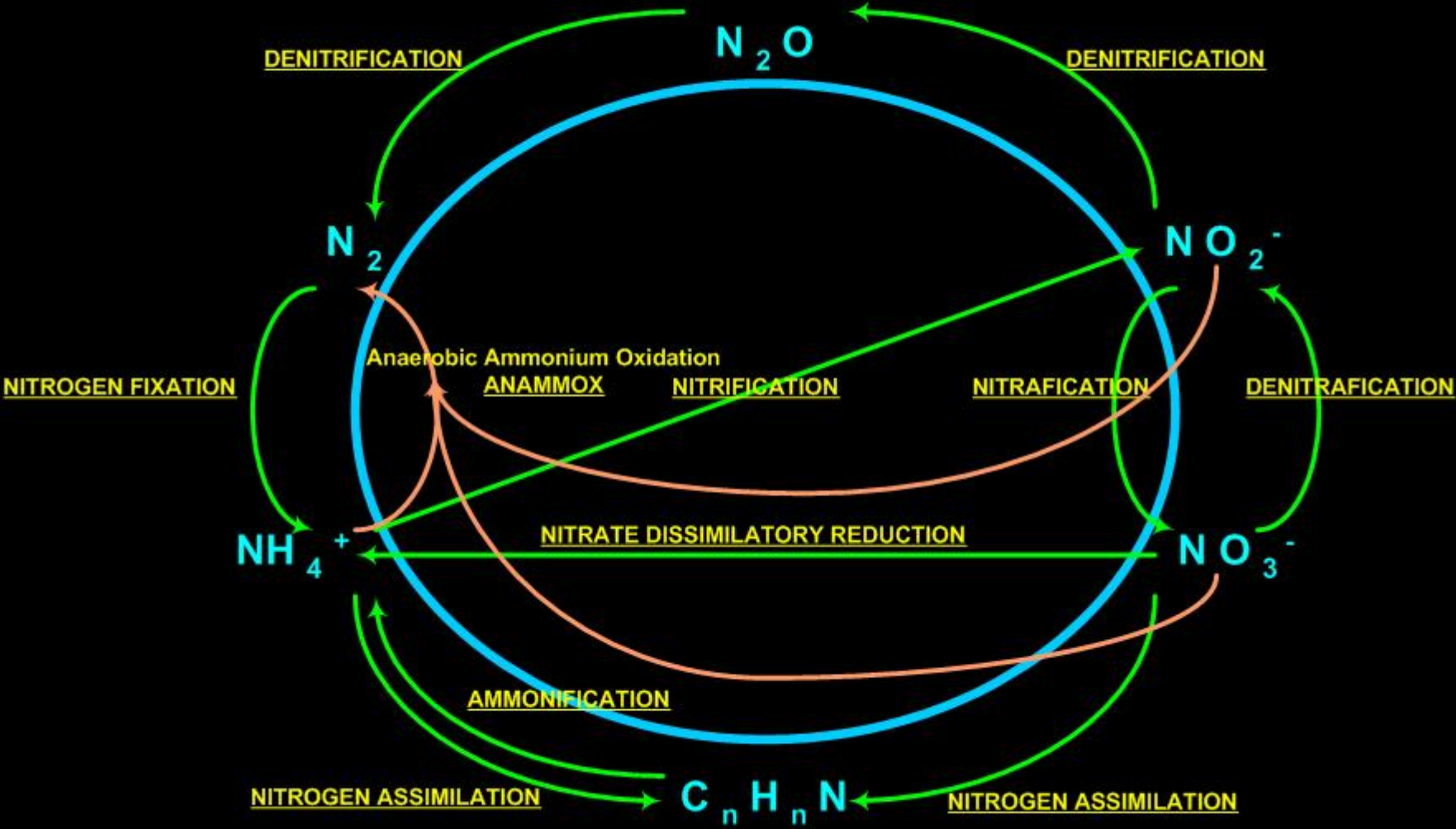


Microbiology and Biochemistry of the Nitrogen Cycle

Process Applications: InNitri



THE NITROGEN CYCLE



THERMODYNAMICS, energy for reactions

$$\Delta H = \Delta G + T\Delta S$$

H is enthalpy energy

G is free energy

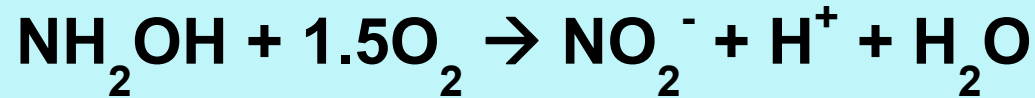
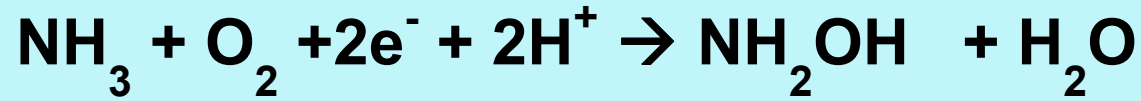
S is entropy energy

$$\Delta G = \Delta H - T\Delta S$$

If ΔG is – the reaction is spontaneous

If ΔG is + the reaction needs an energy input to occur

Nitrification (Nitrosifying Bacteria)



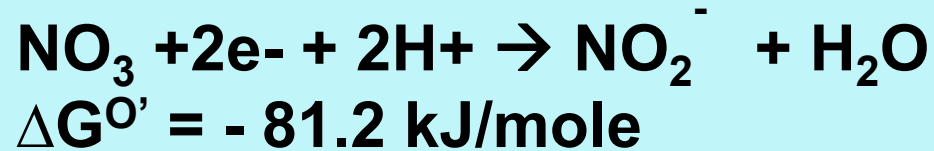
$$\Delta\text{G}^{\circ'} = -287 \text{ kJ/mole}$$

Nitrification (Nitrifying Bacteria)

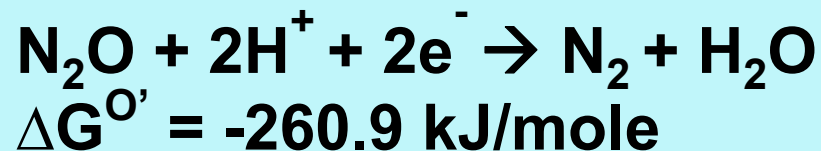
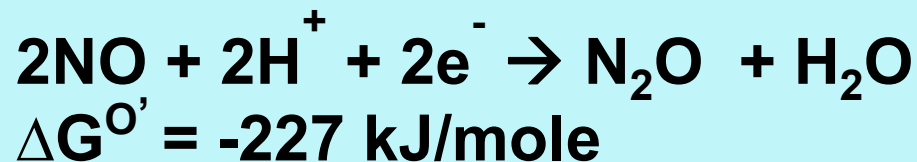
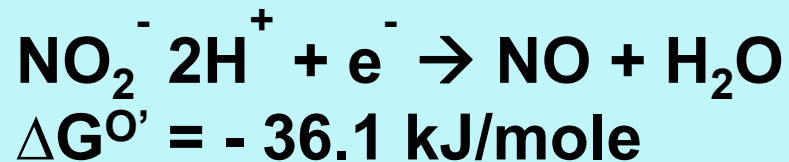


$$\Delta\text{G}^{\circ'} = -76 \text{ kJ/mole}$$

Denitrification (Many Bacteria)



Denitrification (Many Bacteria)



THE MICRO-ORGANISMS INVOLVED IN

NITRIFICATION / DENITRIFICATION and NITRAFICATION / DENITRAFICATION

Nitrogen Compound Reactions

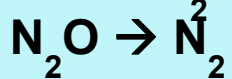
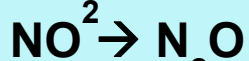
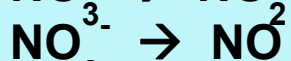
Ammonia Oxidizers
(nitrifying bacteria)



Nitrate Oxidizers
(nitrifying bacteria)



Nitrate Nitrite Reducers
(denitrating and denitrifying bacteria)



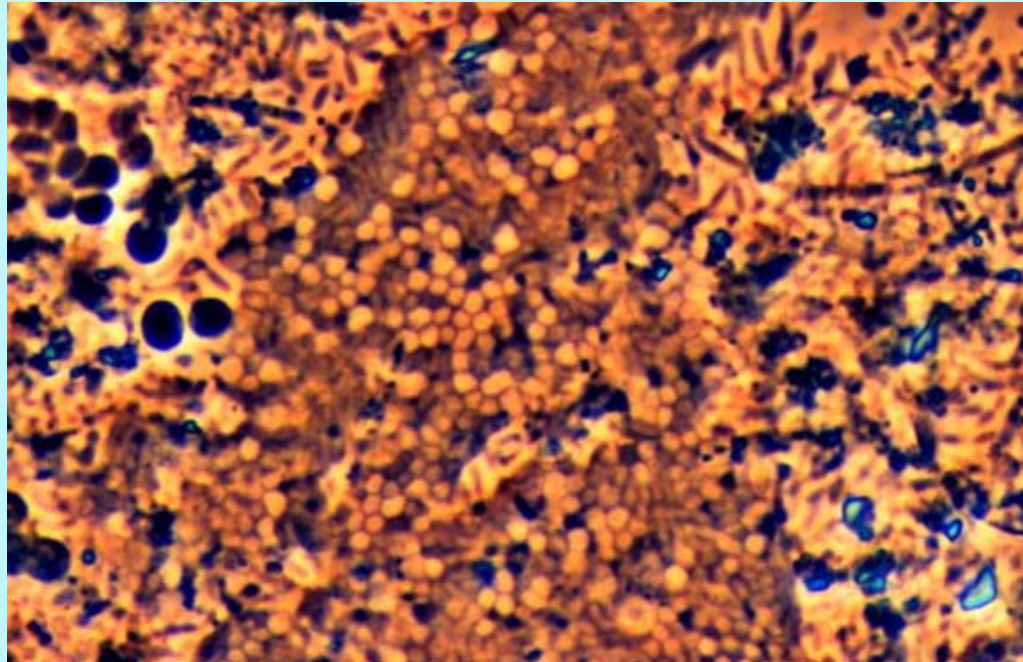
Bacteria

Nitrosomonas, Nitrosococcus,
Nitrosopira, Nitrosolobus, and
Nitrosovibro

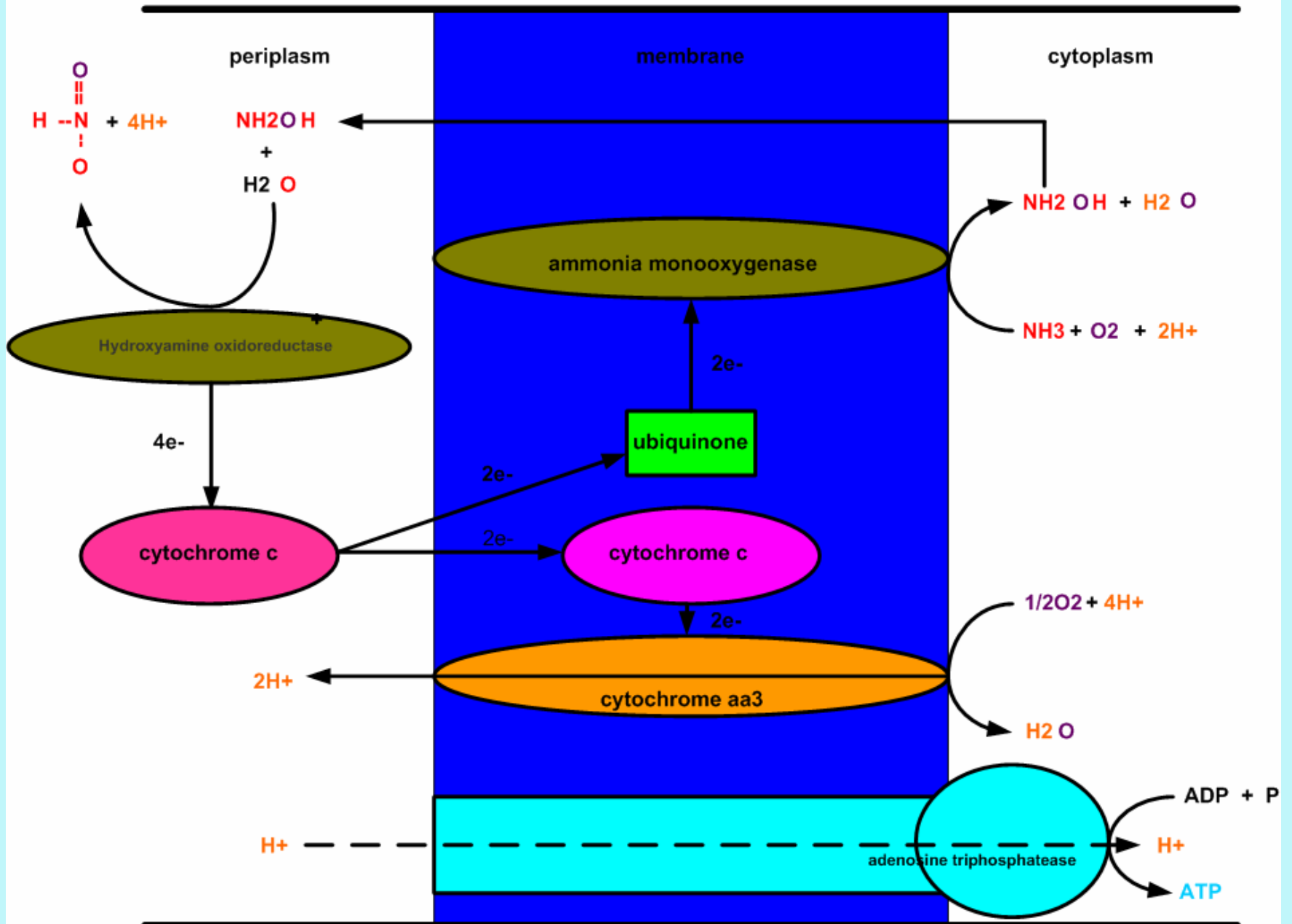
Nitrobacter, Nitrospina,
Nitrococcus, and Nitrospira

Achromobacter, Acinetobacter,
Agrobacterium, Alcaligenes,
Arthrobacter, Baccillus,
Chromobacterium, Corynebacterium
Flavobacterium, Hypomicrobium
Moraxella, Neisseria, Paracoccus,
Propionbacterium, Pseudomonas,
Rhizobium, Rhodopseudomonas,
Spirillum, and Vibrio

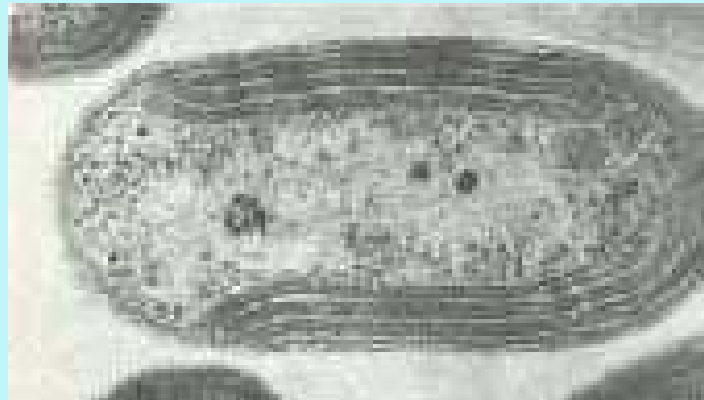
Nitrosomonas



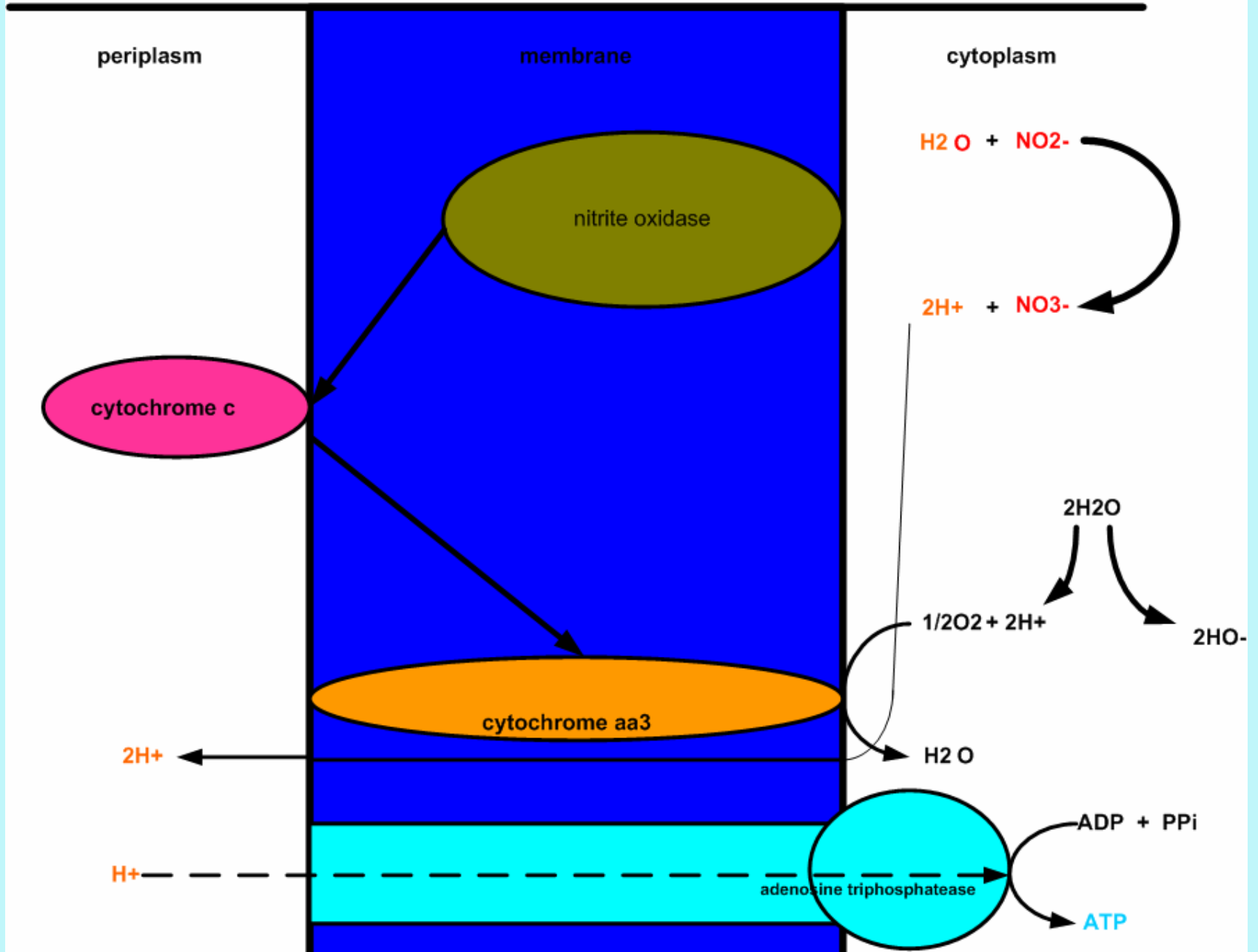
METABOLIC PATHWAY NITRIFYING BACTERIA



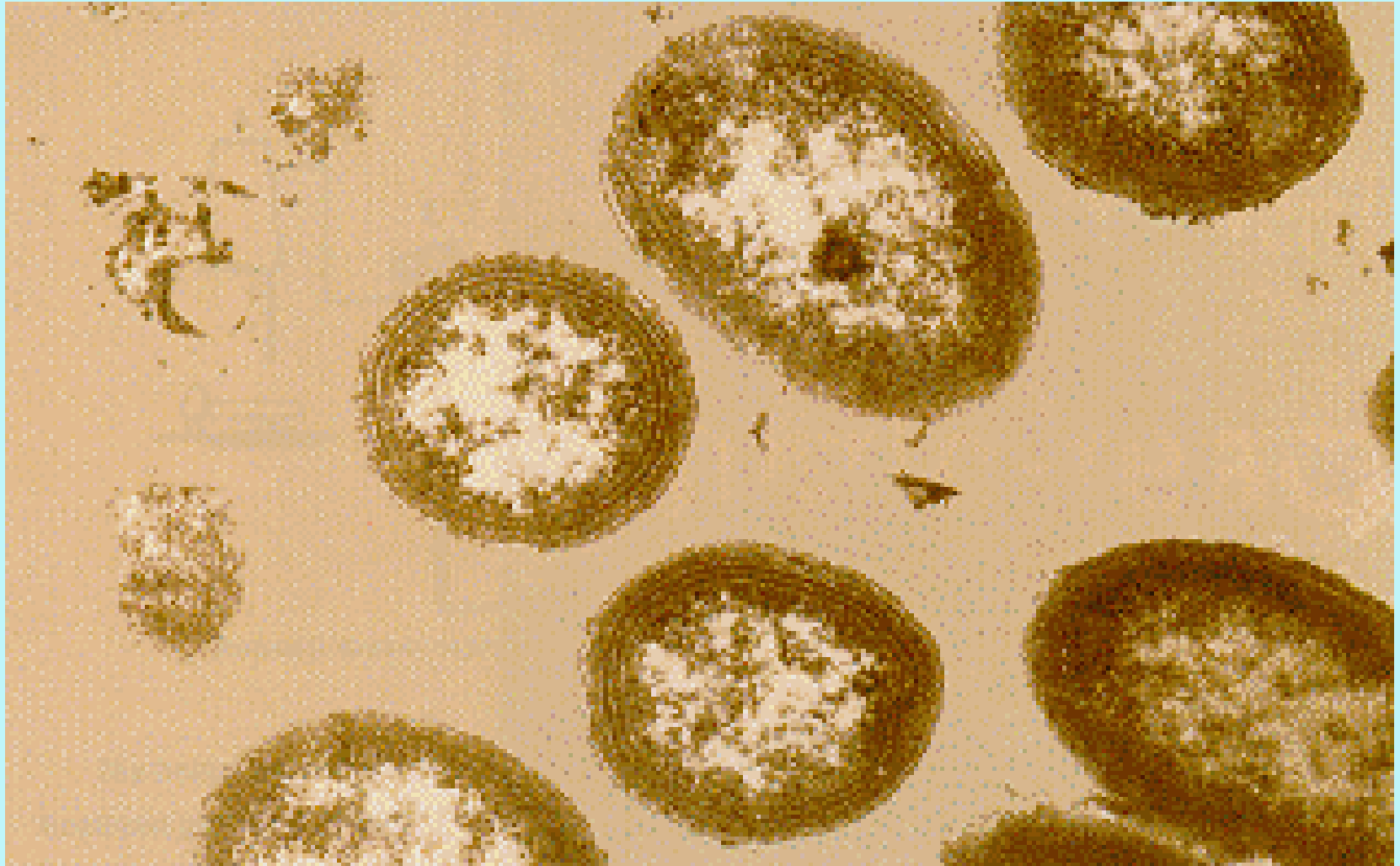
Nitrobacter



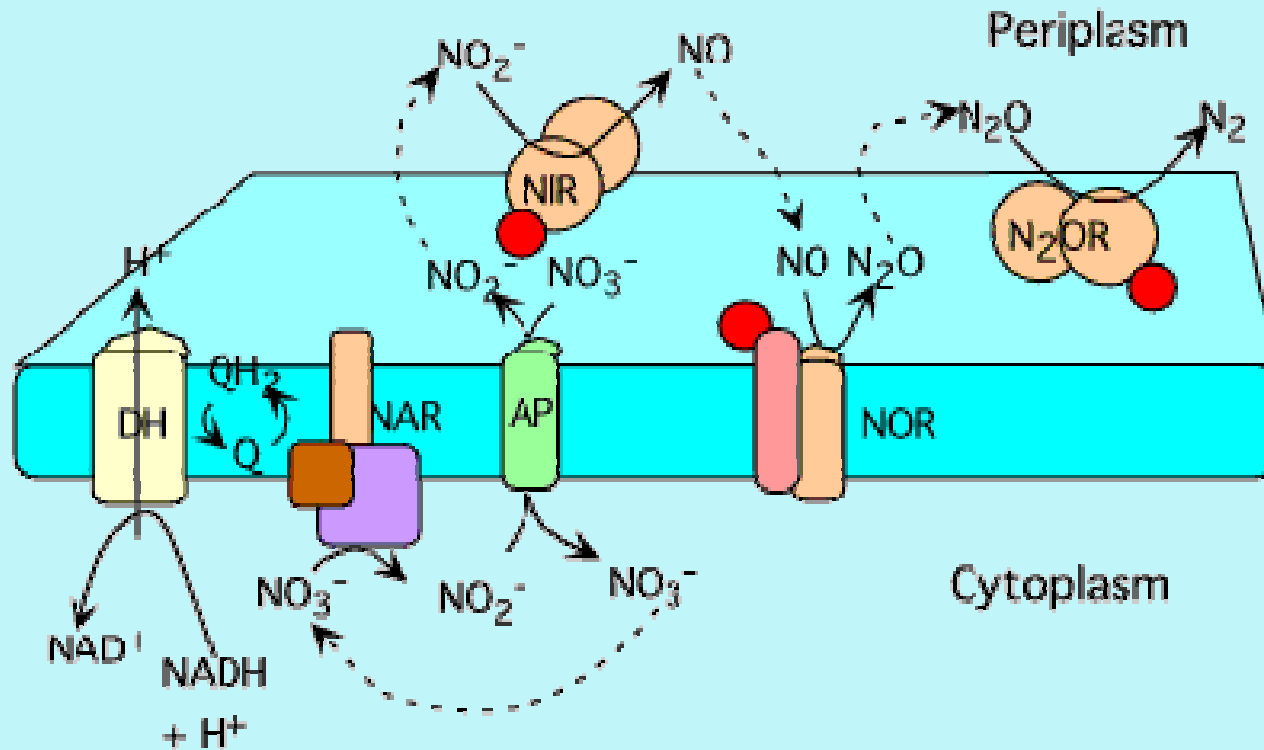
METABOLIC PATHWAY NITRAFIFYING BACTERIA



Denitri- and Denitra- fying Bacteria

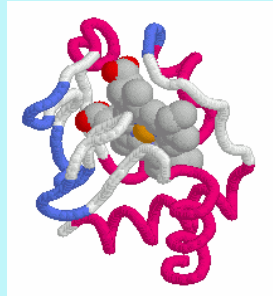
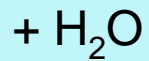
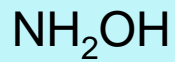


TYPICAL METABOLIC PATHWAY
for
DENITRIFYING and DENITRIFYING BACTERIA



ENZYMES

IMPORTANCE OF IRON IN ELECTRON TRANSPORT



FE is present in all cytochrome c molecules

HAO



2 cyt
 C_{554} ↓

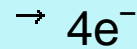
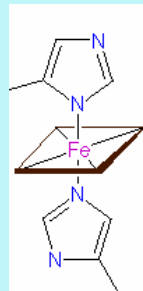
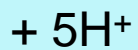
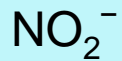


4 cyt
 C_{552}



terminal
oxidase

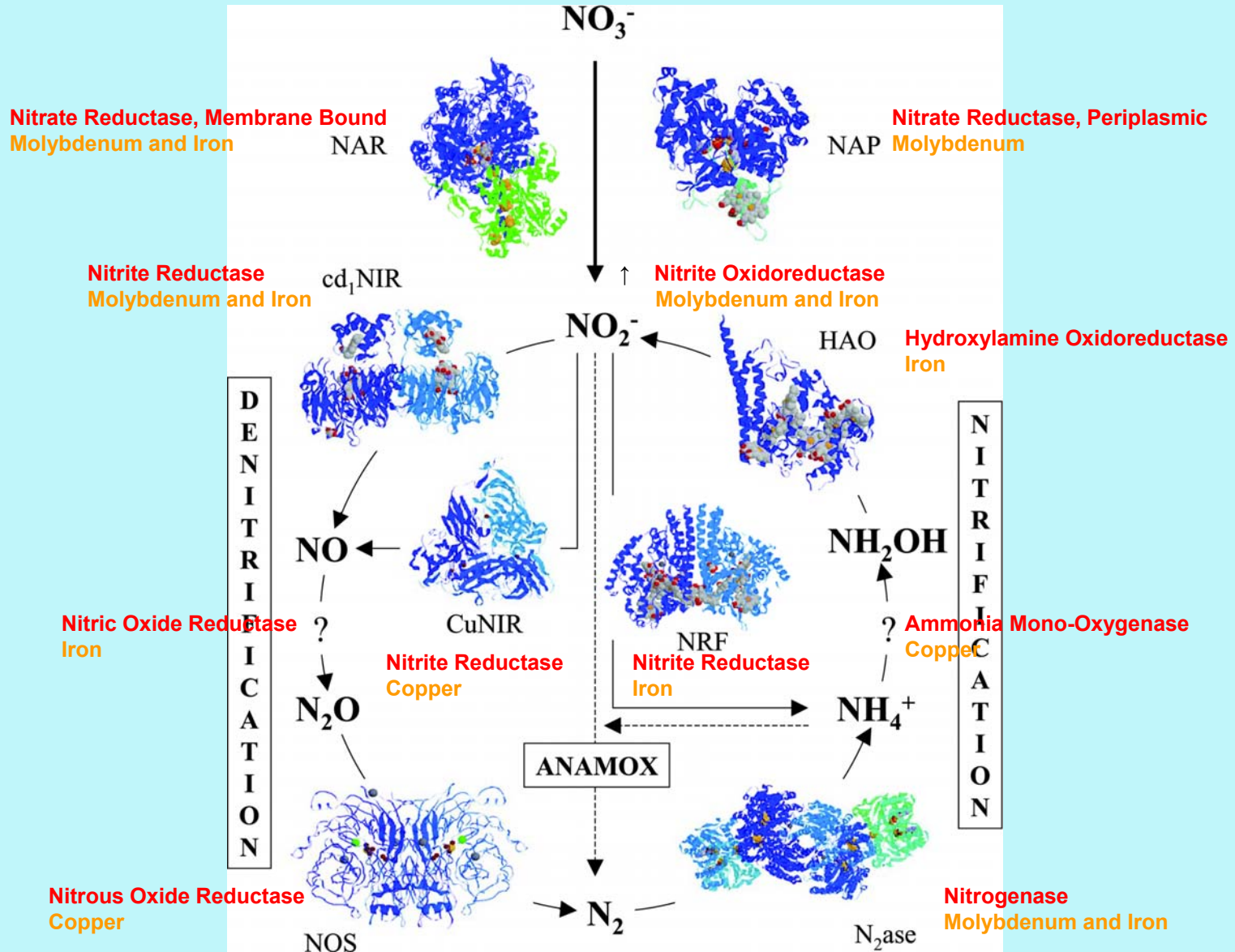
(1)



(2)

ENZYMES

X-ray structures of the enzymes of the bacterial nitrogen cycle illustrating **the metals** necessary for successful bacterial metabolism

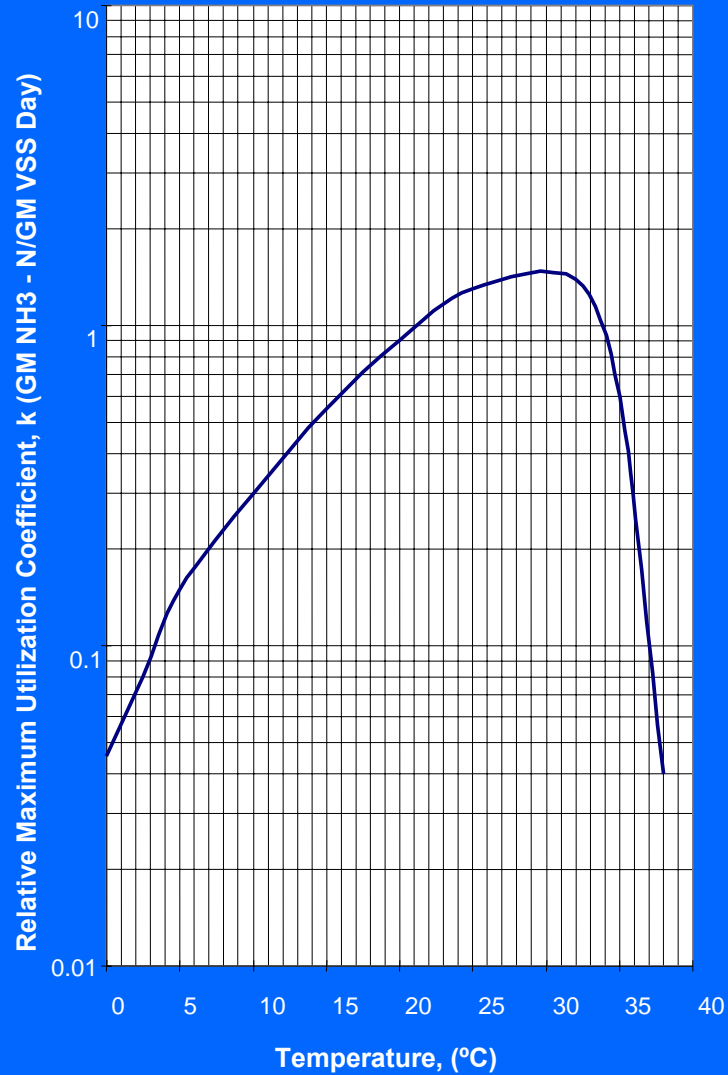


Biological Nitrification and Denitrification Reactor Process Design Parameters

1. TEMPERATURE
2. DISSOLVED OXYGEN LEVEL
3. pH AND ALKALINITY
4. SUBSTRATE LEVELS:
 NH_4^+ , NO_3^- , NO_2^- , C
5. GROWTH RATE OF MICRO-ORGANISMS
6. INHIBITORY SUBSTANCES

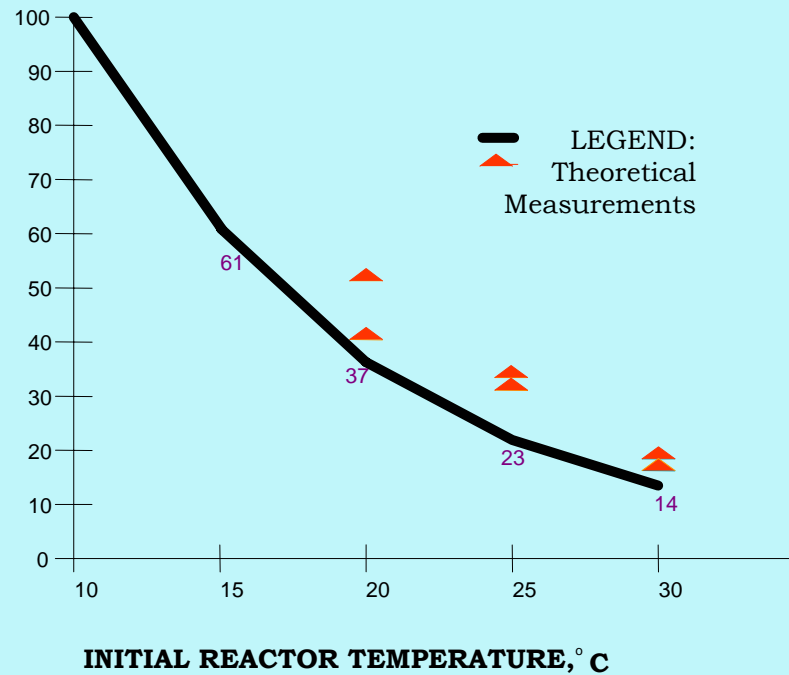
Effect of Temperature

Maximum Ammonia Nitrogen Utilization Coefficient, k , (Nitrosomonas)



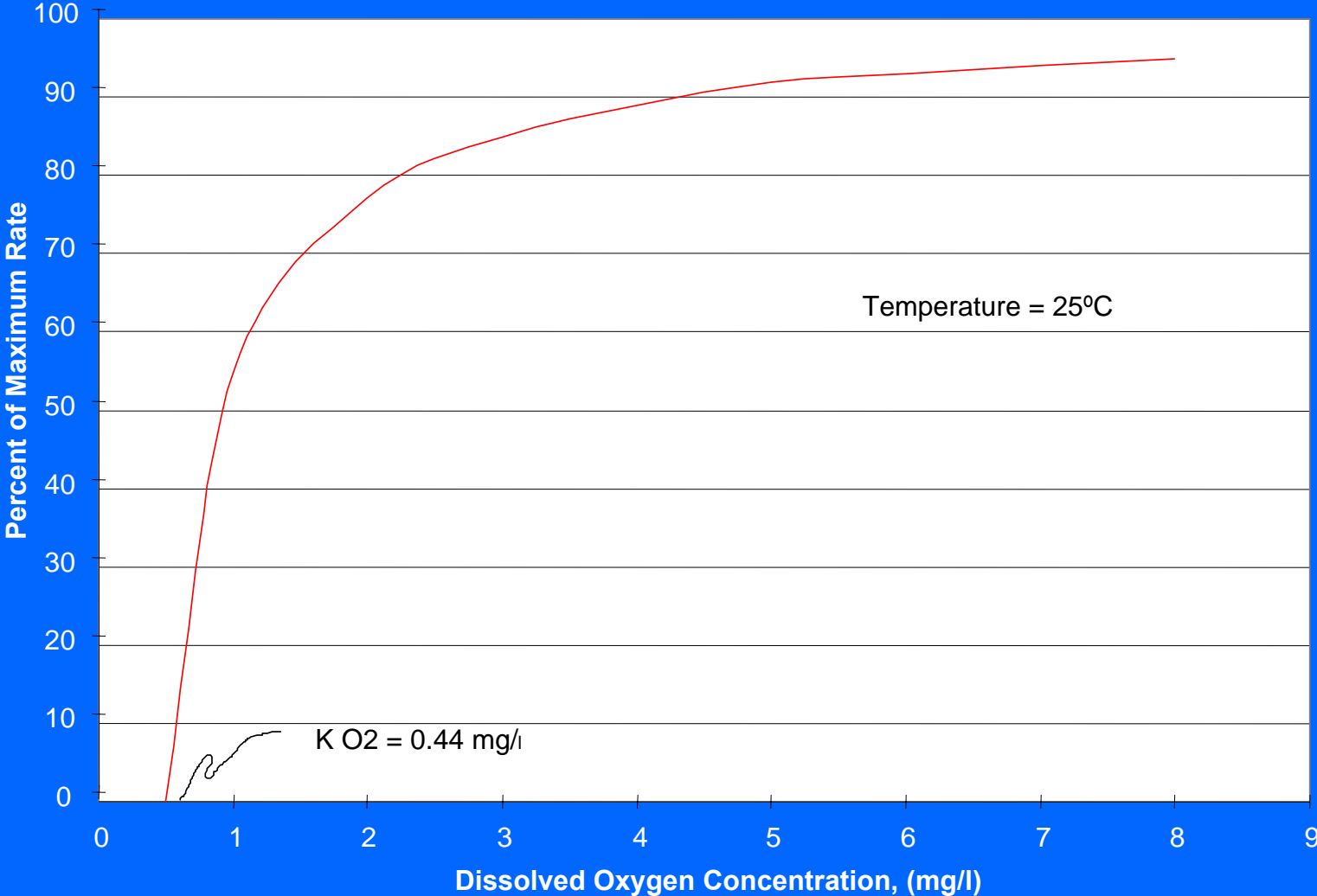
RESEARCH ON “SHOCK” EFFECT OF TEMPERATURE ON NITRIFICATION RATES

**NITRIFICATION RATE AT 10 ° C AS A PERCENTAGE
OF THE RATE AT THE INITIAL TEMPERATURE, %**



Work done @ University of Manitoba in Canada by Melanie Head²

Effect of Dissolved Oxygen on the Growth Rate of Nitrifiers



INFLUENCE of OXYGEN LEVEL on DENITRIFICATION and DENITRAFICATION

Region of Oxygen Control of Enzyme Activity

Region of Oxygen Control of Enzyme Synthesis

N₂O reduction

NO₂ reduction

NO₃ reduction

HYPHOMICROBIUM, spp

nitrite reductase nitrate reductase

THIOBACILLUS DENITRIFICANS

nitrate reductase

nitrite reductase

0

10

20

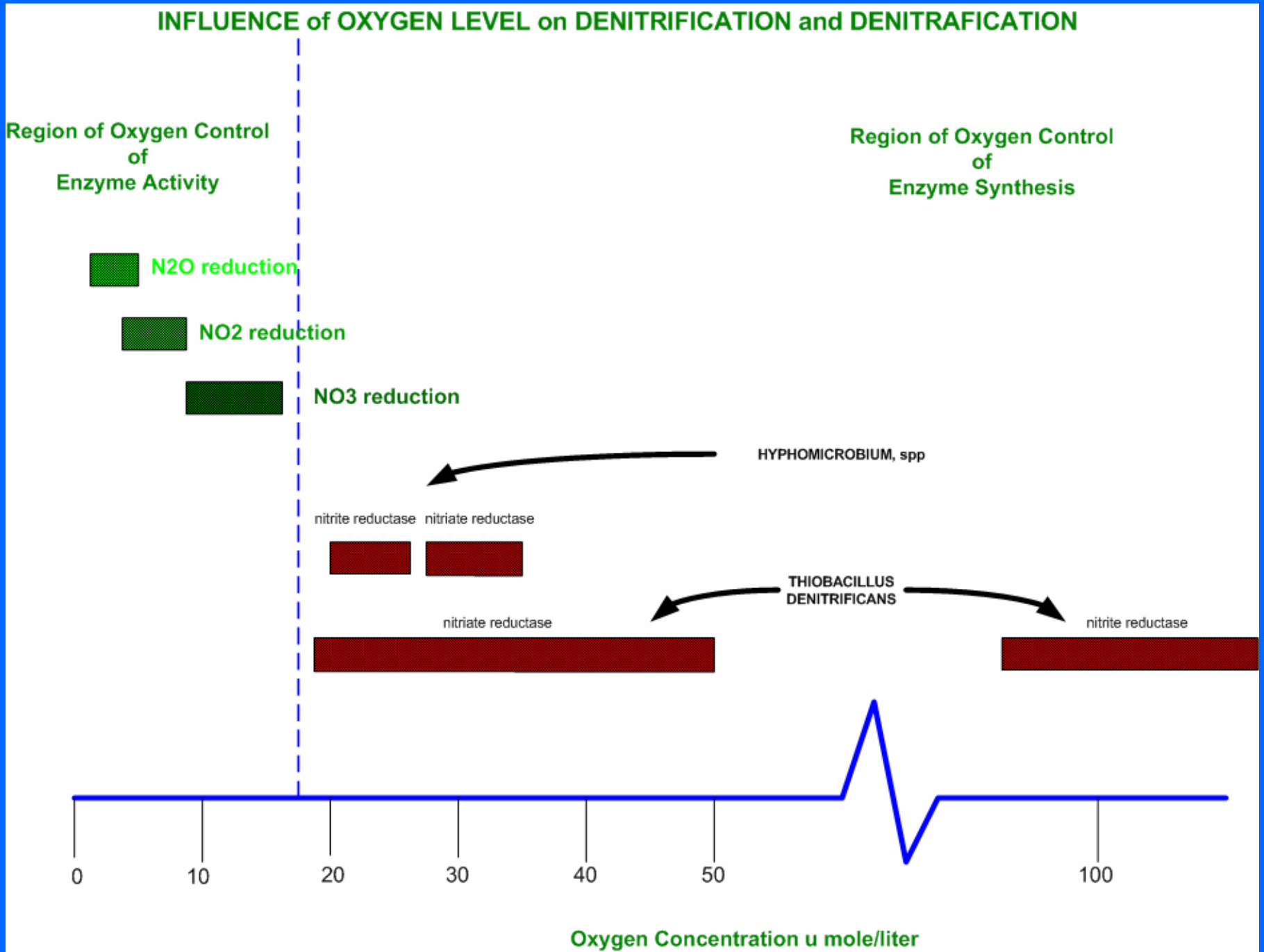
30

40

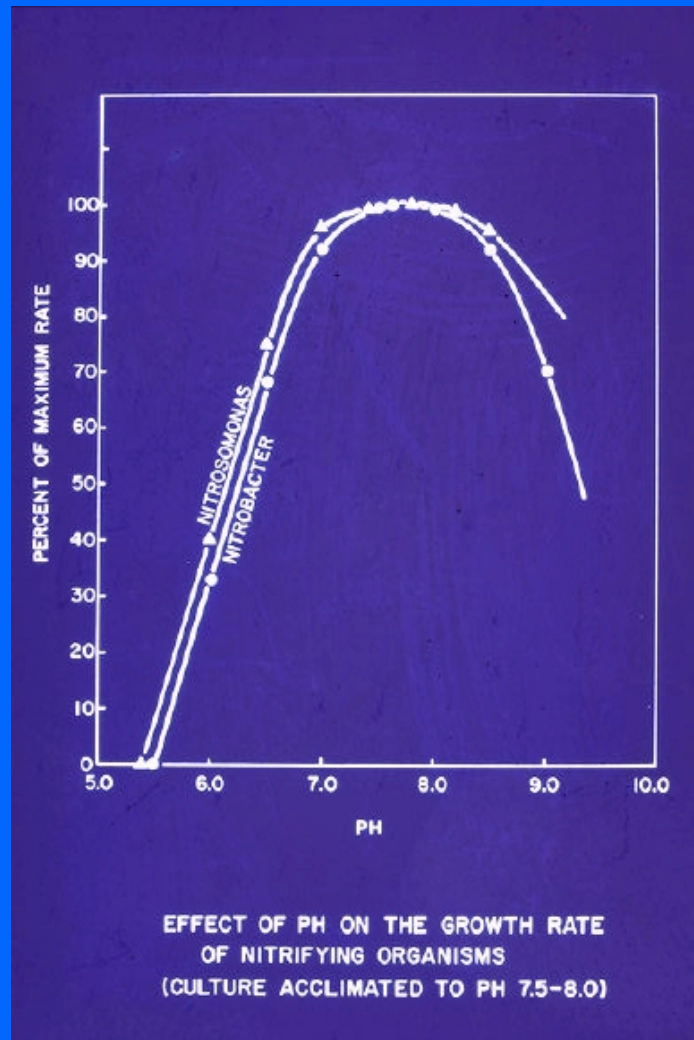
50

100

Oxygen Concentration μ mole/liter



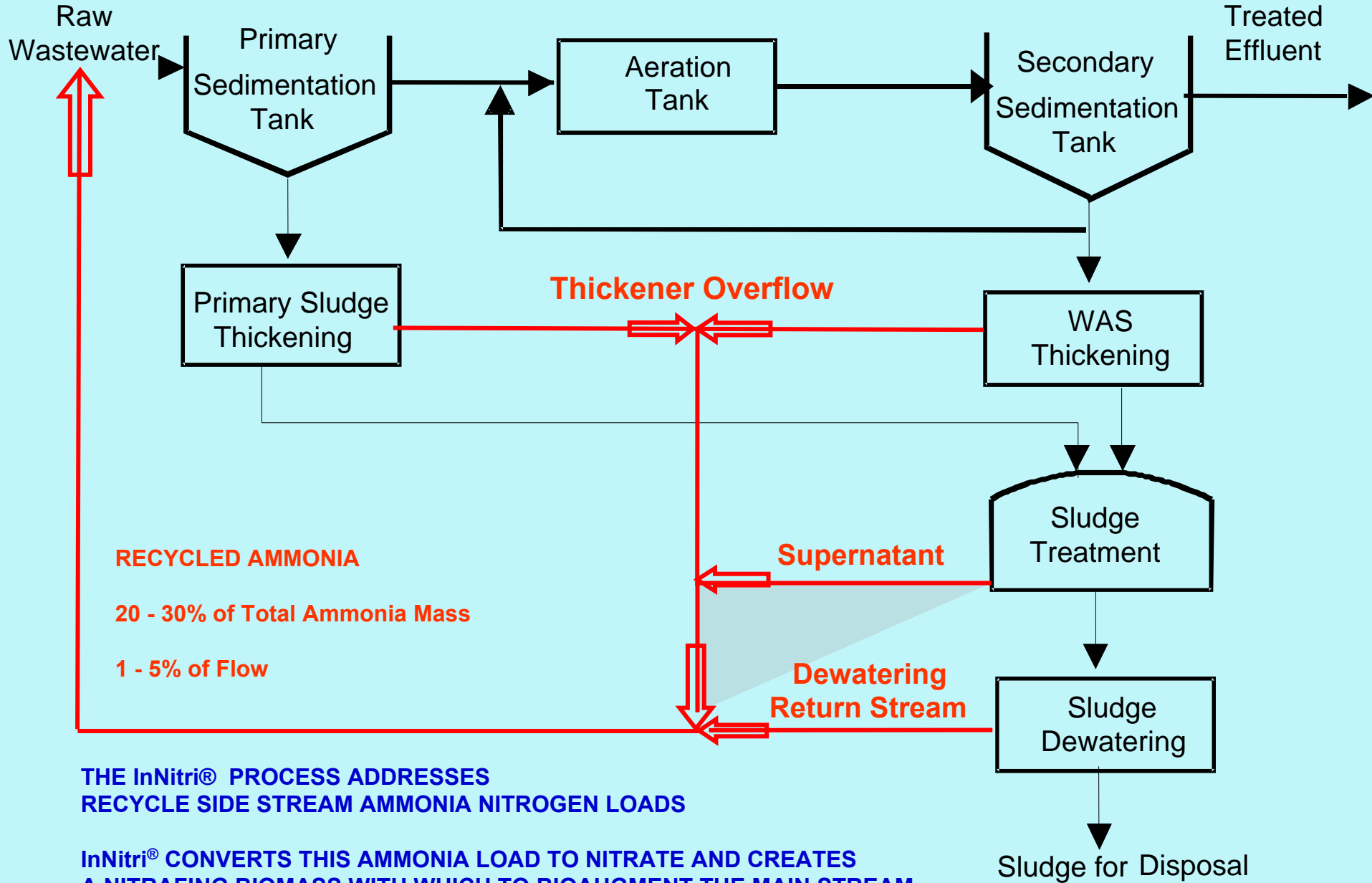
The Effect of pH on the growth rate of Nitrifiers and Nitrafiars



InNitri®

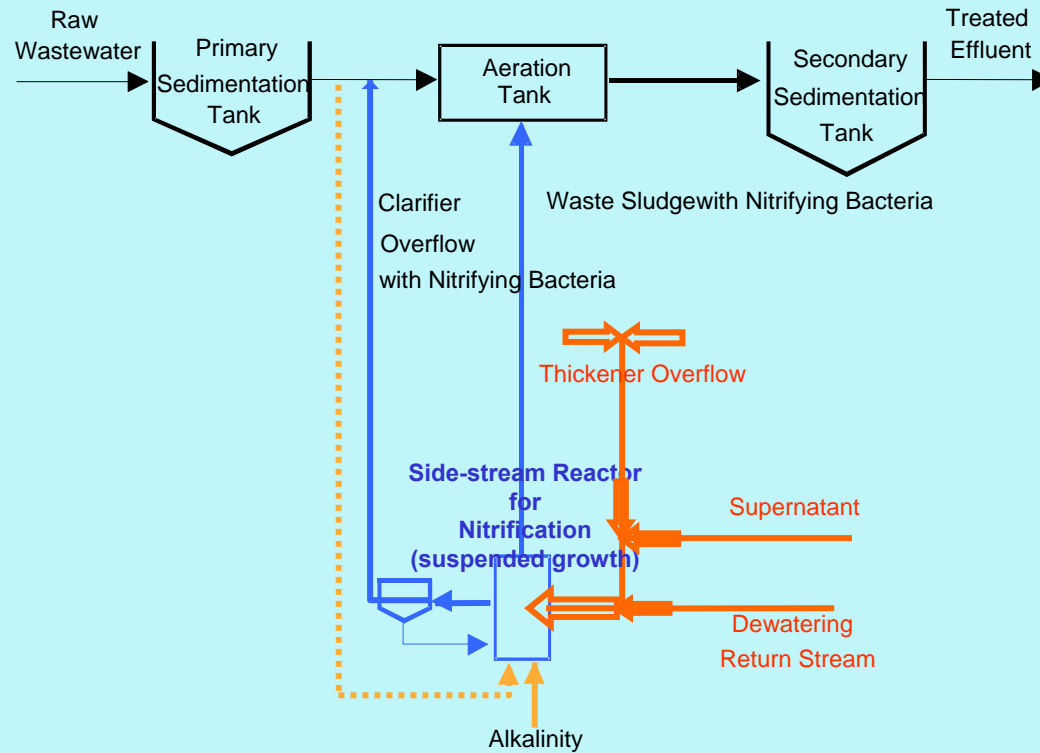
Inexpensive Nitrification

**Peter Kos PhD
Dorr-Oliver
Malcolm Pirnie
Private Consultant**



**THE InNitri® PROCESS ADDRESSES
 RECYCLE SIDE STREAM AMMONIA NITROGEN LOADS**

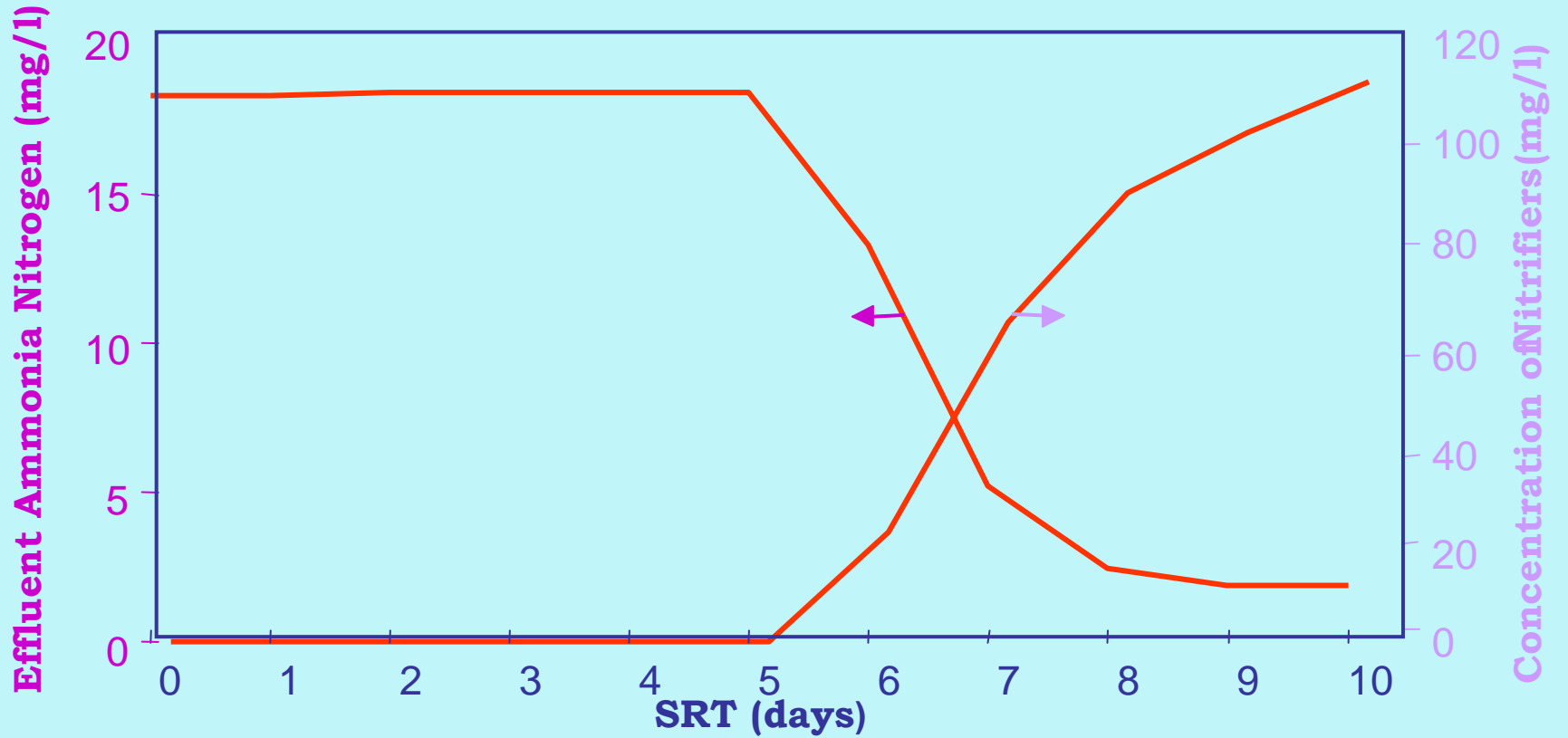
**InNitri® CONVERTS THIS AMMONIA LOAD TO NITRATE AND CREATES
 A NITRAFING BIOMASS WITH WHICH TO BIOAUGMENT THE MAIN STREAM
 REACTOR REDUCING THE SRT NEEDED TO NITRAFY IN THE MAIN STREAM**



InNitri[®] Reactor

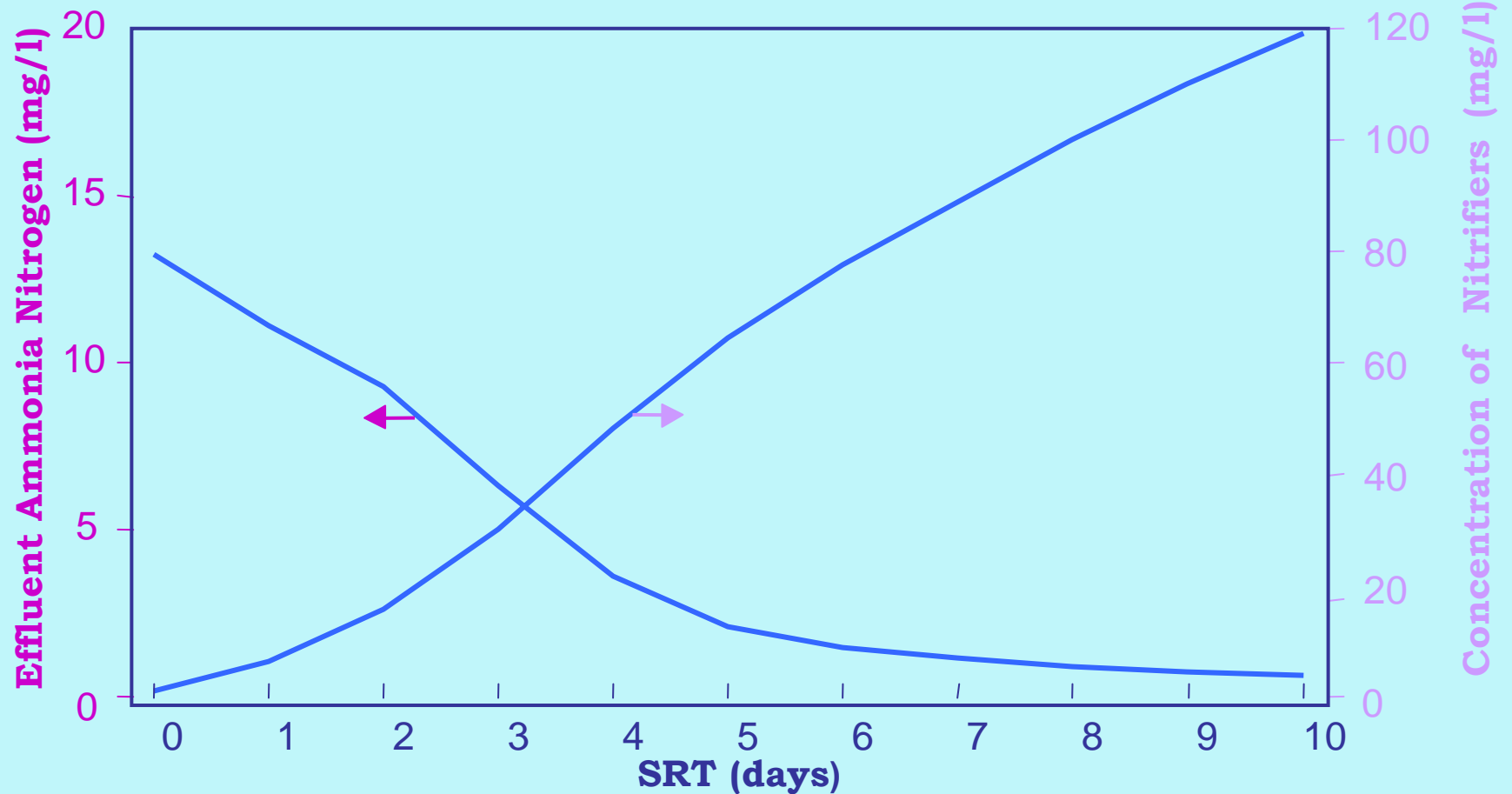
Buildup of Nitrifiers and the Effect on Effluent @ 10 ° C

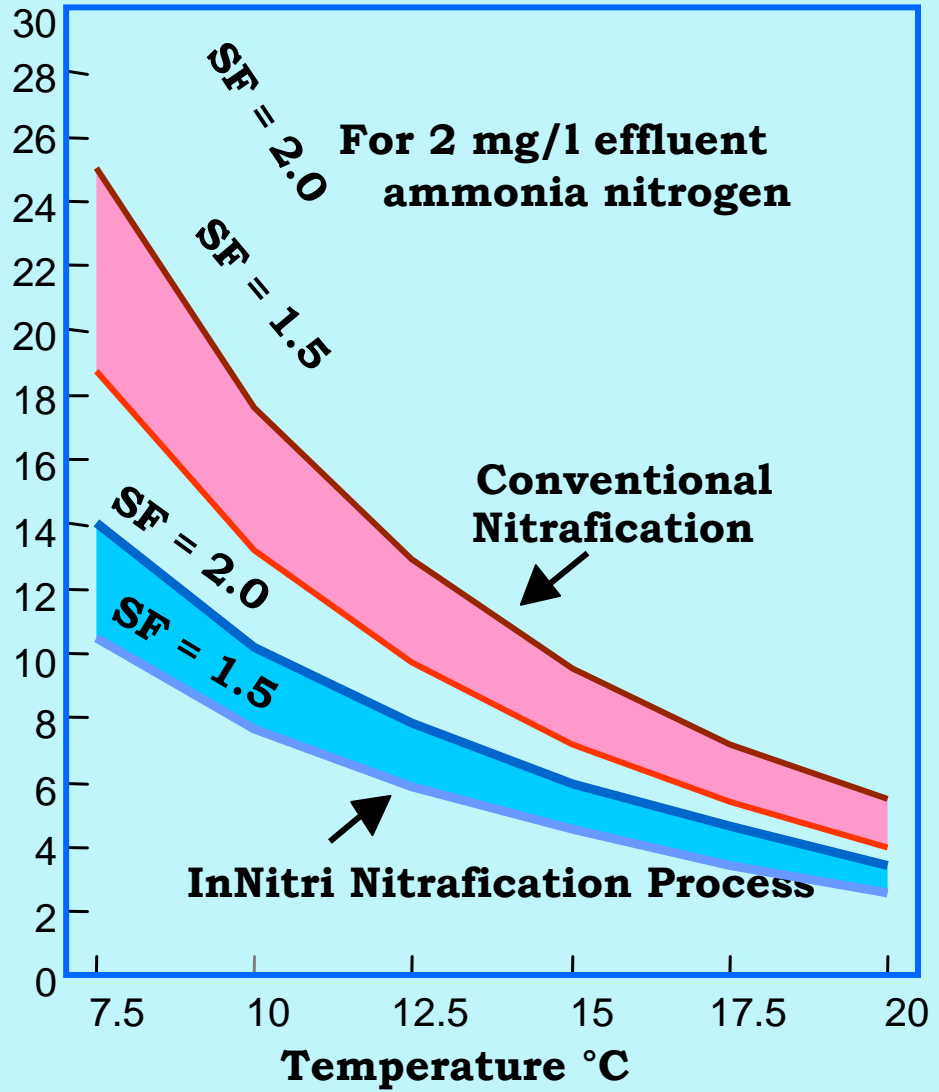
Legend — Conventional Nitrification Process



Buildup of Nitrifiers and the Effect on Effluent @10° C

Legend — Sidestream Nitrification Process





COMMERCIAL DEVELOPMENT

Projects in North America

LOCATION	NITROGEN LOAD lbs/day	COMMISIONING DATE	STATUS
Tucson, AZ	2043	Demonstration Program	(P)
Richmond, VA	2852	Designed Ready for Bid	(D)

(P) in demonstration **(D)** in design; **(C)** in construction; **(O)** in operation

Tuscon, AZ, USA, Ina Road, Pilot Plant

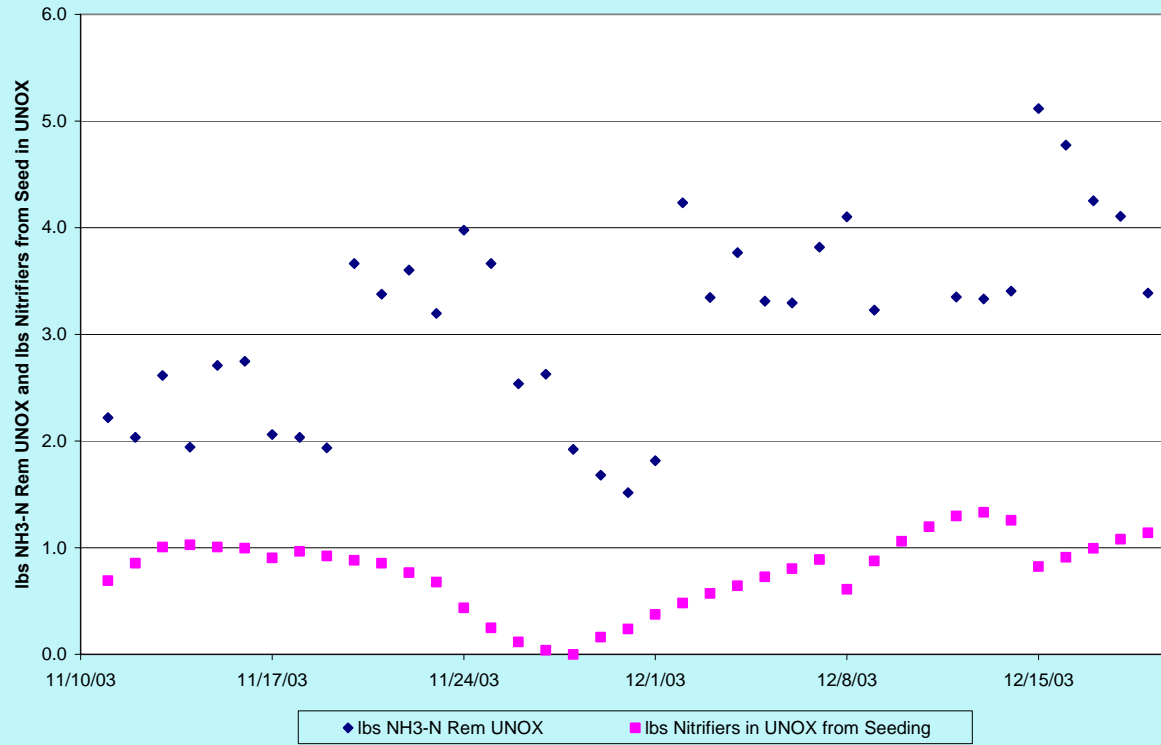


The InNitri Reactor

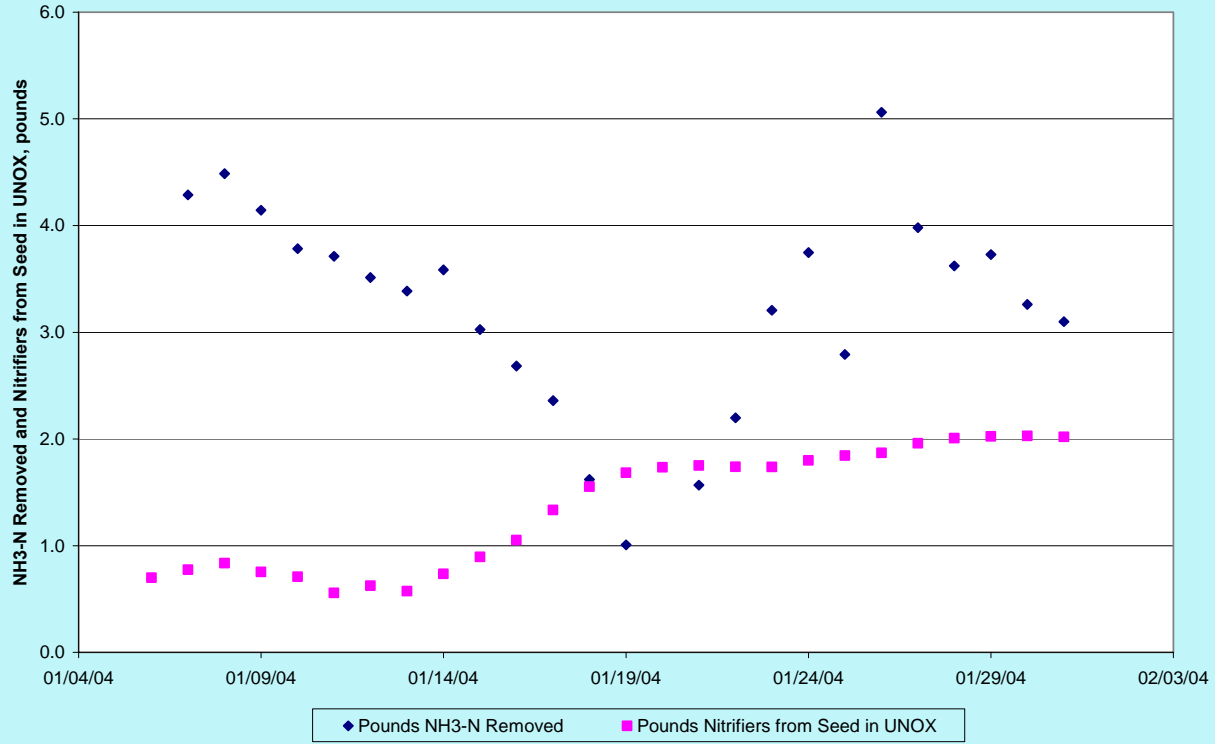
CENTRATE TREATMENT SYSTEM SUMMARY PERFORMANCE

Operating Conditions	Phase 1	Phase 2
Duration, days	39	25
Average SRT, days	3.78	4.75
Average Feed NH ₃ -N, mg/l	767	940
Average Effluent NH ₃ -N, mg/l	12	4
Average Temperature, °C	27	29
Average Dissolved Oxygen, mg/l	3.1	3.1
Average / Maximum NH ₃ -N loading, lbs/1000ft ³ /day	26 / 38	35 / 42
Average Percent of Seed produced transferred to UNOX™ System, %	60%	80%
Equivalent Centrate Flow for 25 MGD UNOX™ Flow, gpd (Based on observed seed transfer, assuming a 50 mg/l TSS concentration in the final clarifier effluent of the centrate nitrification system.)	200,000	250,000

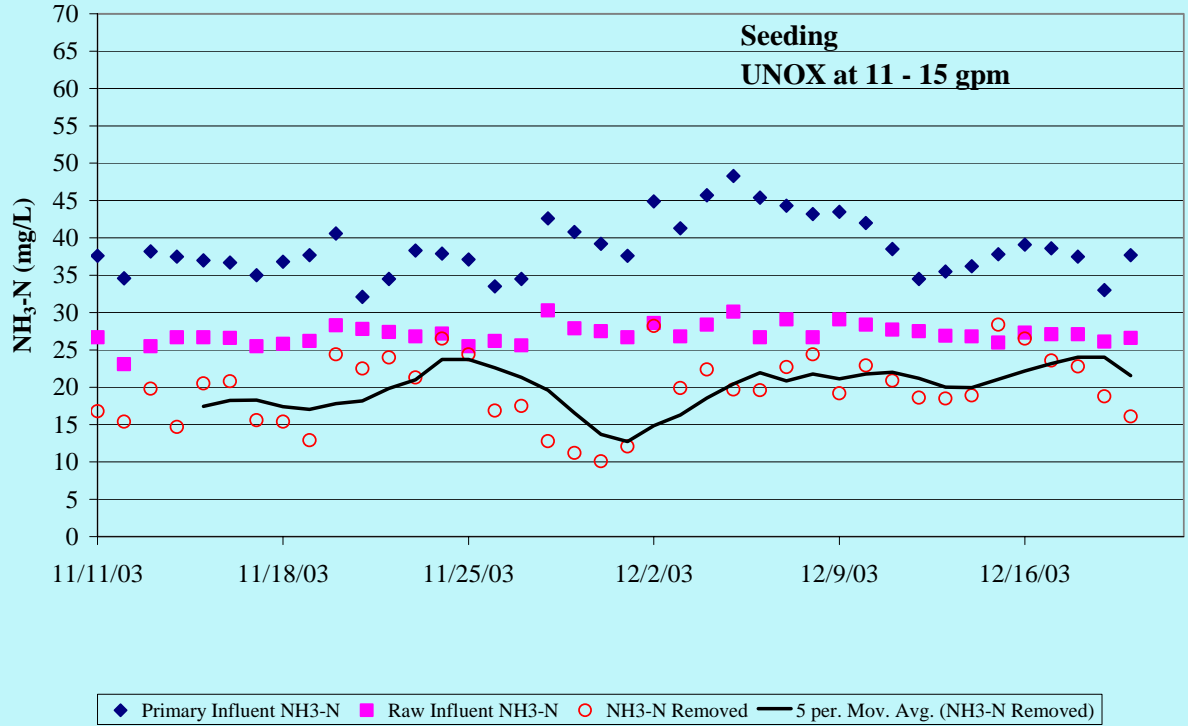
UNOX System
NH3-N Removal vs Seed Quantity



NH3-N Removal v Seed Quantity



UNOX Reactor



Richmond, Virginia *InNitri*[®] System



**80 MGD Activated
Sludge Plant**

**Design Engineer
Greeley & Hansen**

**Bid Tender 3rd OTR 2009
Construction 4th QTR 20 09**

Reason for Bioaugmentation

**Inability to achieve nitrification
in winter**

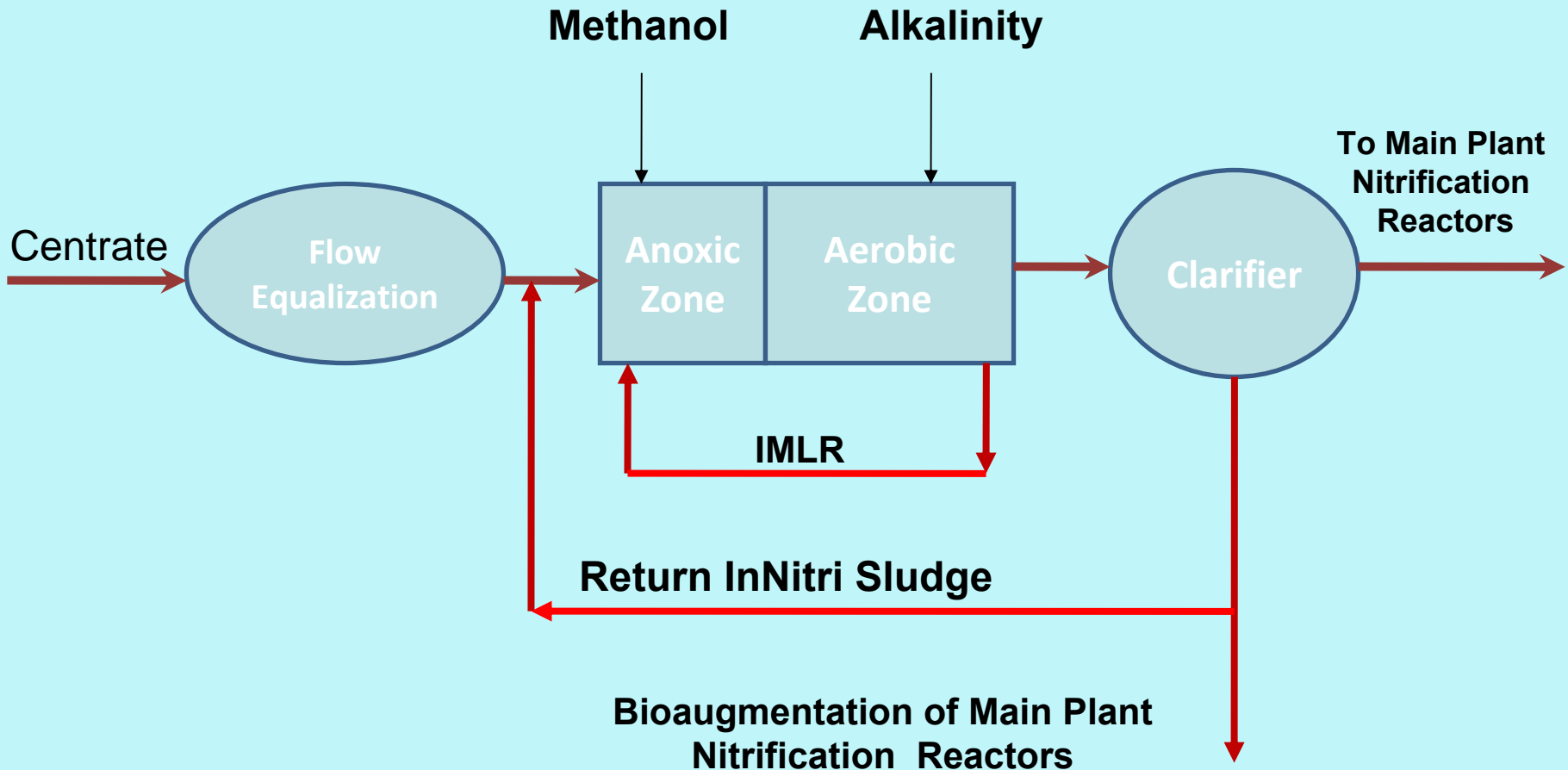
***InNitri* System Process Design Parameters**

Richmond, Virginia

<u>Process</u>	<u>Average</u>	<u>Maximum</u>
Flow, MGD	0.3	0.36
CBOD,mg/l	830	830
TSS, mg/l	380	380
TKN, mg/l	1000	1000
NH3, mg/l	850	850
Alkalinity, mg/l	3500	3500
Temperature, c	20 - 27	20 - 27
IMLR Ratio to Flow	5	4.2
IMLR flow, MGD	1.5	1.5
Alkalinity Addition, mg/l	2100	2100
Methanol Addition (30%), gpd	2950	2950
RAS, MGD	0.3	0.3

***InNitri* System Process Schematic**

Richmond, Virginia





Dr Peter Kos

WE, THANK YOU FOR YOUR TIME
ARE THERE ANY QUESTIONS

