THE UNIVERSITY OF QUEENSLAND AUSTRALIA | CREATE CHANGE

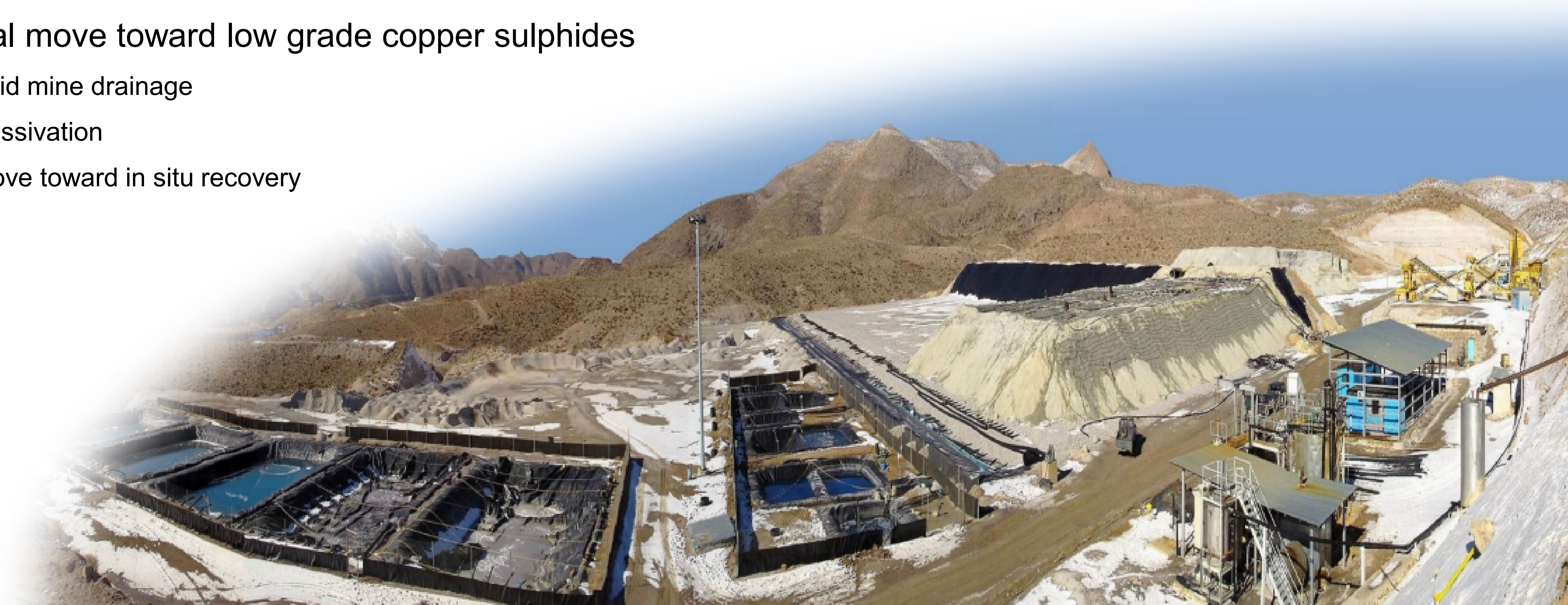
Bioengineering For In Situ Leach Applications

Complex Orebodies – 5 Nov, 2019


2006 1 18

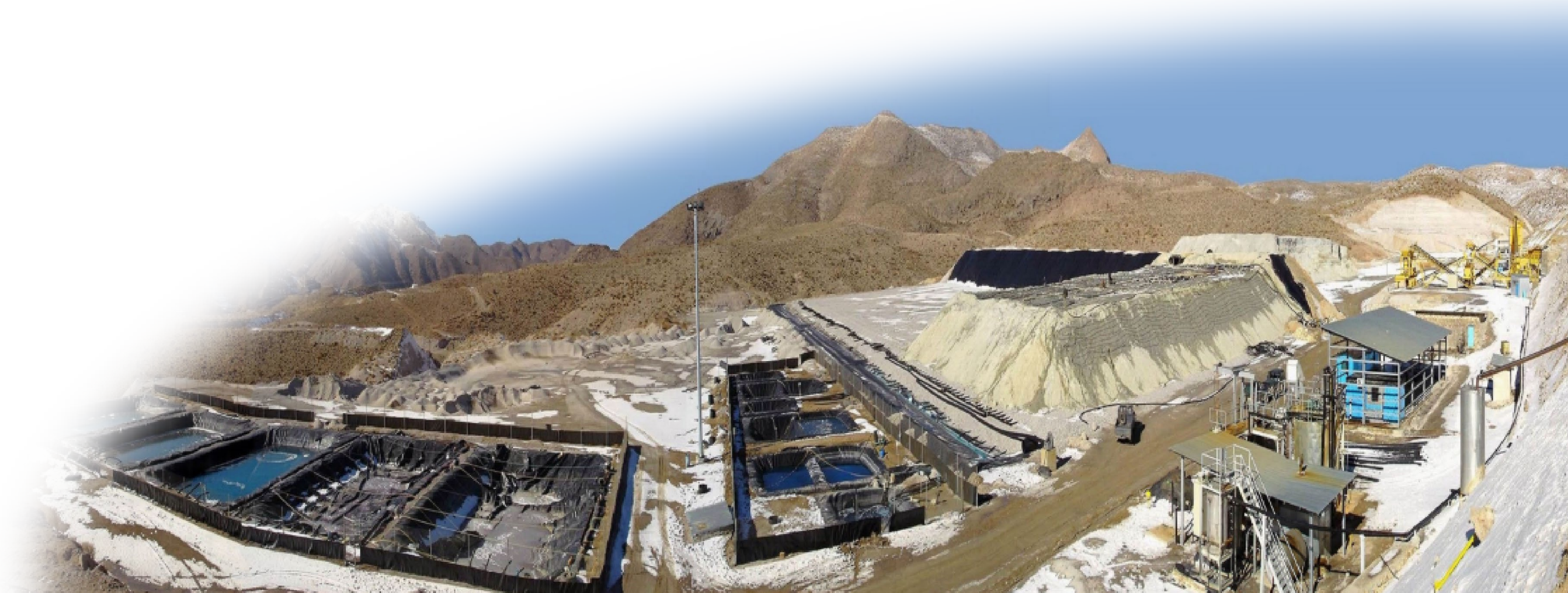
Bird's-eye view

- Australia is world's 5th leading copper producer
- ~$10B of Australian economy
- 13% of world copper reserves
- Global move toward low grade copper sulphides
  - Acid mine drainage
  - Passivation
  - Move toward in situ recovery



Chalcopyrite leaching strategies

Technology	Location	% Recovery	Timescale	Challenges
Bioleach	Globally	60-70%	Months - Years	Sulfuric acid waste, passivation, nutrient and O_2 supply



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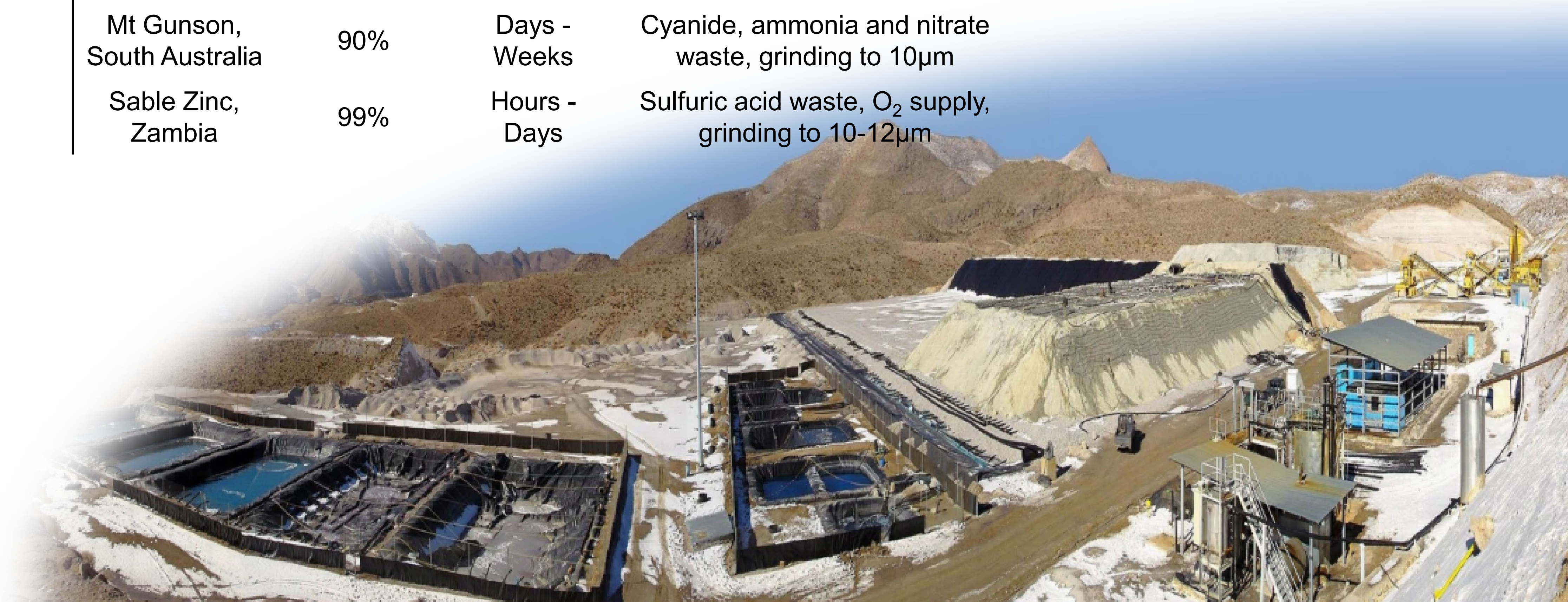
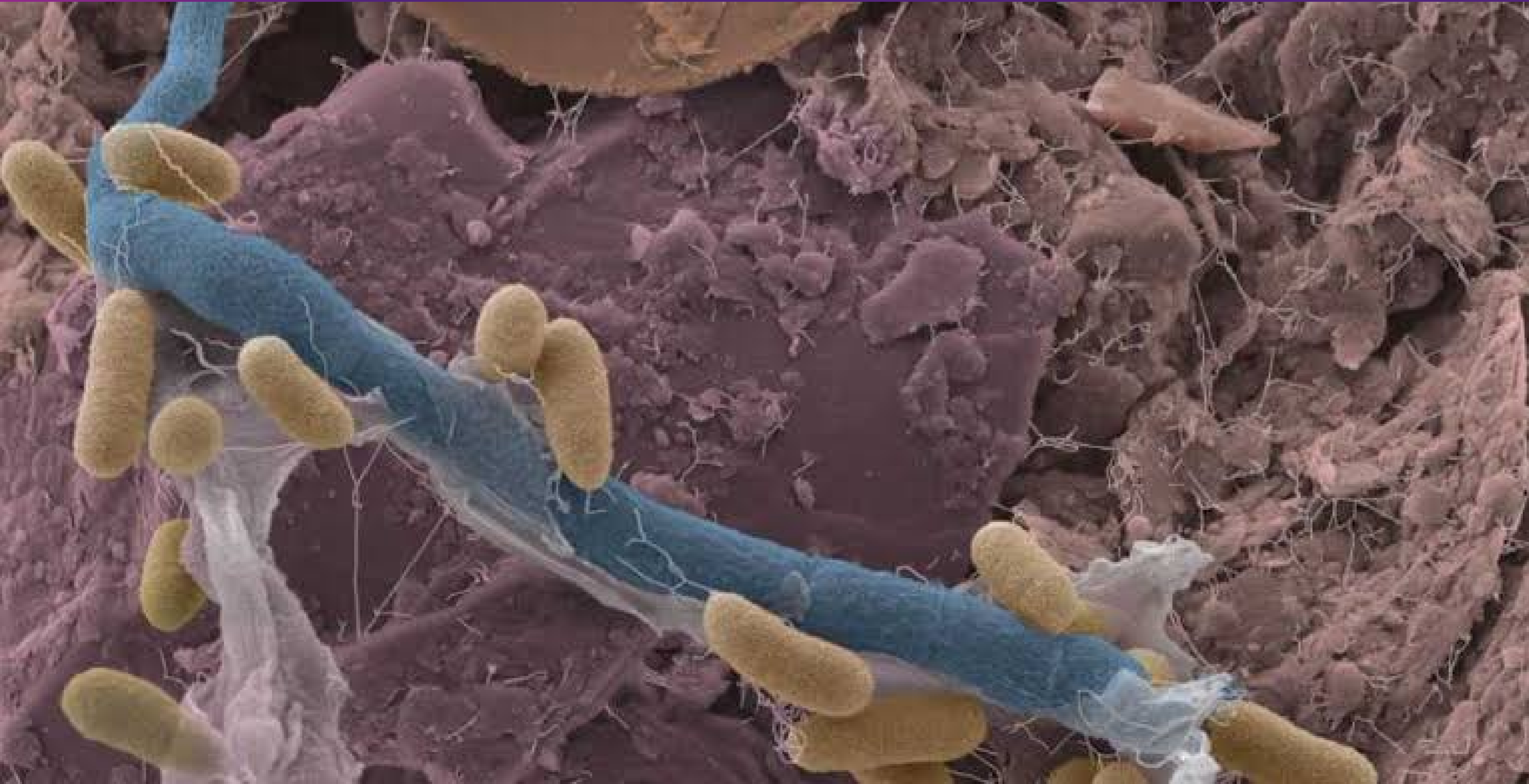
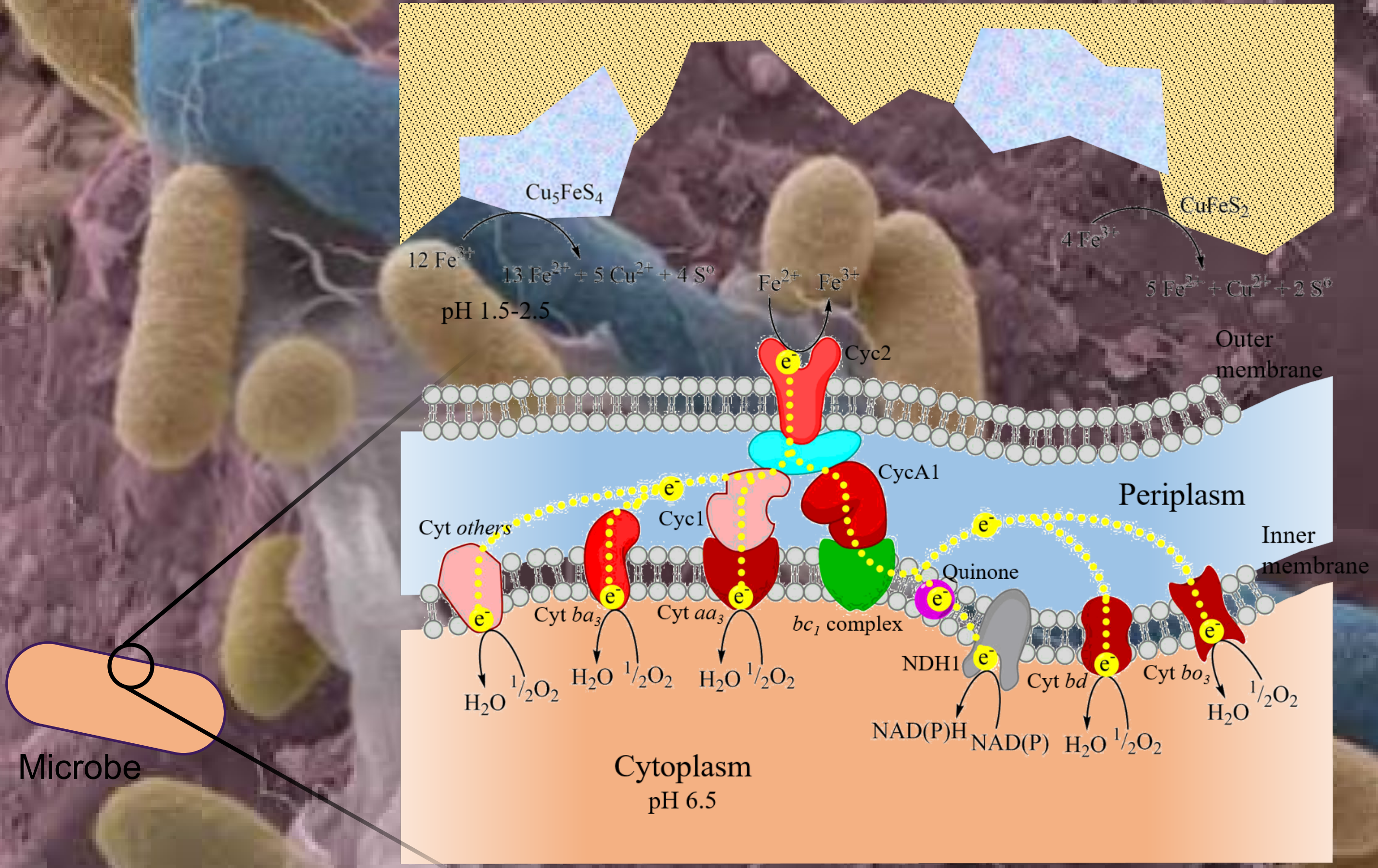
Oxidative leach	Sable Zinc, Zambia	99%	Hours - Days	Sulfuric acid waste, O_2 supply, grinding to 10-12μm





Scientific background



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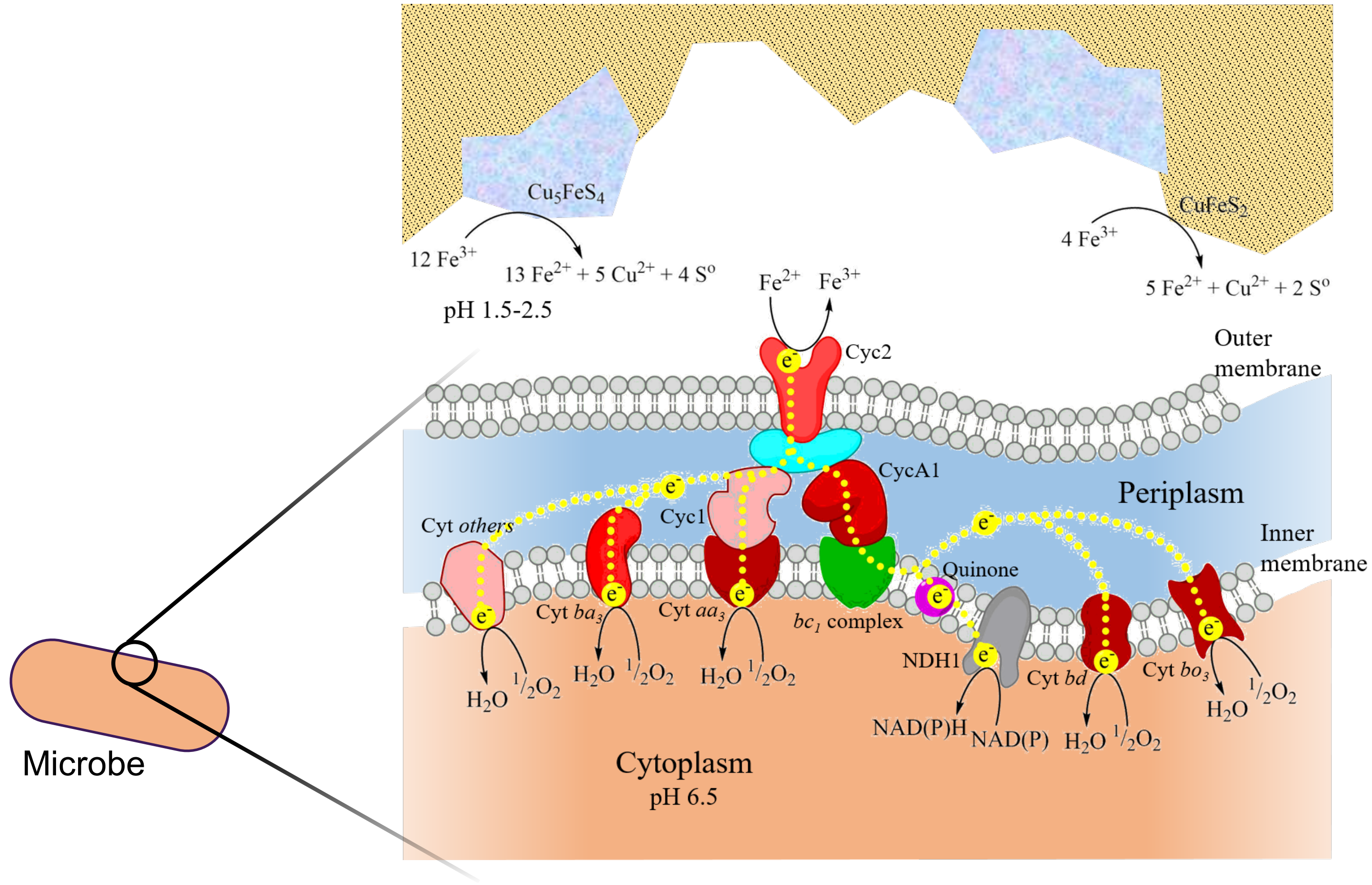
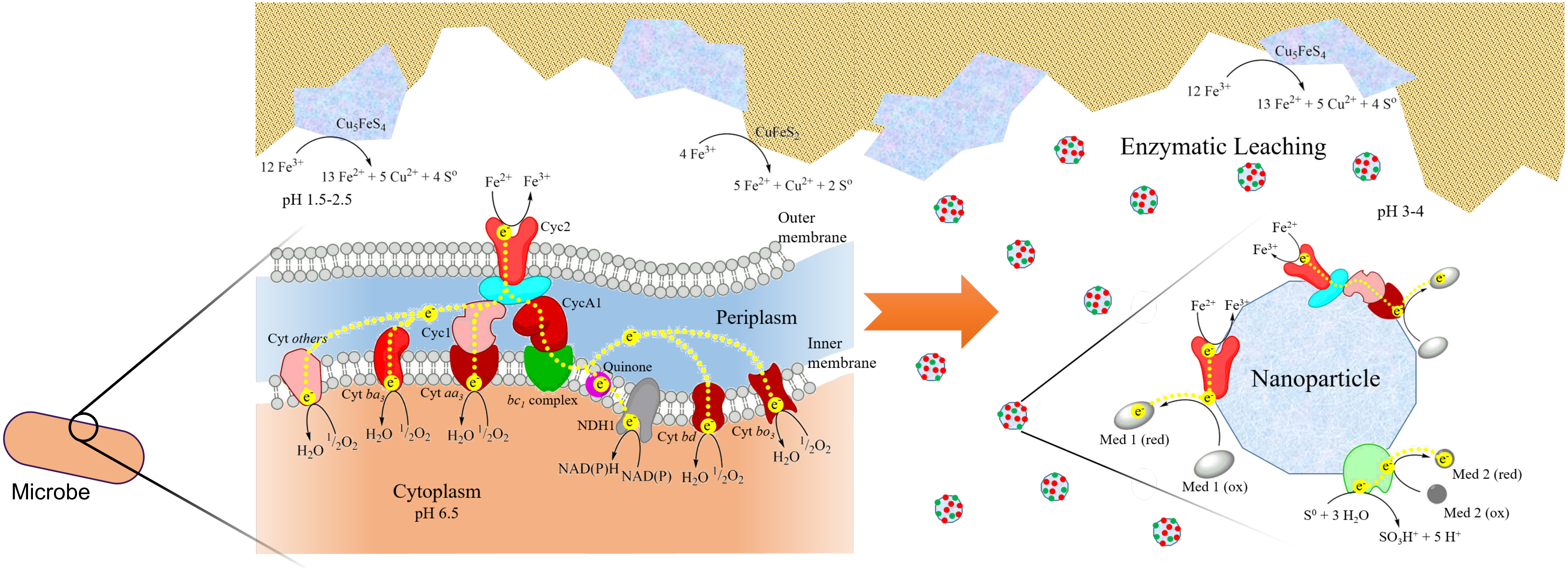


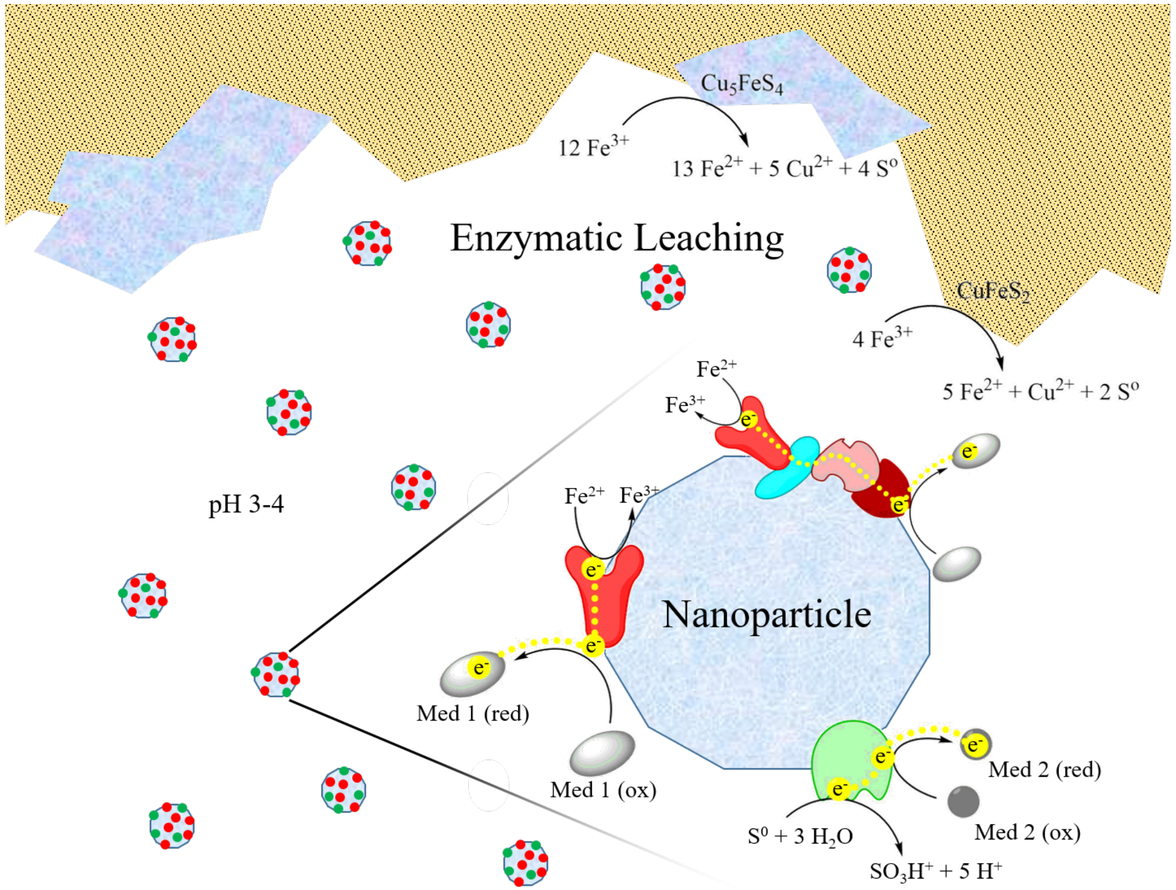
- Bioleach and AMD microbes thrive in low pH environments
- Generate energy by converting Fe(II) to Fe(III), then transferring electrons to O_2
- Fe(III) drives Cu leaching from sulfide ores
- Leaching produces more Fe(II), which feeds the cycle

Scientific background

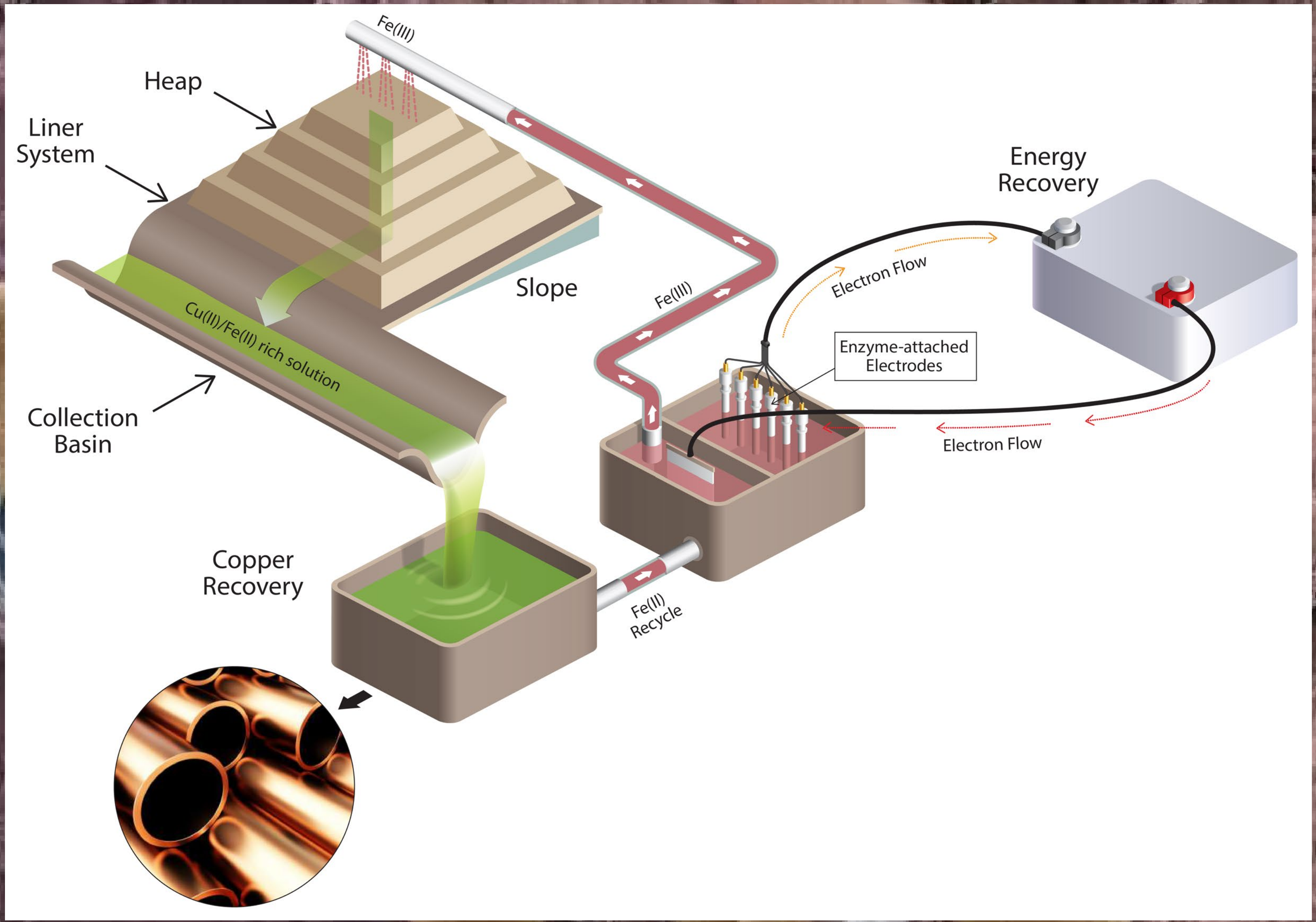


Scientific background

- Fe-oxidising enzyme(s) can be isolated from microbe
- Paired with an artificial terminal electron acceptor to drive the same process in more neutral pH
- Incorporate sulfur-oxidising enzymes to break up polysulfide and passivation layers

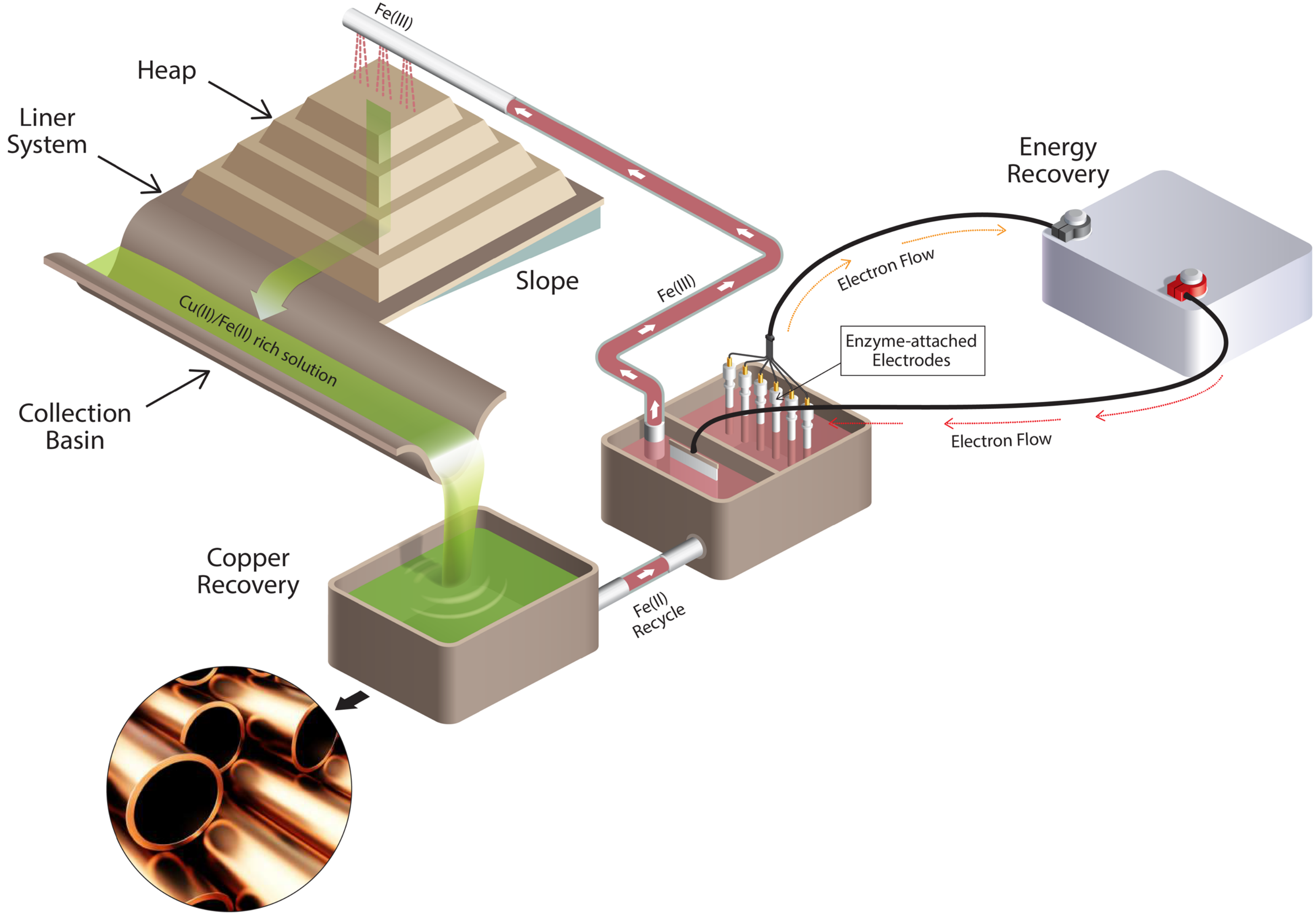


Putting it all together



Putting it all together

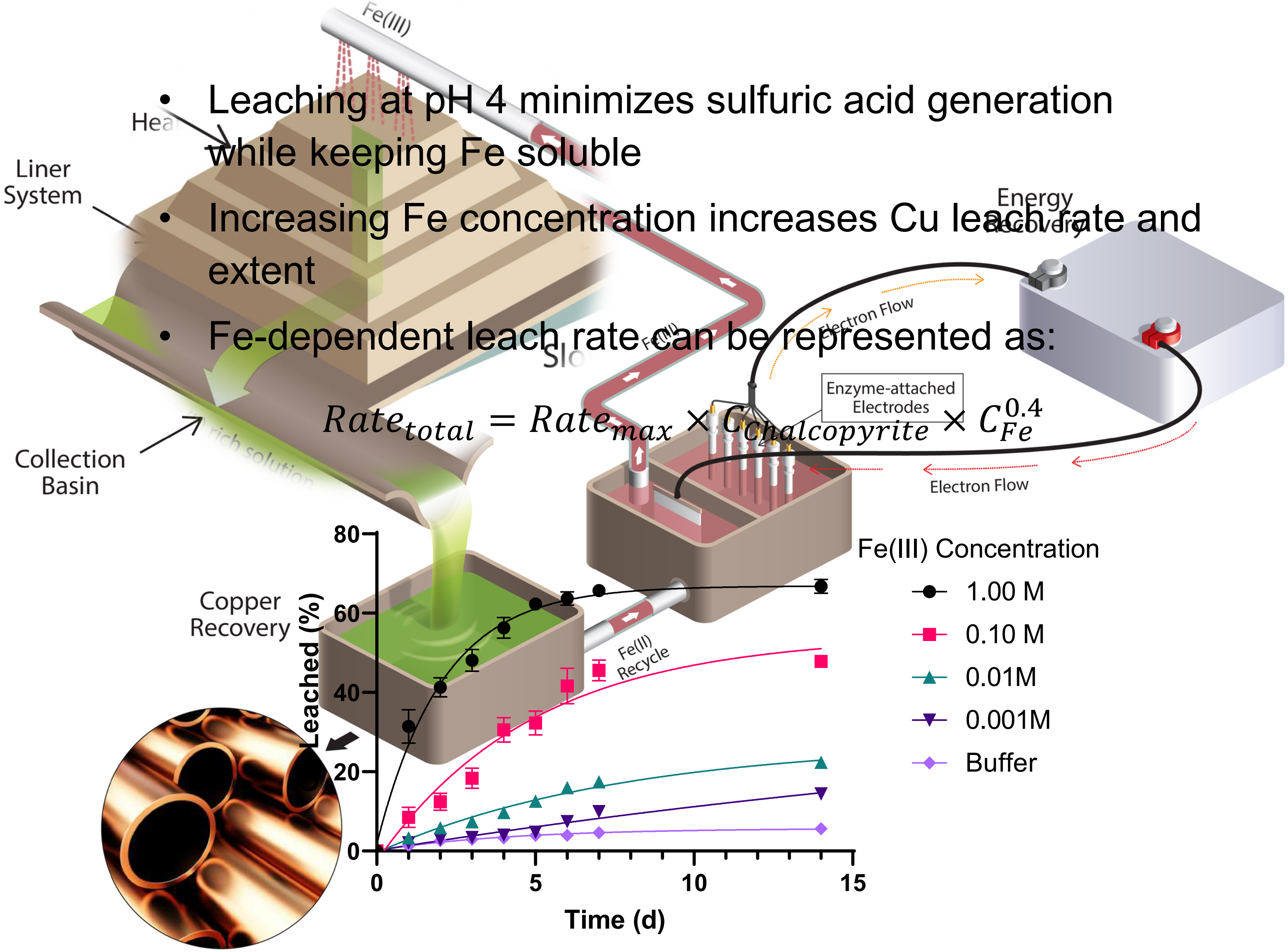
1. Enzyme discovery
2. Leaching conditions
3. Enzyme integration
4. Process development

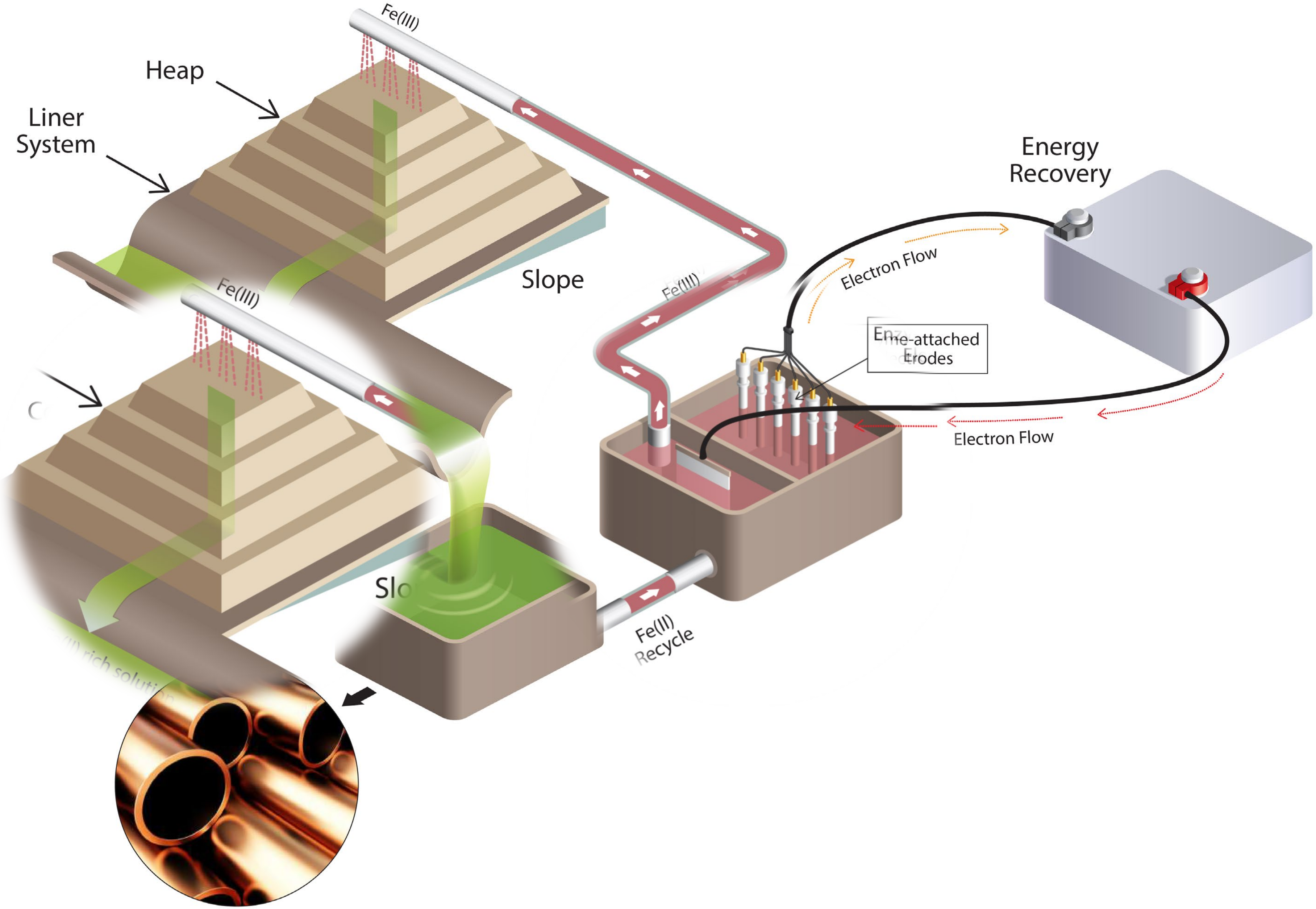


Leaching conditions

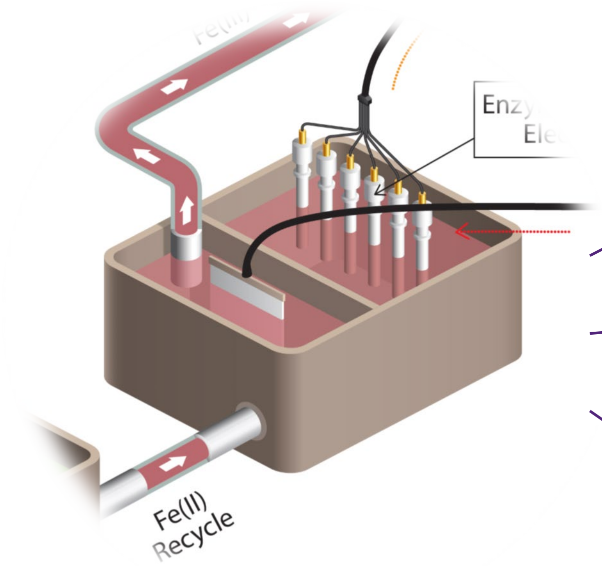
- Leaching at pH 4 minimizes sulfuric acid generation while keeping Fe soluble
- Increasing Fe concentration increases Cu leach rate and extent
- Fe-dependent leach rate can be represented as:

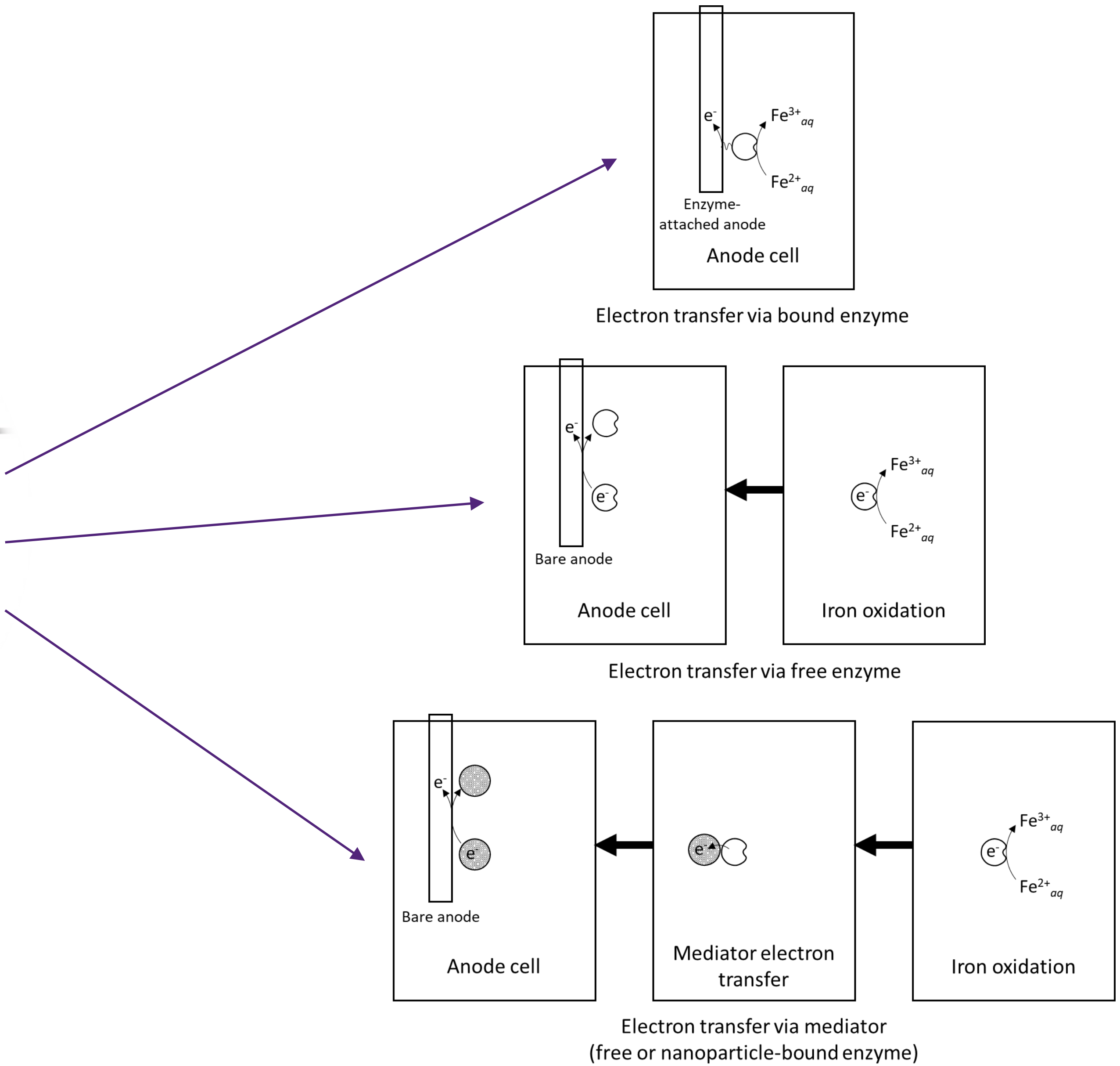
$$Rate_{total} = Rate_{max} \times C_{Chalcopyrite} \times C_{Fe}^{0.4}$$



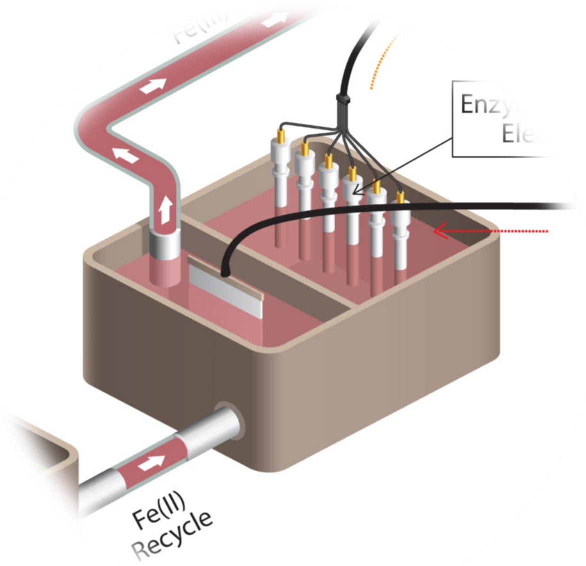

Fe(III)
Heap
Liner
System
Slope
Energy
Recovery
Electron Flow
Fe(III)
Fe(III)
Electron Flow
Fe(II)
Recycle

Enzyme integration



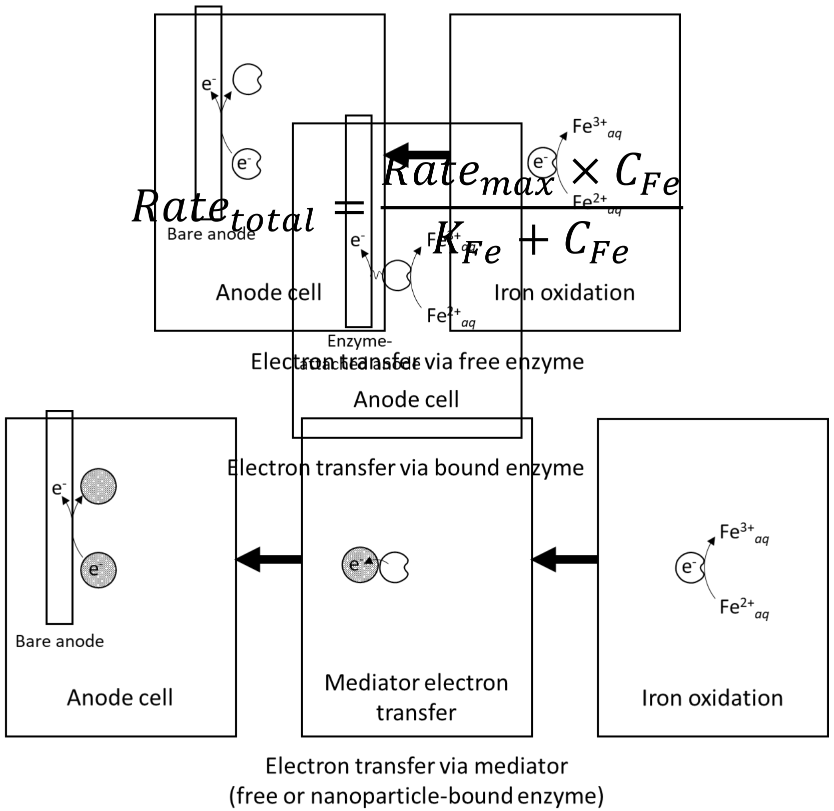


Enzyme integration

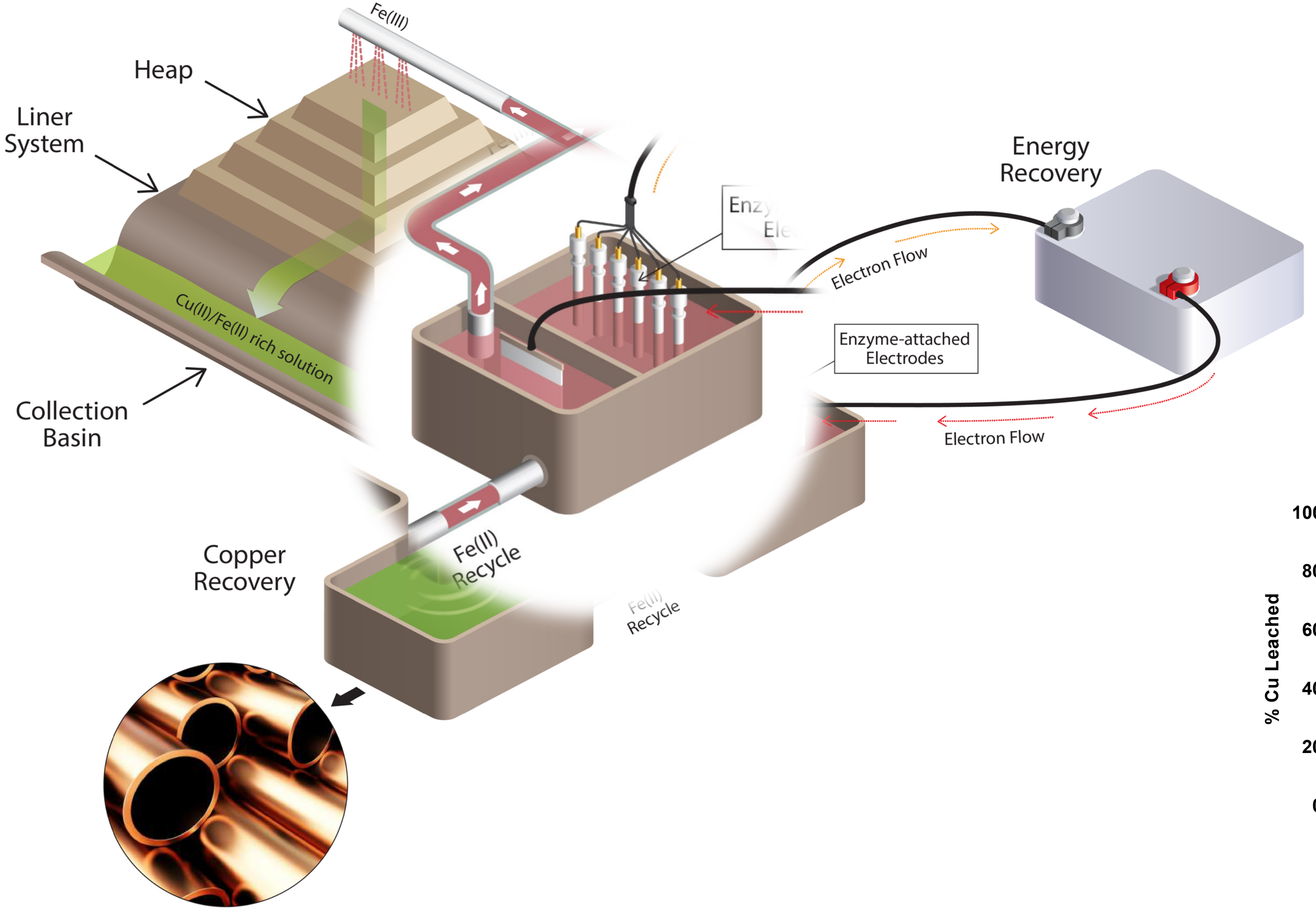


- Preliminary results show 1 g of enzyme can turn over 80 g Fe per hour
- Enzymatic Fe-oxidation can be represented as:

$$Rate_{total} = \frac{Rate_{max} \times C_{Fe}}{K_{Fe} + C_{Fe}}$$

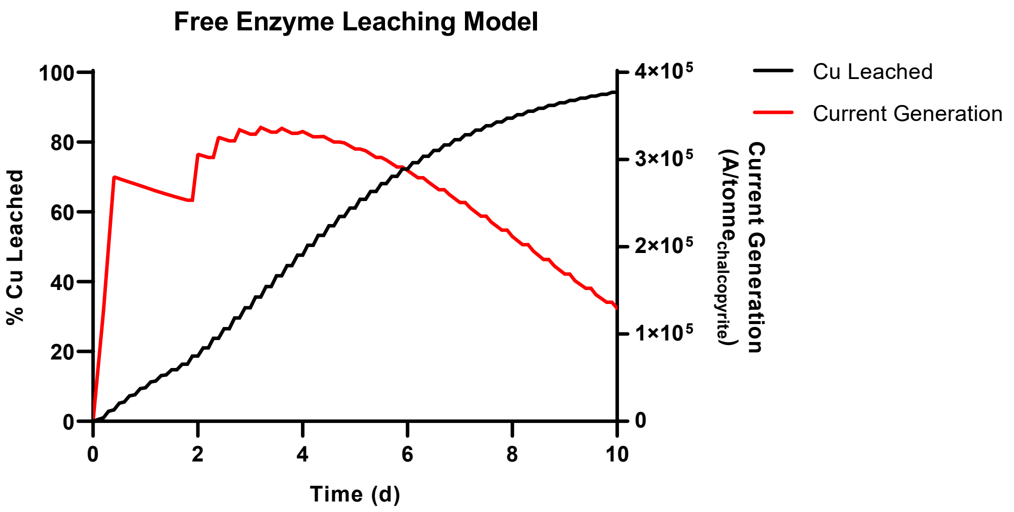


Process development

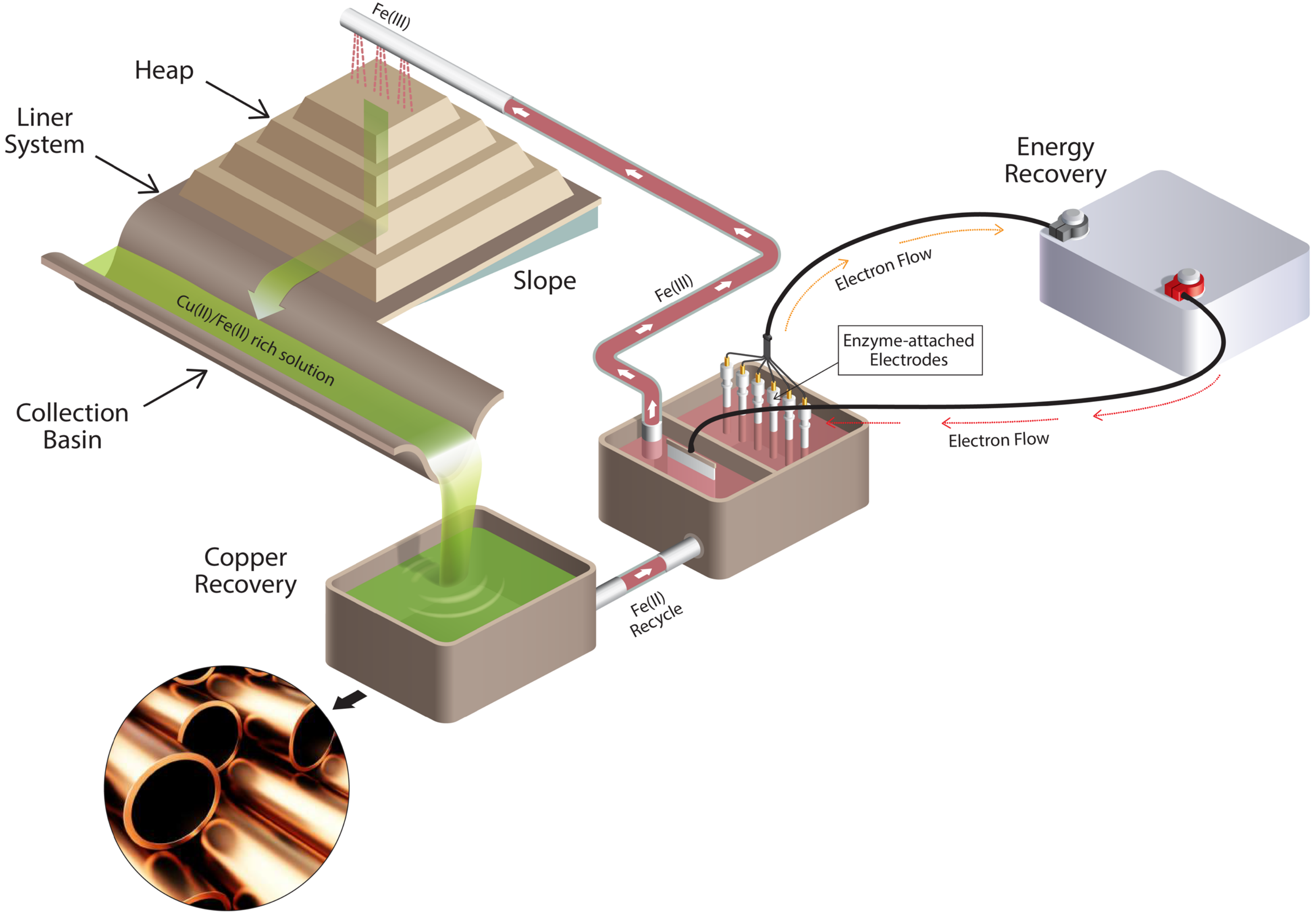


Technology	% Recovery	Timescale
Bioleach	60-70%	Months - Years
Glycine	90%	Days - Weeks
Oxidative leach	99%	Hours - Days
**Enzyme leach*	*>95%*	*Days - Weeks*

**Theoretical production*



Ongoing challenges



1. Enzyme stability
2. Enzyme turnover
3. Passivation
4. Energy recovery
5. In situ integration

Our team

Microbiology

Prof. Gene Tyson
ACE - 0.10 FTE

Biochemistry

Prof. Gary Schenk
SCMB - 0.15 FTE

Geology, Mining & Mineral Processing

Prof. Gordon Southam
SEES - 0.05 FTE

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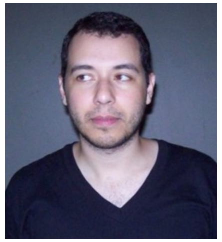
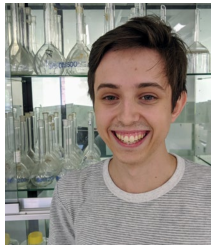
SMI - 0.20 FTE

Dr. Robert Hoelzle
ACE - 1.00 FTE



Dr. Marcelo Pedroso
SCMB - 1.00 FTE



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Dr. Bernardino Virdis
AWMC - 0.05 FTE

Electrochemistry

Prof. Paul Bernhardt
SCMB - 0.10 FTE

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Thank you

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