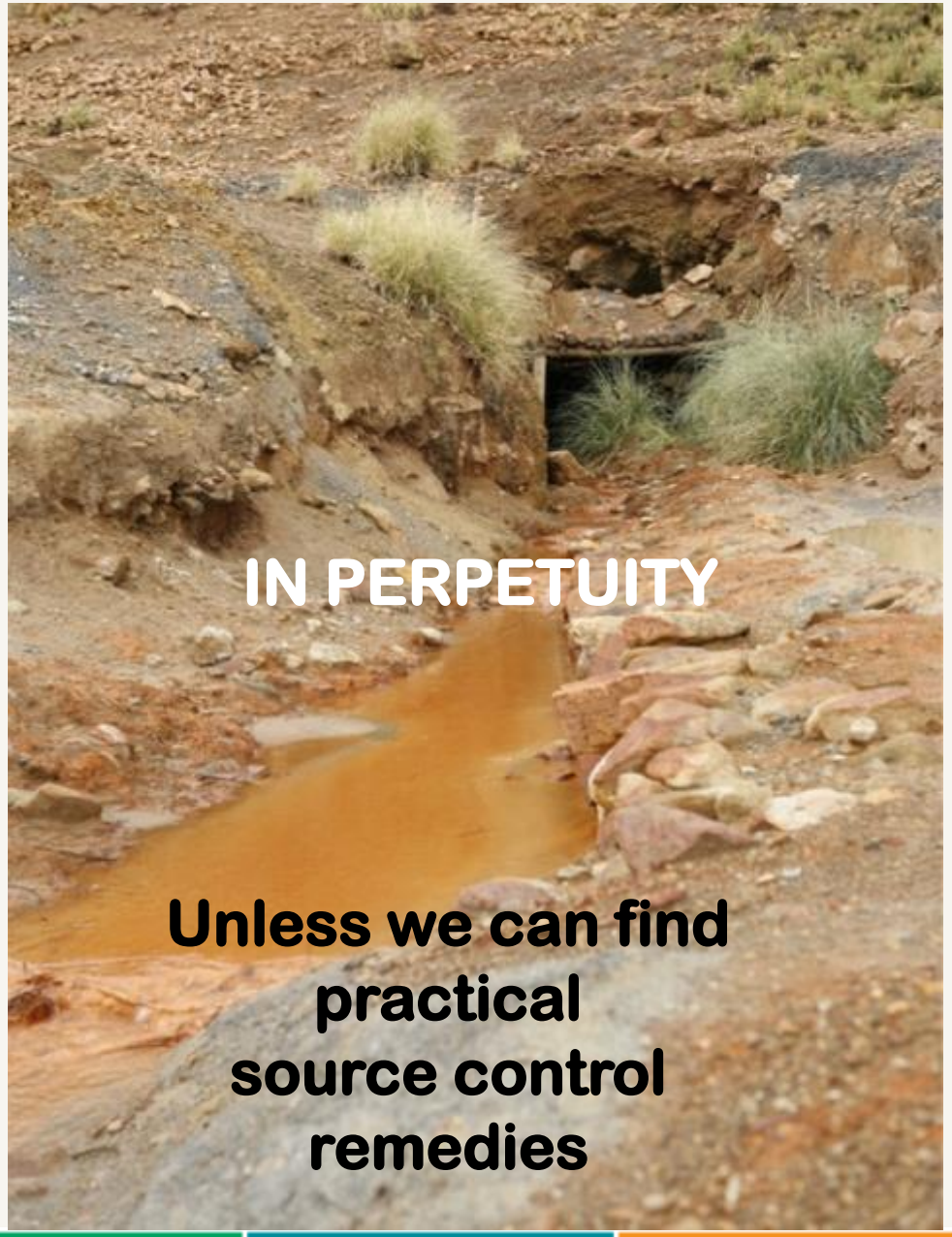
# A Pathway to Walk-Away? 30 Year Old Technology to Suppress Acid Rock Drainage Revisited

*By Jim Gusek, P.E.*
*Golden, Colorado*

Linkan ENGINEERING

*Solutions for the World of Water*

# Acid Rock Drainage

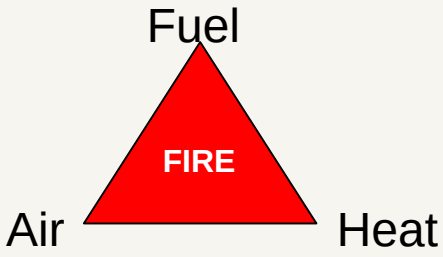


# OUTLINE

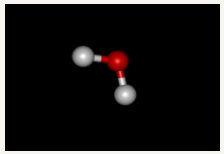
- ARD Suppression Background
  - ARD Tetrahedron
  - History
  - How Bactericides Work

- A Pathway to Walk-Away?
  - Employ New Technologies
  - **D**ecimate, **O**ut-Compete; **S**ustain [**DOS**]

# Acid Rock Drainage Tetrahedron

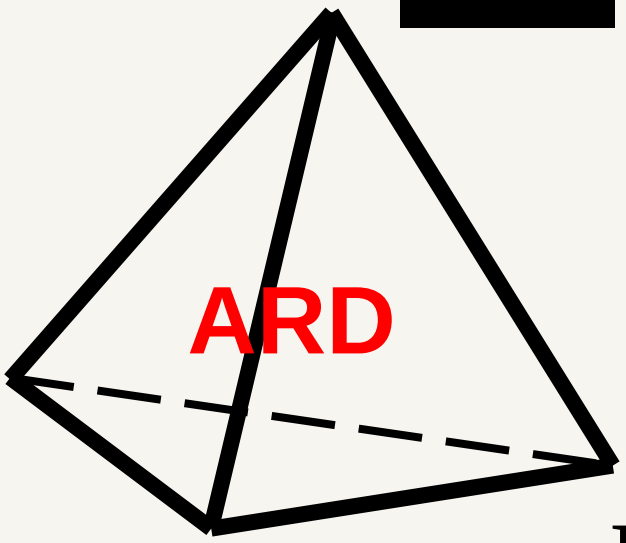



Water



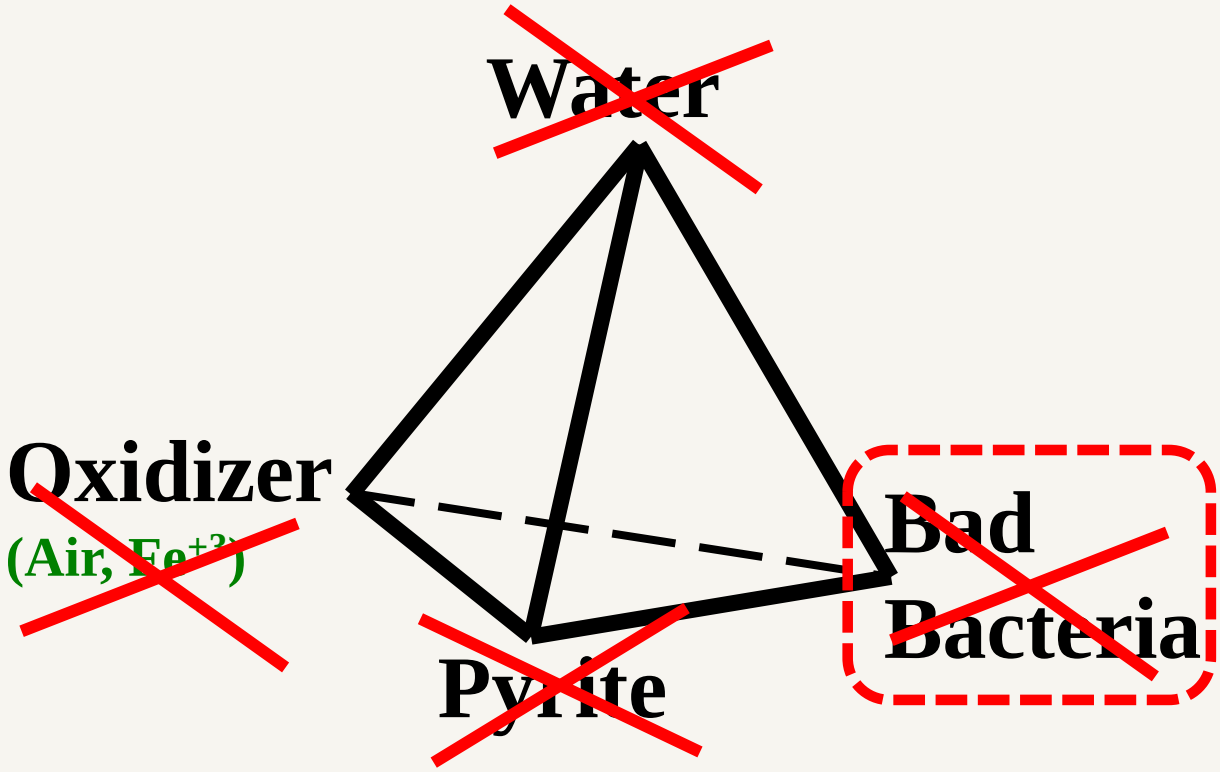
Oxidizer

(Air, $Fe^{+3}$)




Bacteria

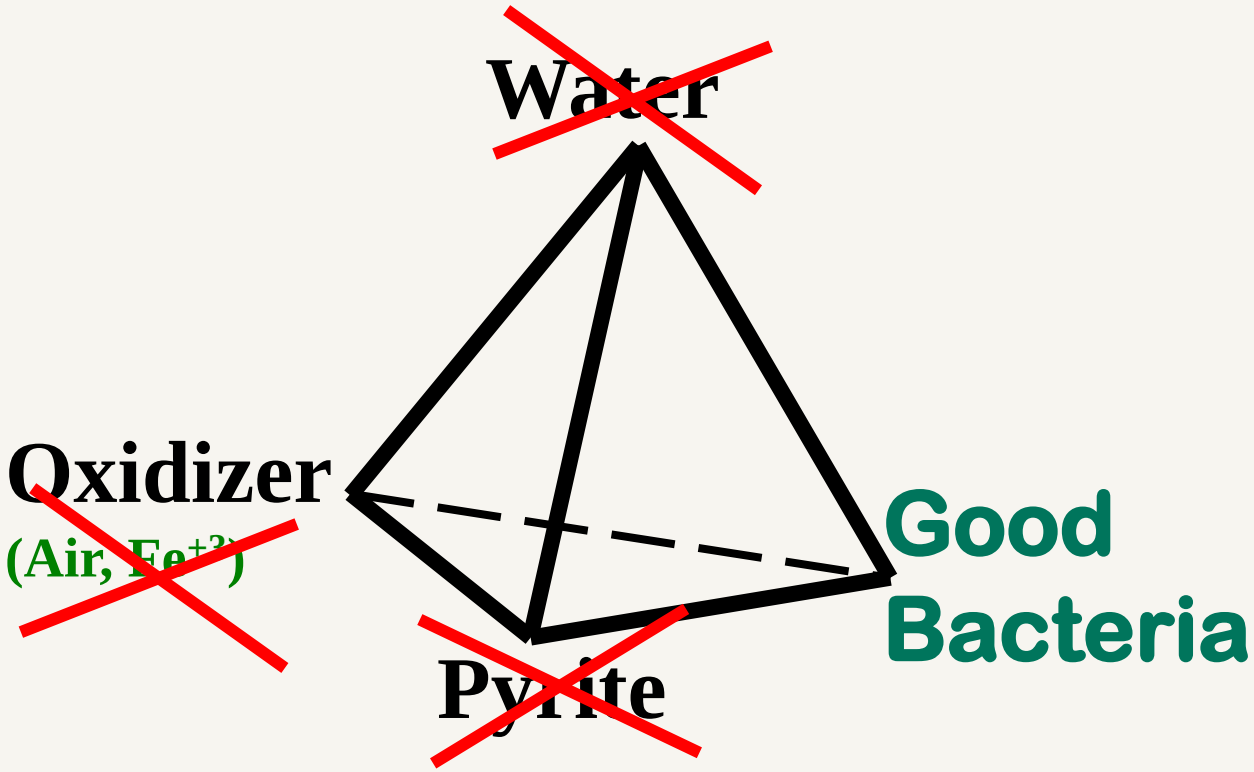
# Acid Rock Drainage Tetrahedron




DO NOTHING = PERPETUAL TREATMENT

DO SOMETHING (anything) = PATHWAY TO WALK-AWAY

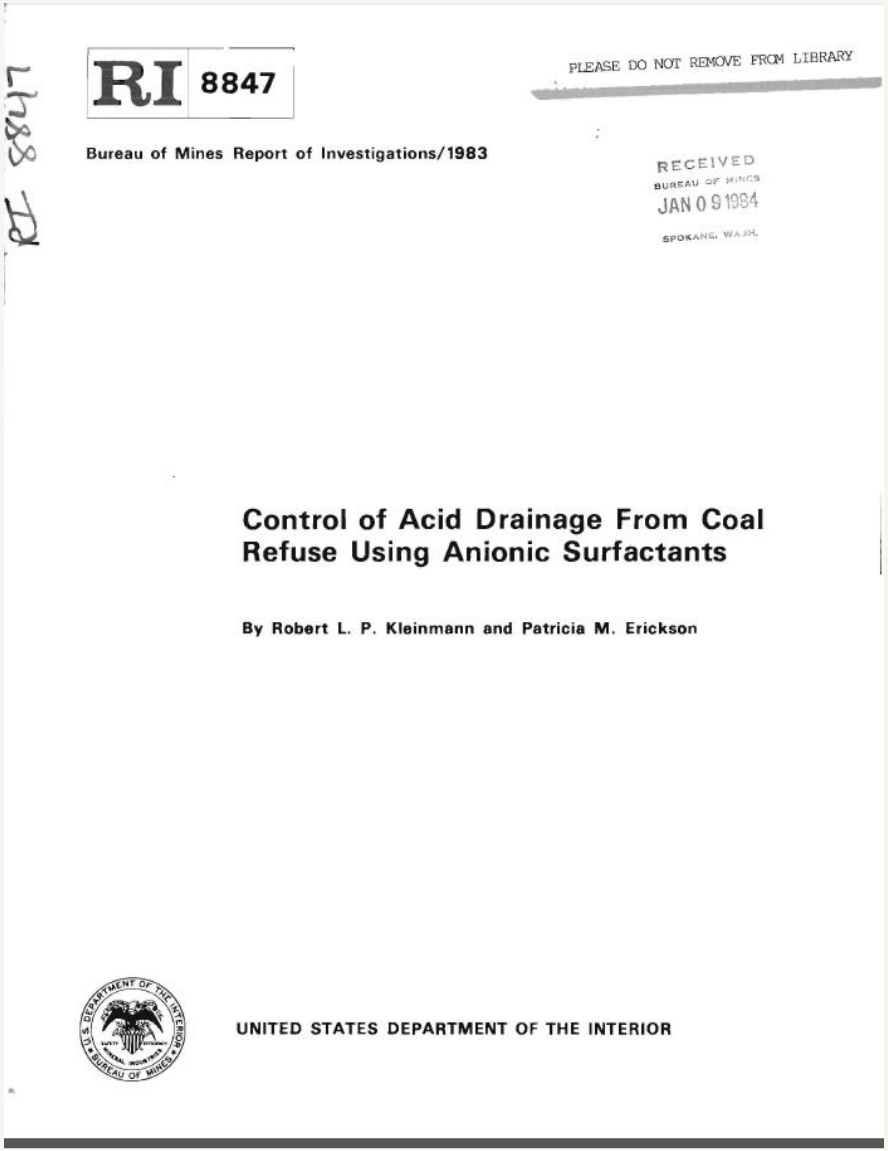
# Acid Rock Drainage Tetrahedron




## "PROBIOTIC"
## PATHWAY TO WALK-AWAY

# History

- Bacteria are important (1950)
- Common surfactants are effective bactericides (1980s-1990s)
- Kleinmann & Erickson USBM RI 8847 (1983)



RI 8847

PLEASE DO NOT REMOVE FROM LIBRARY

Bureau of Mines Report of Investigations/1983

RECEIVED
BUREAU OF MINES
JAN 09 1984
SPOKANE, WASH.

Control of Acid Drainage From Coal Refuse Using Anionic Surfactants

By Robert L. P. Kleinmann and Patricia M. Erickson

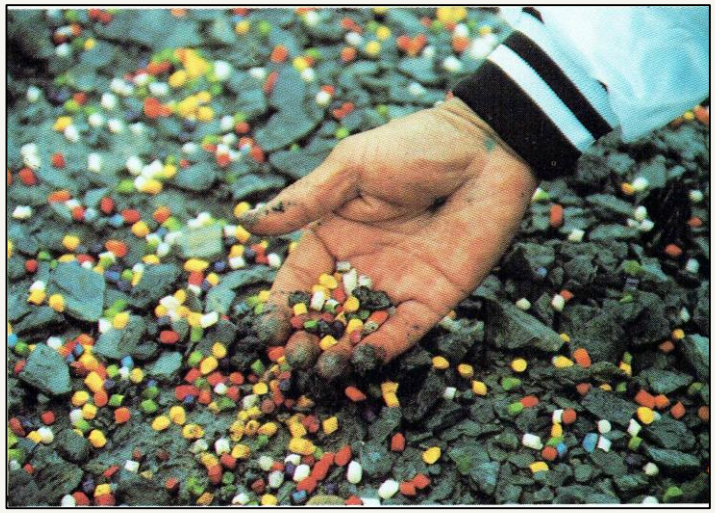
UNITED STATES DEPARTMENT OF THE INTERIOR

# Kleinmann & Erickson 1983

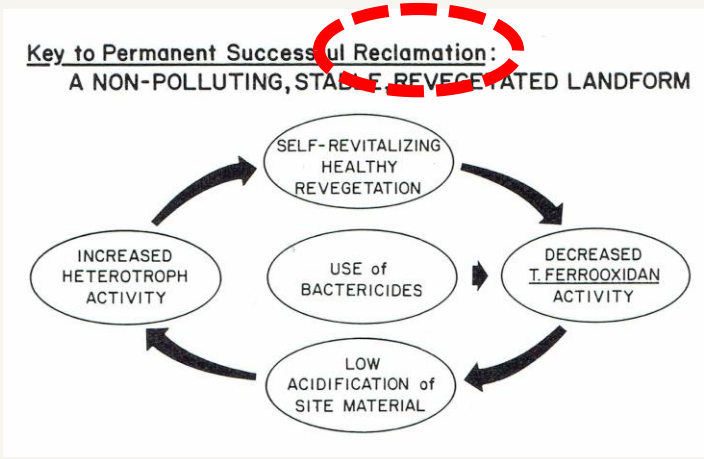
- *Thiobacillus ferrooxidans* dramatically increases rate of pyrite oxidation
- Developed a laboratory procedure to determine application rates
- Case studies : two sites
  - 60% to 95% decrease in acid production
  - 90% to 95% decrease in iron
- Temporary effect: must re-apply three times per year – improvement required

# History

- Bacteria are important (1950)
- Common surfactants are effective bactericides (1980s-1990s)
- Kleinmann & Erickson USBM RI 8847 (1983)
- **Development & Use of Controlled-Release Product "ProMac™" (1985 to 2000)**
- **Probiotic Bacteria Substitution w/Organics (1990 to 2008)**
- **Revegetation is a key requirement for sustainability**



Zaburunov, 1987



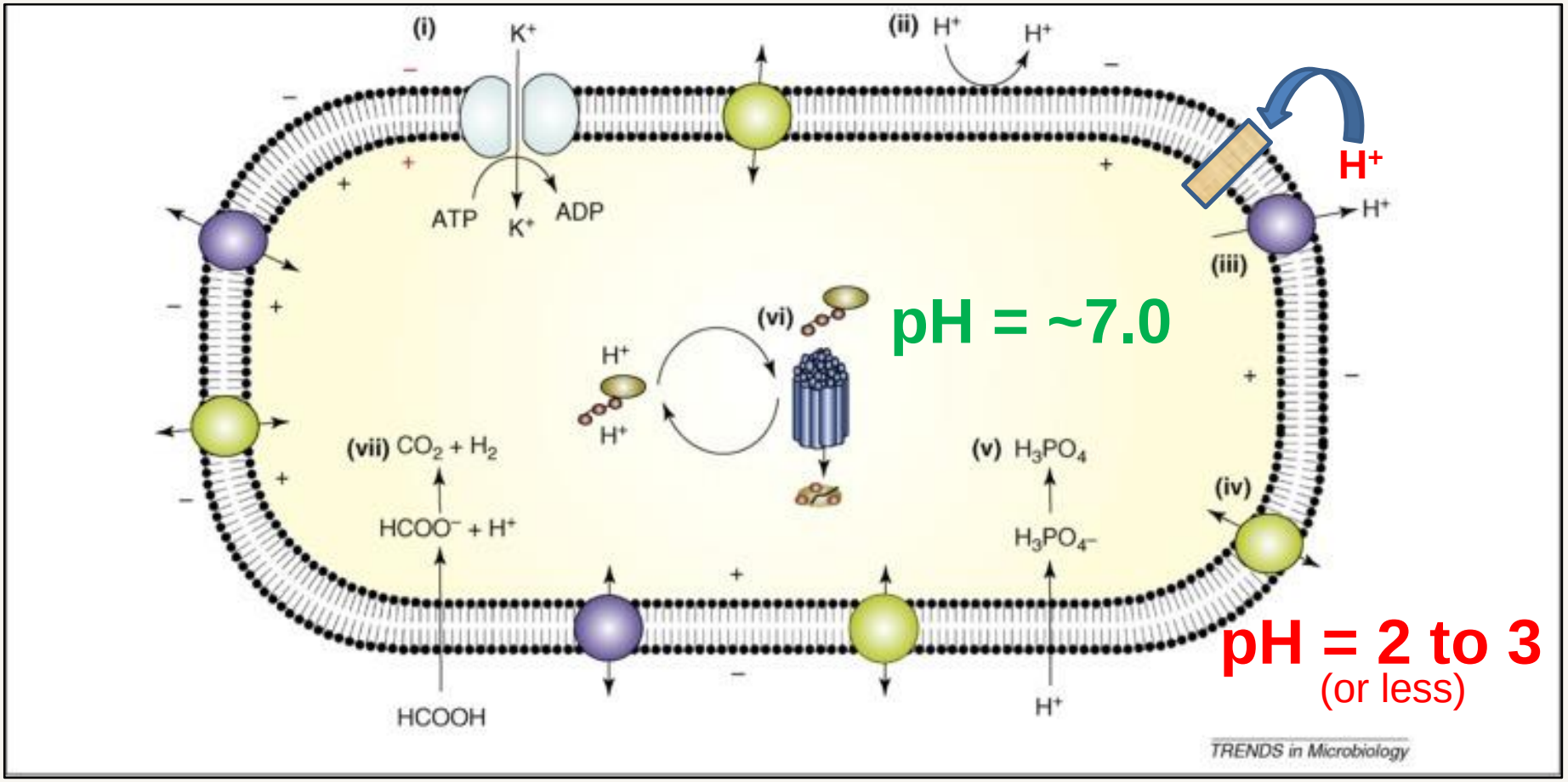
# Known Bactericides

- Sodium lauryl sulfate (SLS)
- Sodium laureth sulfate (SLES)
- Slow release commercial products – ProMac™ (n… …ger available)
- Alkyl-benze… …honate (laundr… …ergent is cheaper tha… …)
- …odium Thiocyanate (NaSCN)
- Bi-Polar Lipids (patented)


Some of these concepts are 35 years old

# How Bactericides Work

## (Anionic Surfactants)



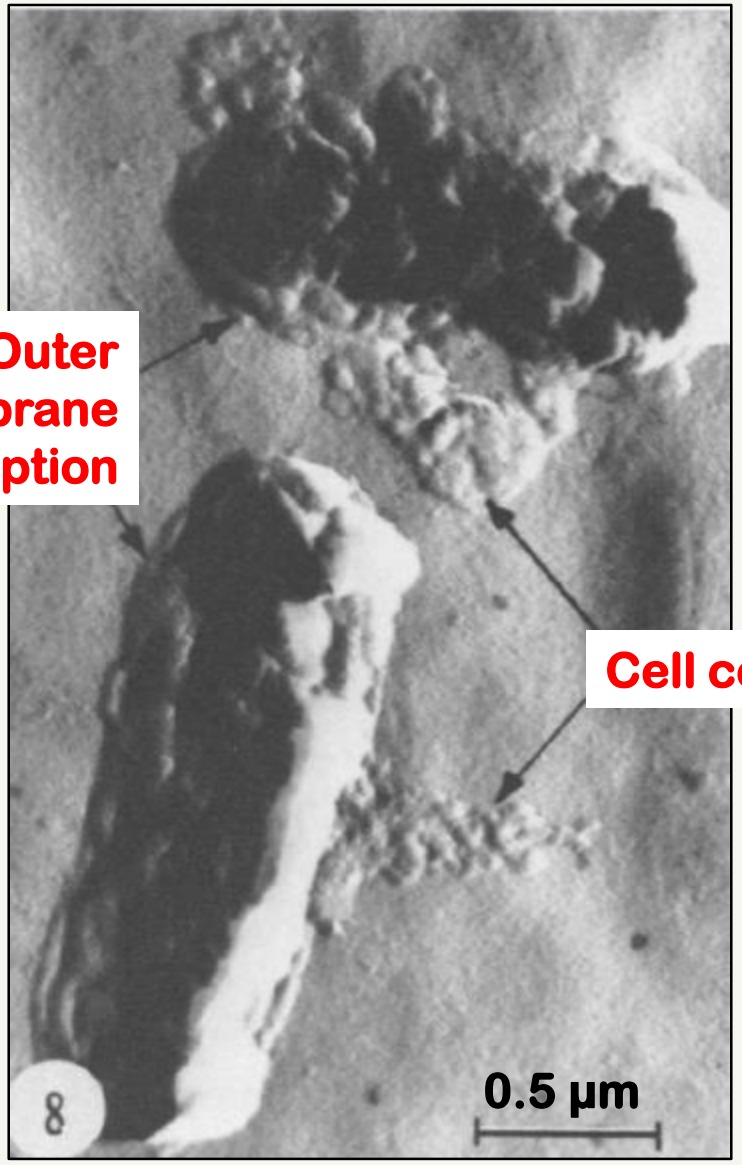

After Baker-Austin & Dopson (2007)

# Organic Amendments

- Organic acids (Tuttle, et al., 1977)
- Composted sewage sludge (Pichtel & Dick, 1990)
- Composted paper mill sludge (ditto)
- Pyruvic acid (ditto)
- Water-soluble extract from composted sewage sludge (ditto)
- Spent brewery grain (Lindsay et al., 2010)
- Waste milk & dairy products (Jin et al., 2008)

# How Bactericides Work

## (Organic Acids)




Tuttle, et al. 1977

# Bactericide Case Histories

1. Coarse Coal Refuse; Route 43, Jefferson County, OH (1984)
2. Branchton Coal Refuse, Butler County, PA (1990)
3. North Fork Coal Mine, Wise County, VA (1987)
4. Dawmont Coal Refuse, Harrison County, WV (1986)
5. Norton Coal Refuse, Randolph County, WV (1984)
6. California Gulch Superfund (OU-11), Lake County, CO (2004) [*Organic Matter/Biosolids*]
7. Fisher Coal Mine, Indiana County, PA (1995)

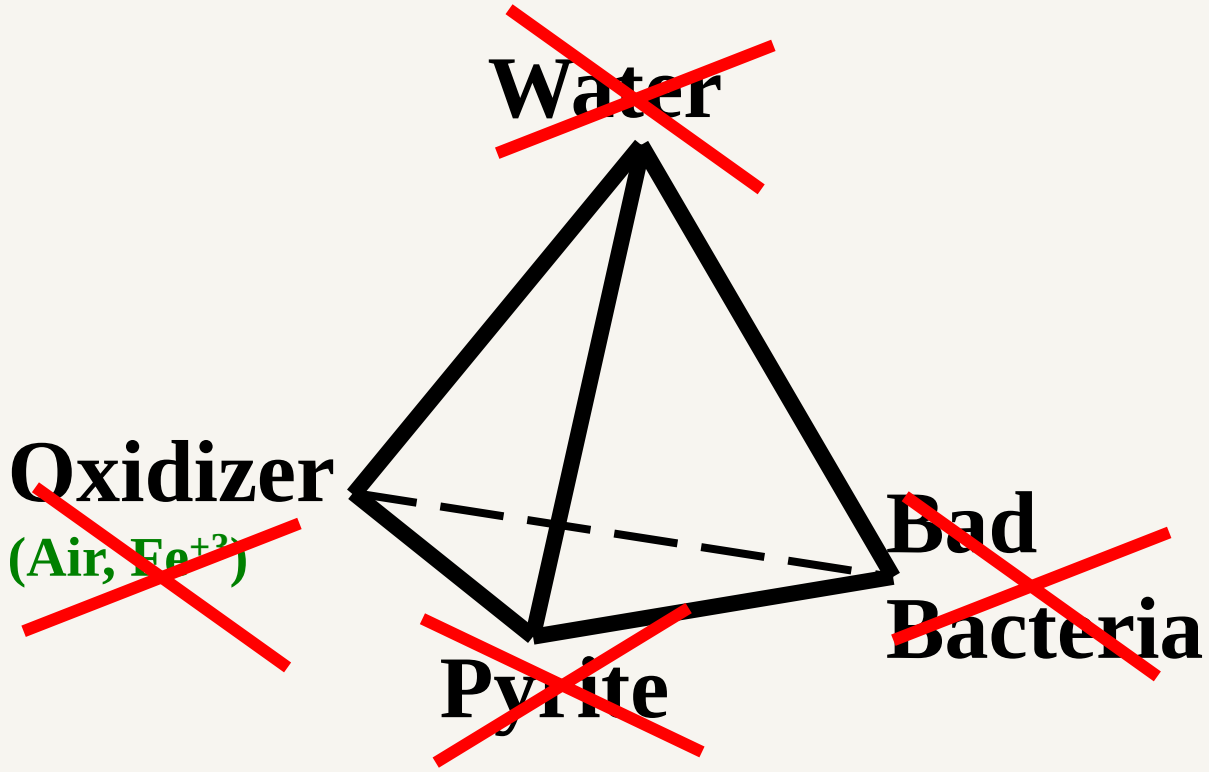
Ref: Gusek, 2016

# DECIMATE; OUT-COMPETE; SUSTAIN [DOS]

1. Primary application of SLS to **decimate** acid-loving bug populations
2. Application of waste milk or other organic (with inoculant) to make heterotrophic **good bugs** happy & **out-compete** acid-loving bugs
3. Establishing a vibrant and **sustain**able vegetative cover to keep **good bugs** happy for decades or <u>longer</u>

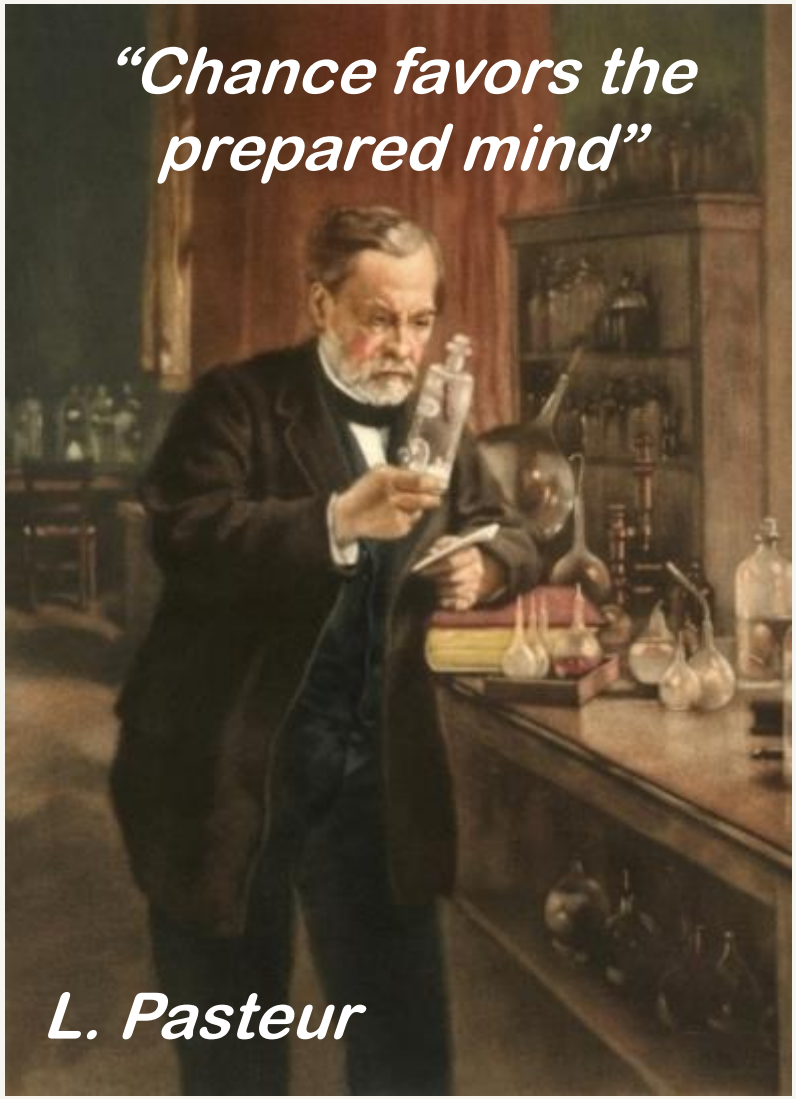


# Acid Rock Drainage Tetrahedron




**DO SOMETHING (anything) = PATHWAY TO WALK-AWAY**

# Thank You

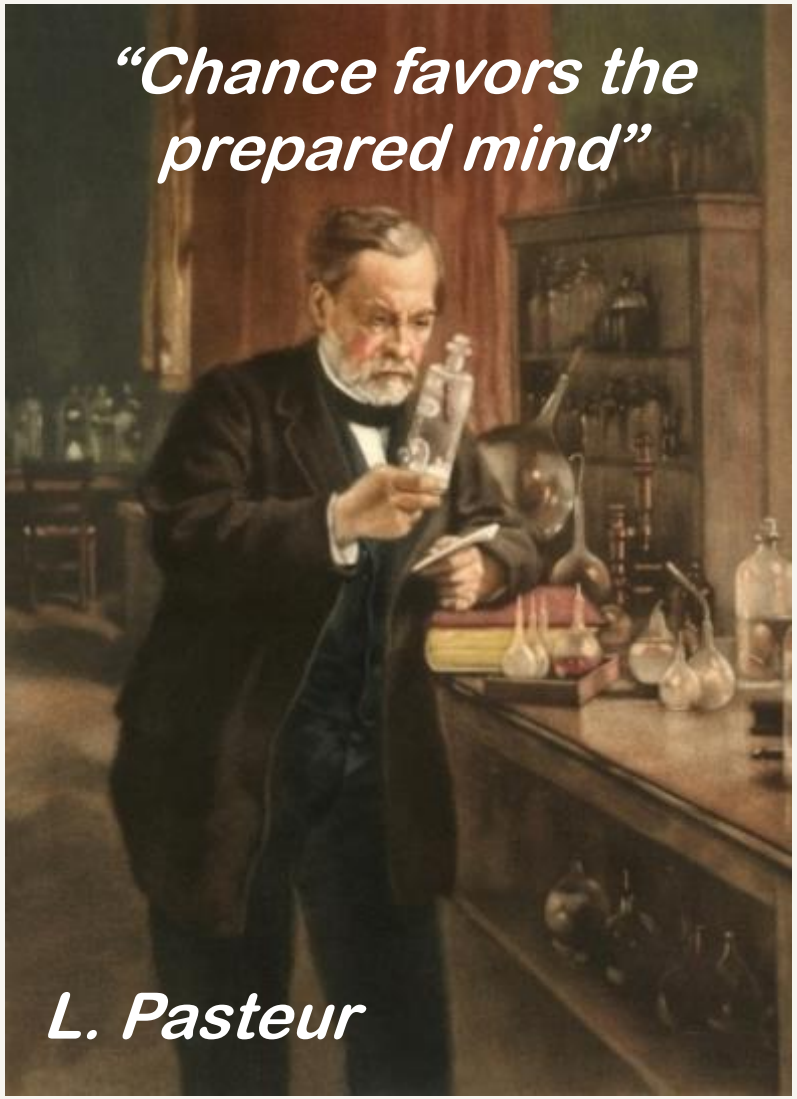



***Nihil simul inventum est et perfectum***

*- Latin Proverb*

jim.gusek@linkan.biz

# Thank You




***Nothing is invented and perfected at the same time.***

*- Latin Proverb*

jim.gusek@linkan.biz