

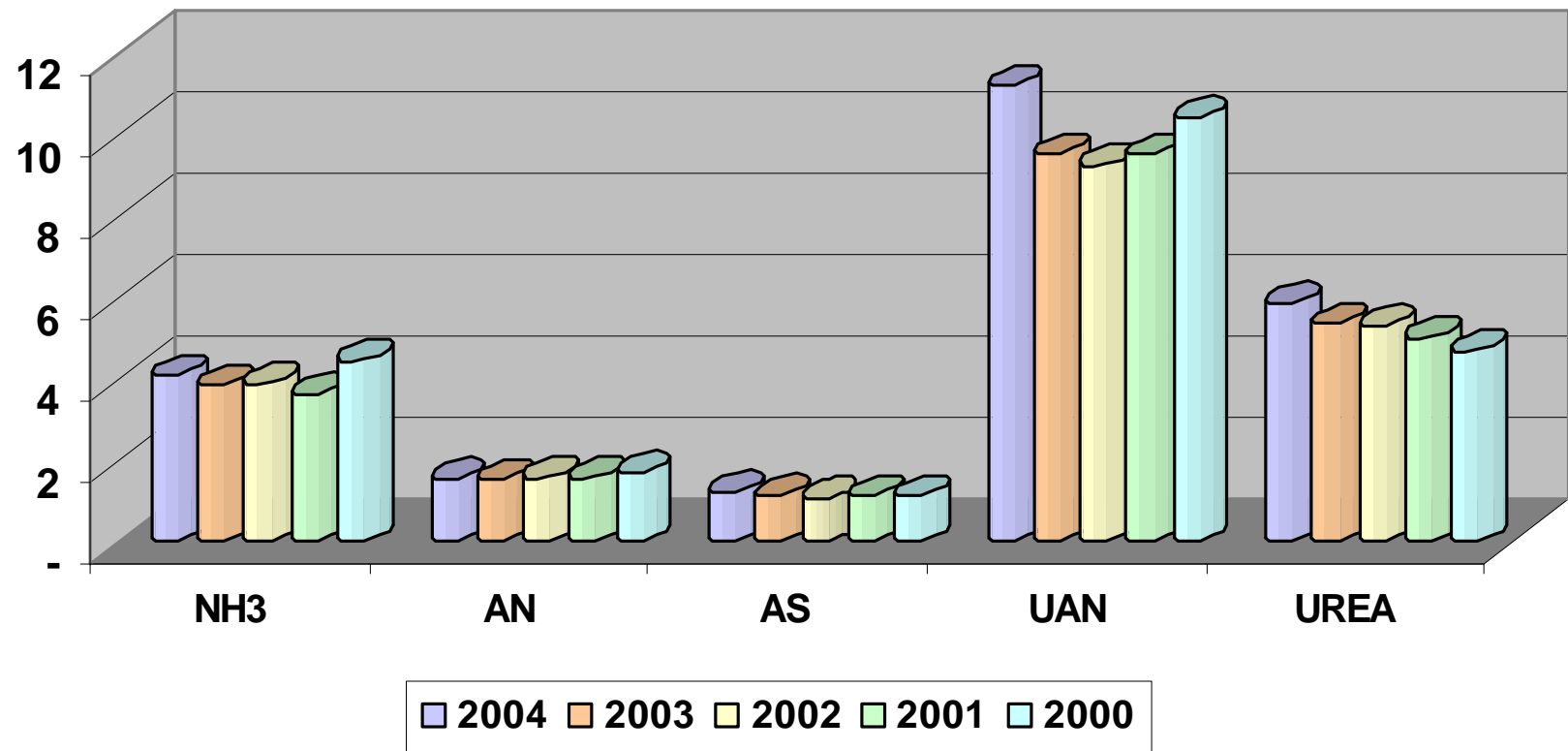


# **Urease and Nitrification Inhibitors**

**The Fertilizer Institute  
November 3, 2005**

Allen Sutton  
Business and Product Development

## US Nitrogen Consumption (in million tons)



# INHIBITOR TECHNOLOGY

- **Nitrogen Stabilizer**-A substance added to a fertilizer which extends the time the nitrogen component of the fertilizer remains in the soil in the [urea or] ammoniacal form. (Official 2001)
- **Urease Inhibitor**-A substance which inhibits hydrolytic action on urea by urease enzyme. When applied to soils a urease inhibitor results in less urea nitrogen lost by ammonia volatilization. (Official 1997)
- **Nitrification Inhibitor** –A substance that inhibits the biological oxidations of ammoniacal nitrogen to nitrate nitrogen. (Official 2001)
- AAPFCO Terms as defined by the Association of American Plant Food Control Officials

# **Improving Nitrogen Efficiency**

- 1. Realistic Nitrogen Recommendations**
- 2. Proper Timing of Nitrogen Application**
- 3. Urease Inhibitors**
- 4. Nitrification Inhibitors**

# **Methods of Improving Nitrogen Efficiency**

- **Enhanced Nitrogen Feeding**

There are opportunities to enhance nitrogen feeding by helping nitrogen to be at the right place, right time, and in the most advantageous form when the crop needs it.

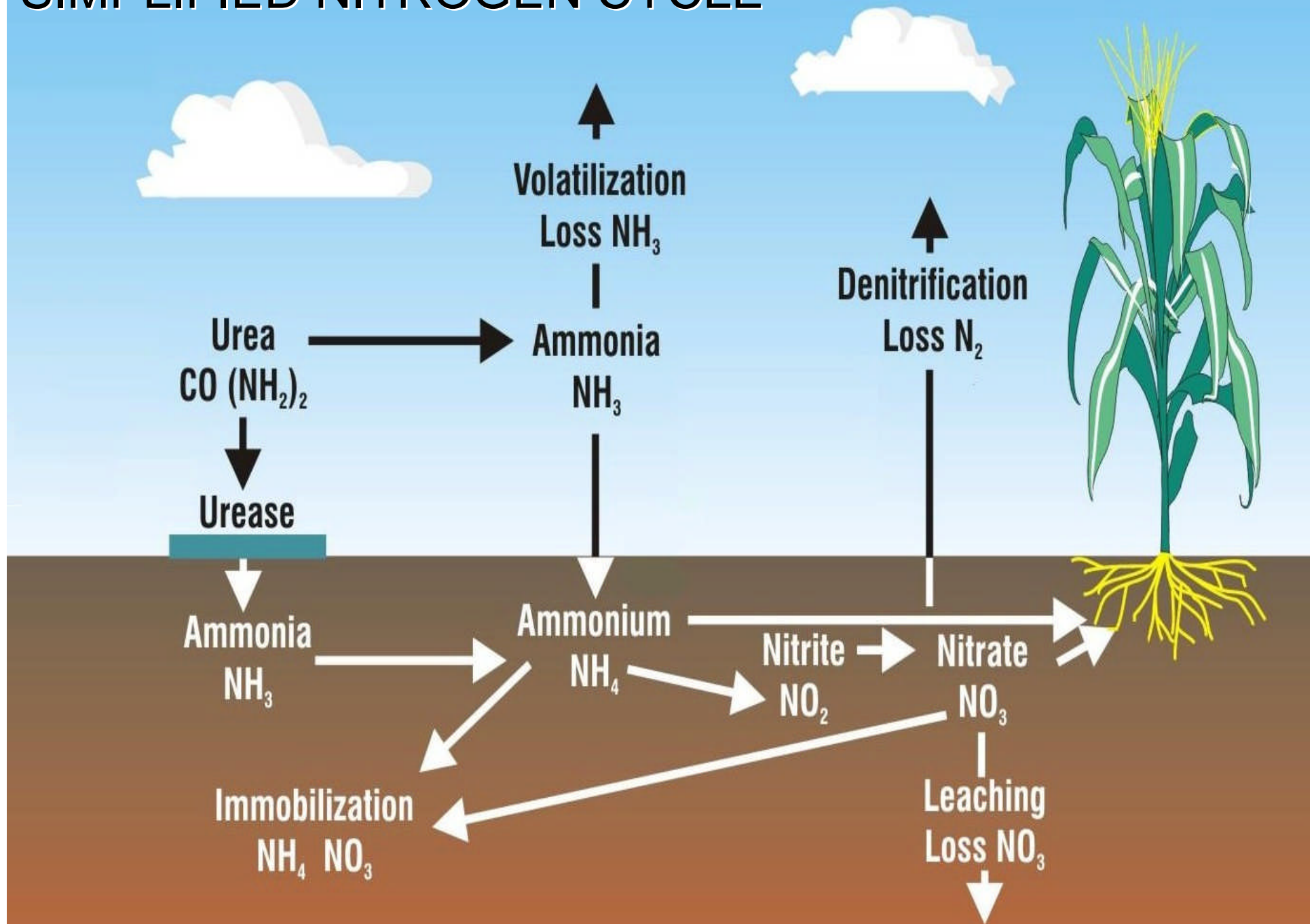
- **Minimized Nitrogen Loss**

There are five major avenues of nitrogen loss. Mechanical and chemical technology exists to reduce these losses of applied nitrogen.

# FATE OF FERTILIZER NITROGEN AFTER APPLICATION (Crop Uptake 40-70%)

Immobilization	$\text{NH}_4\text{NO}_3$	10 – 40%
Erosion	$\text{NH}_4$	0 – 20%
$\text{NH}_3$ Volatilization	Urea	0 – 30%
Leaching	$\text{NO}_3$	0 – 20%
Denitrification	$\text{NO}_3$	5 – 35%

# SIMPLIFIED NITROGEN CYCLE



# Immobilization

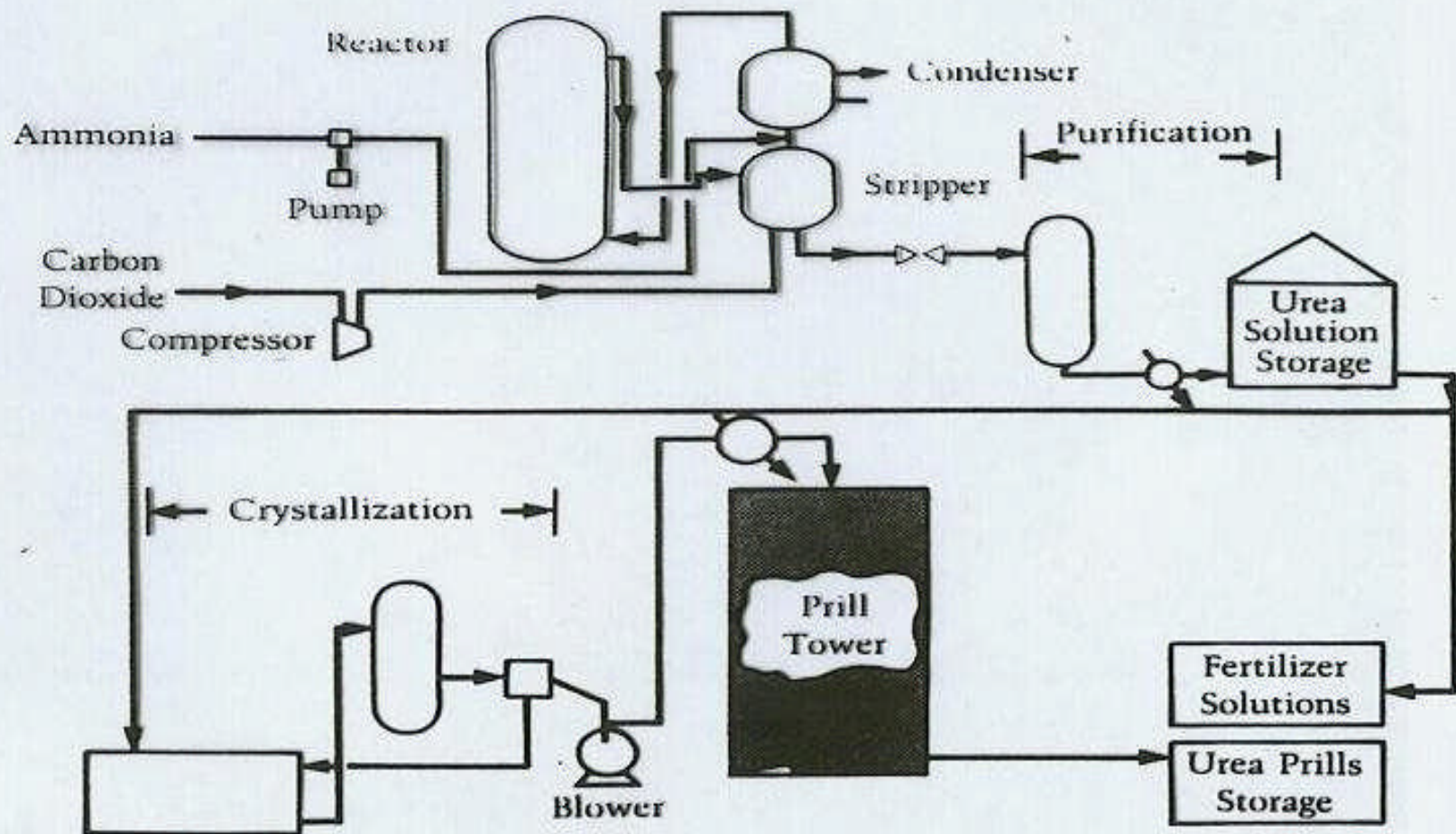
- Can account for 10-40% tie up of applied nitrogen.
- The nitrogen isn't lost; however, often is not available to the growing crop.
- Placing nitrogen below the carbon rich zone can reduce immobilization.
- Urea containing compounds can be leached by rainfall thru the carbon rich zone.
- Urease inhibitors can aid in this process.



# Erosion

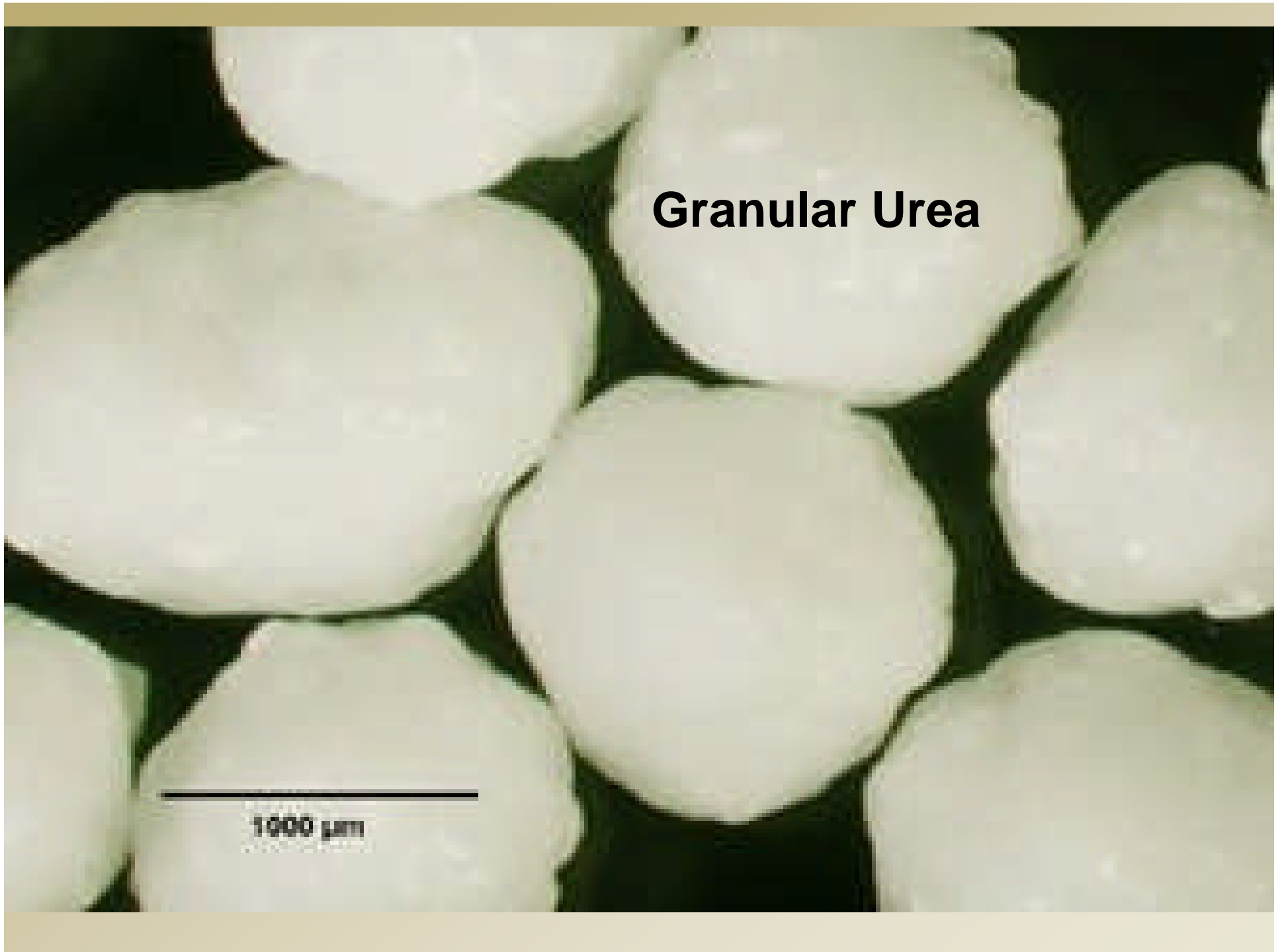
- Nitrogen is lost when soil erodes.
- Losses of Nitrogen can be as high as 20%.
- Conservation tillage is our best deterrent to erosion losses.

## PRODUCTION OF UREA



# Granular Urea

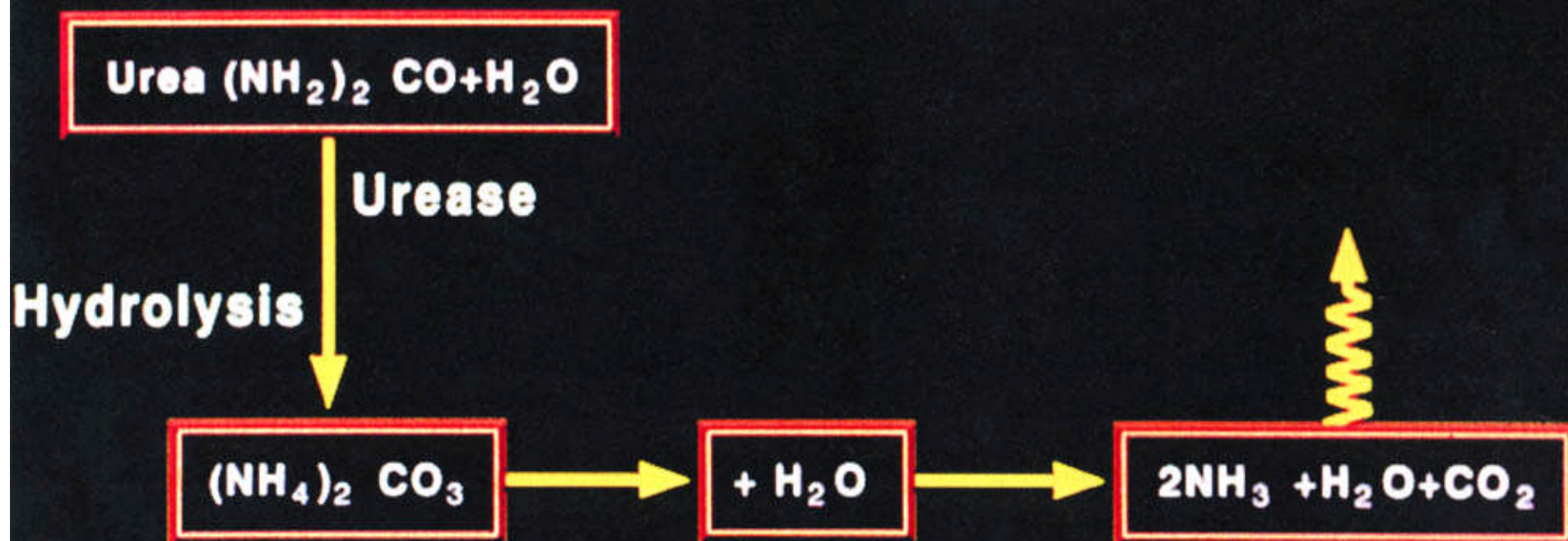
1000  $\mu\text{m}$





# WHY UREA VOLATILIZES

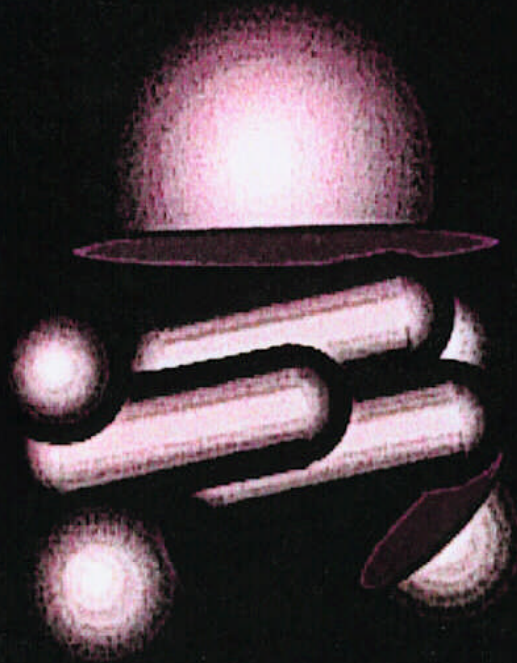
When urea is applied to the soil it rapidly hydrolyzes (a chemical reaction resulting in breakdown of susceptible chemical bonds) to ammonium carbonate.



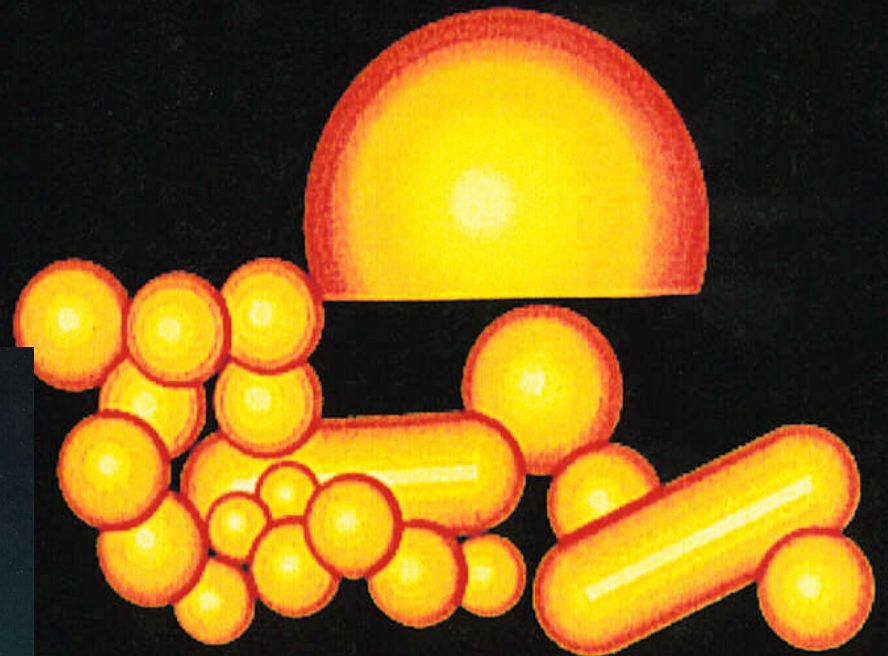
Ammonium carbonate is unstable and breaks down to ammonia and carbon dioxide. The ammonia is either absorbed by the soil or volatilizes. The hydrolysis reaction is increased by the urease enzyme.



# Urea

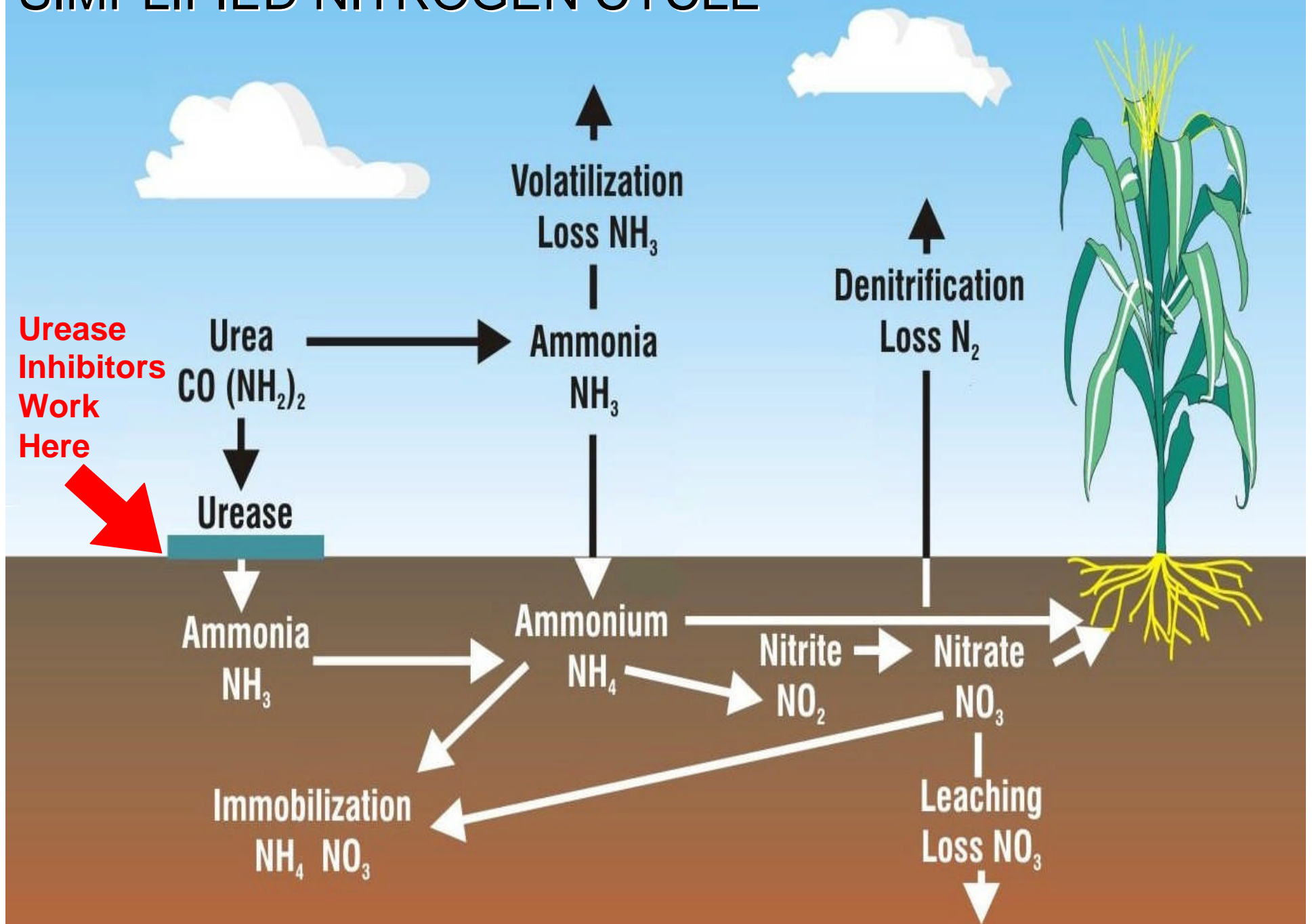


**Urease** Is Present Throughout  
The Soil And Becomes Active  
When Urea Comes In Contact  
With The Soil



# Urease

# SIMPLIFIED NITROGEN CYCLE



# Urease Inhibitors

- Volatilization can occur anytime atmospheric moisture and urease are available in temperatures that range from 11°F to 105°F.
- Urease inhibitors block the conversion of urea to ammonia for a period of one to two weeks allowing time for incorporation by rainfall or other means.

# Compounds Tested as Urease Inhibitors

- NBTPT ( or NBPT): N-(n-butyl) thiophosphoric triamide
- BNPO ( or NBPTO): N-(n-butyl) phosphoric triamide
- TPT: thiophosphoryl triamide
- PPD/PPDA: phenyl phosphorodiamidate
- CHTPT: cyclohexyl thiophosphoric triamide
- CNPT: cyclohexyl phosphoric triamide
- PT: phosphoric triamide
- HQ: hydroquinone
- P-benzoquinone
- HACTP hexaamidocyclotriphosphazene
- Thiophyridines, thiophyrimidines, thiophyridine-N-oxides
- NN-dihalo-2-imidazolidinone
- N-halo-2-oxazolidinone



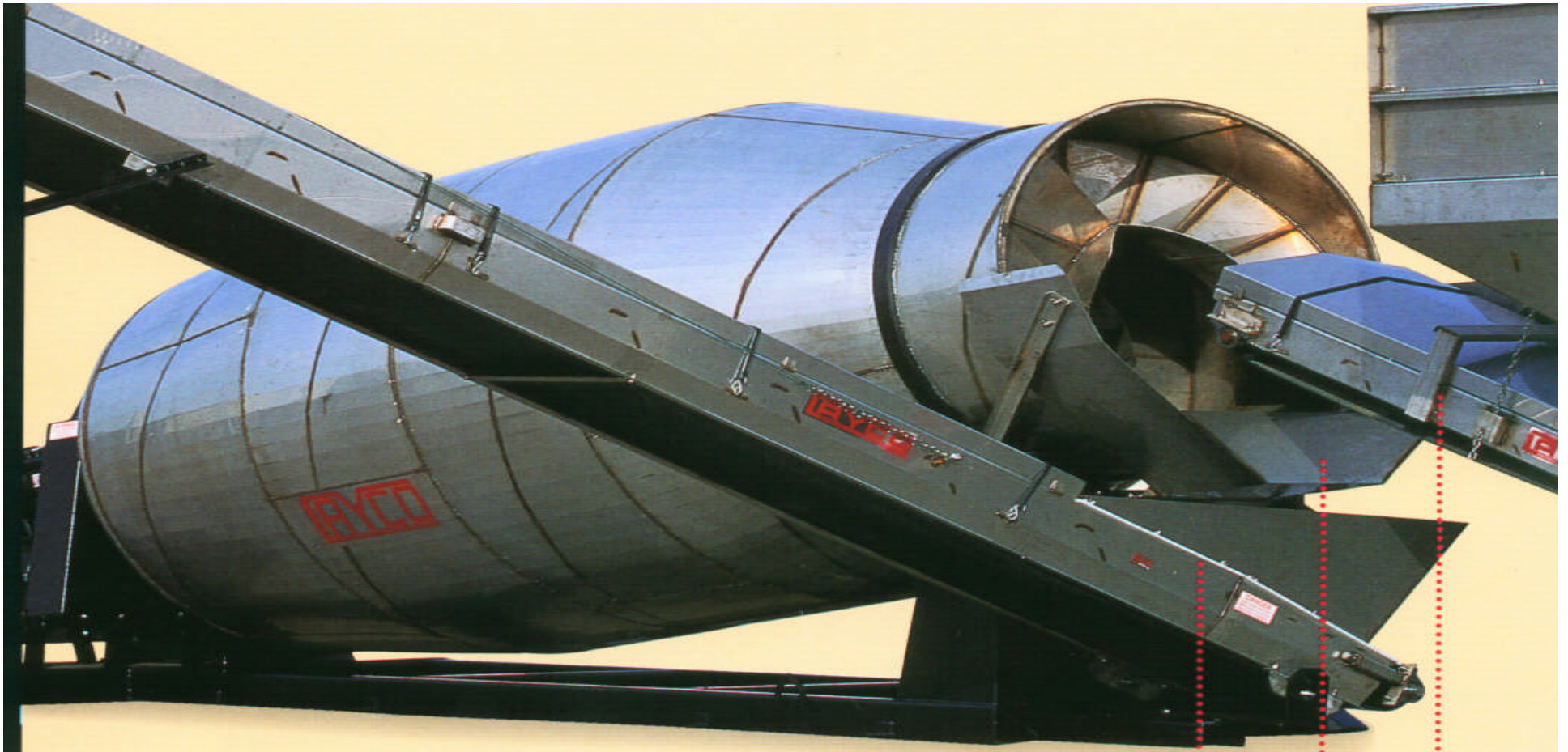
“However, only one urease inhibitor has gained practical and commercial importance: NBTPT ( or NBPT): N-(n-butyl) thiophosphoric triamide”

Martin Trenkel, Controlled  
Release and Stabilized  
Fertilizers in Agriculture

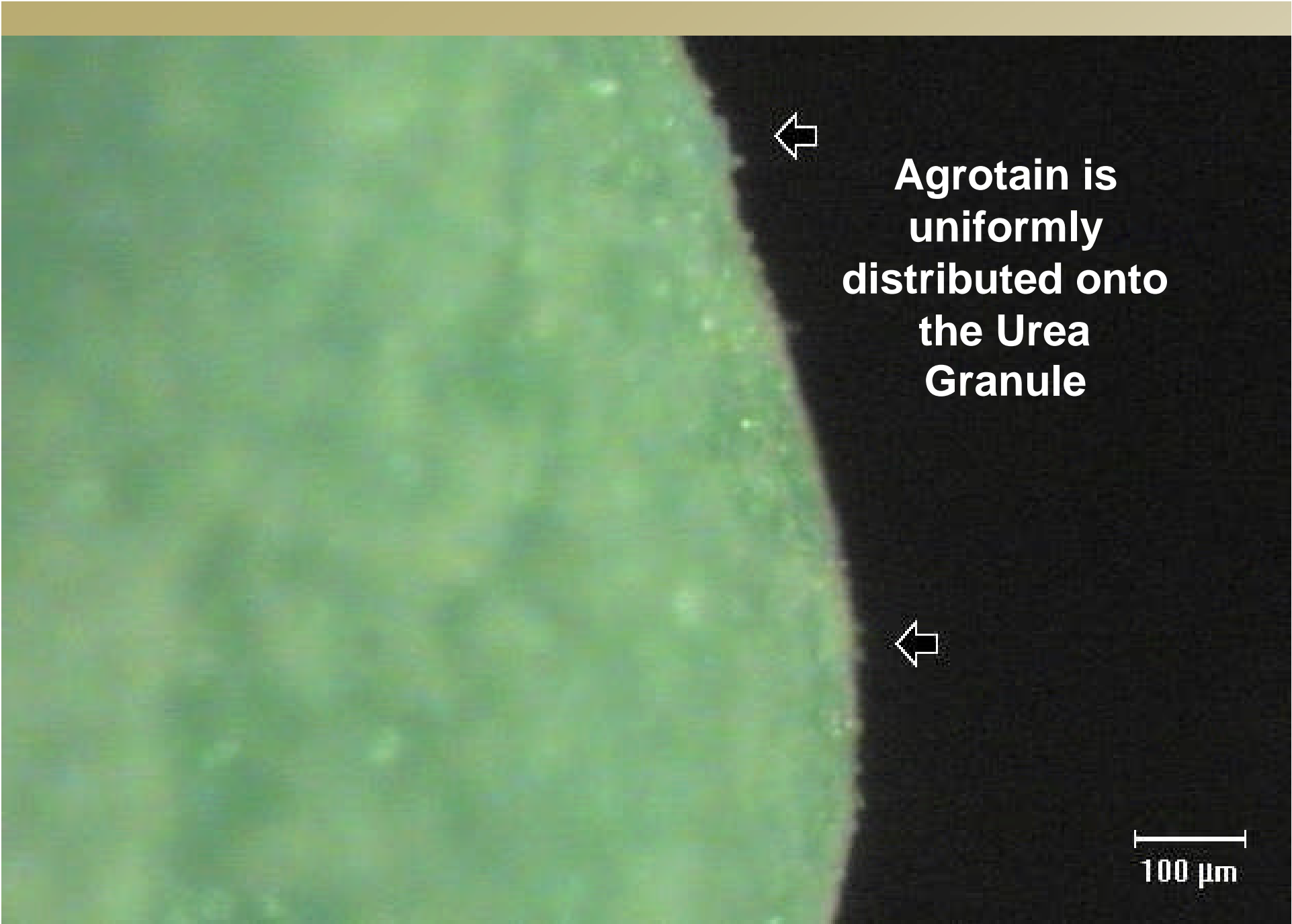
# What is AGROTAIN?



- N-(n-butyl)thiophosphoric triamide(NBPT)
- Urease enzyme inhibitor
- Revolutionary fertilizer additive that increases the efficiency of Urea/UAN fertilizer
- 21 patents, in over 70 Countries



**AGROTAIN is easily blended with urea at the fertilizer facility in vertical or horizontal blenders in a matter of minutes**



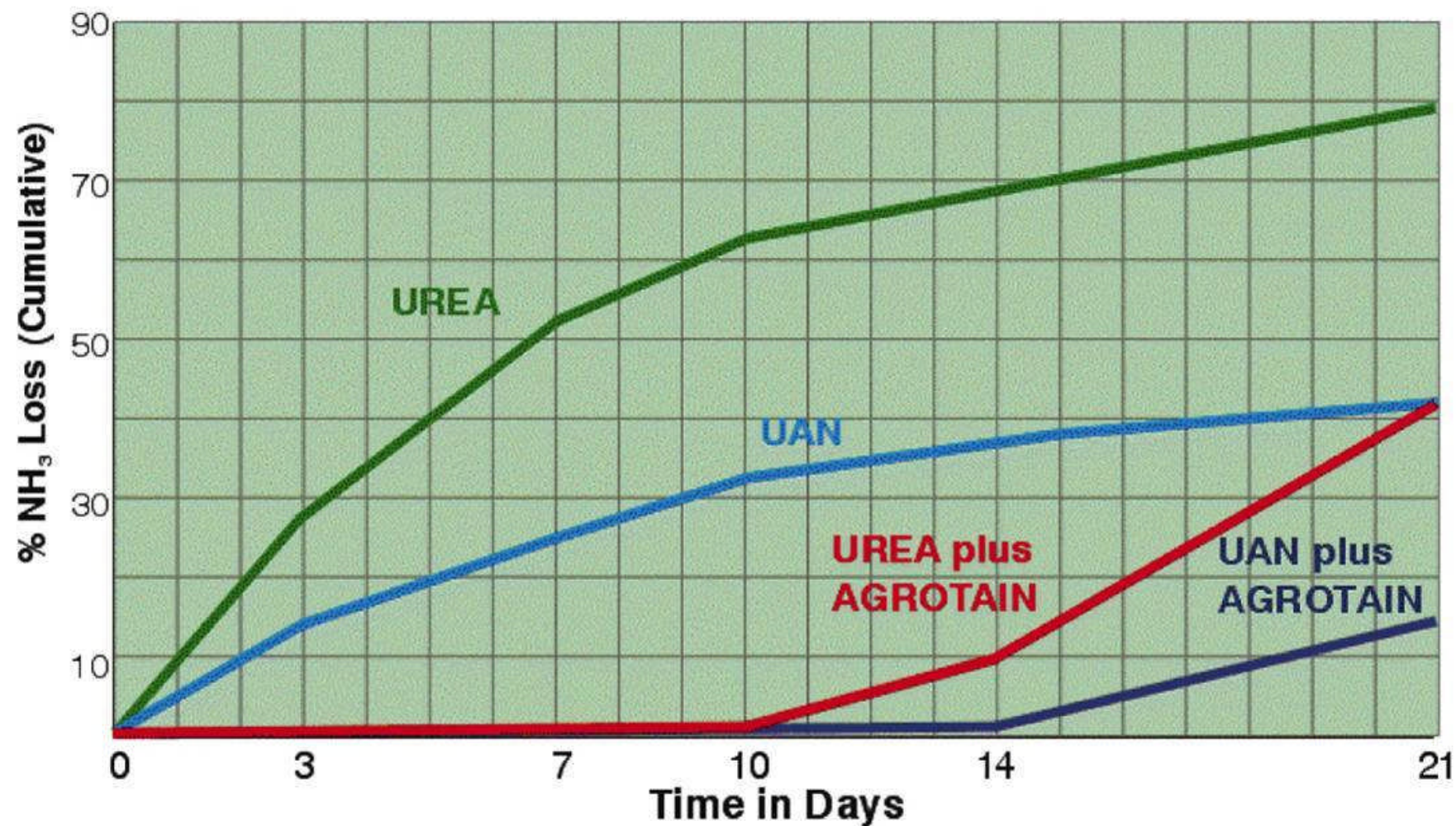
A scanning electron micrograph (SEM) showing a green, textured plant surface on the left and a dark, granular surface on the right. Two white arrows point from the text towards the interface between the two surfaces. A scale bar is located in the bottom right corner.

**Agrotain is  
uniformly  
distributed onto  
the Urea  
Granule**

100  $\mu\text{m}$



## Volatilization for UAN and Urea With and Without AGROTAIN



Assumes adequate moisture and drying conditions.

Soil Conditions: 30% Residue • pH of 7.0 AGROTAIN Rate: UAN – 2 Qts/Ton • Urea – 4 Qts/Ton

# Nitrification Inhibitors

- Slow the conversion of  $\text{NH}_4^+$  to  $\text{NO}_3^-$  by controlling the population of Nitrosomonas and Nitrococcus bacteria.
- By controlling these bacteria populations, the conversion process of ammoniacal ( $\text{NH}_4^+$ ) nitrogen to nitrate ( $\text{NO}_3^-$ ) nitrogen is reduced.

# Nitrification Inhibitors

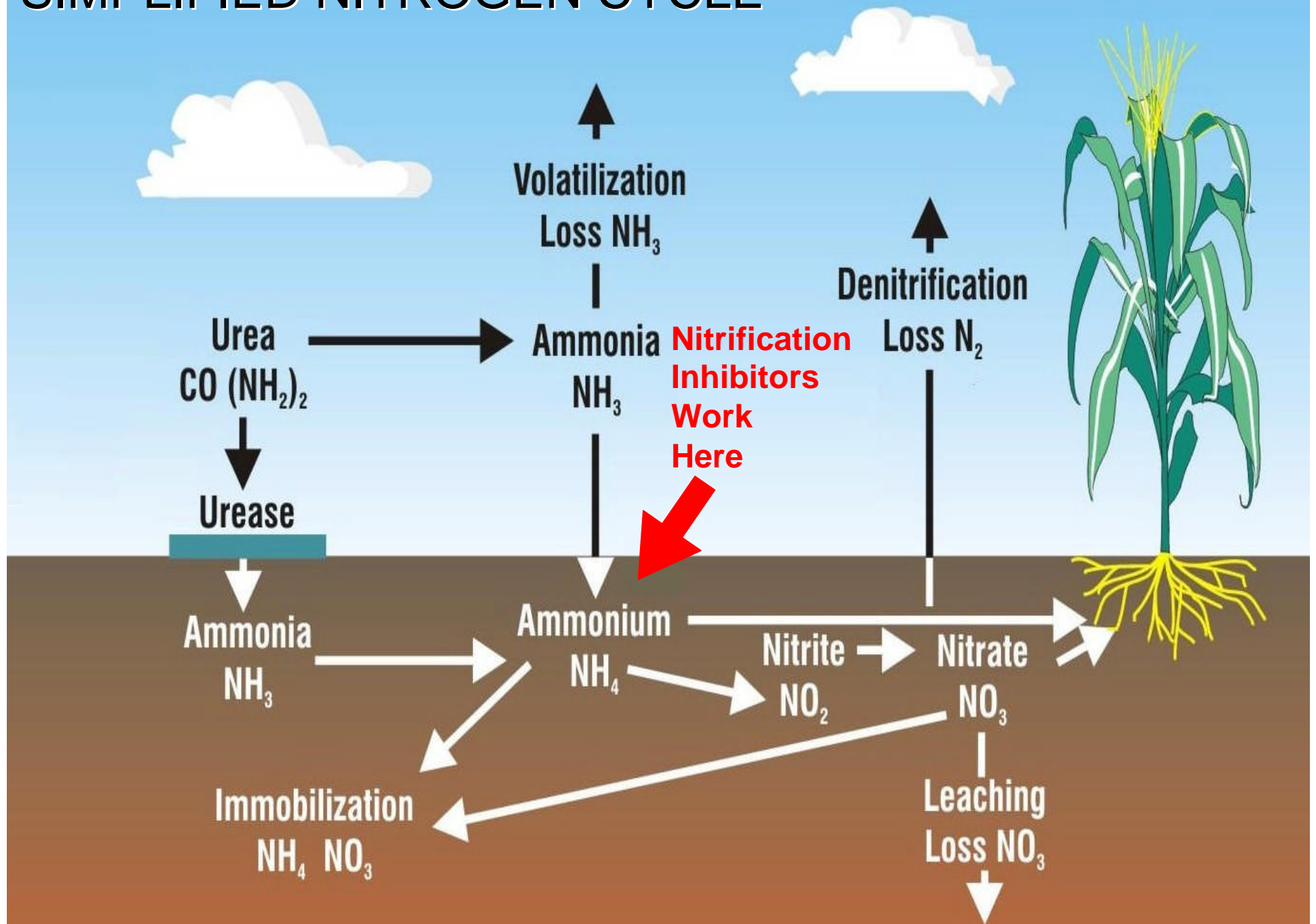
- DCD: dicyandiamide
- Nitrapyrin (2-chloro-6-(trichloromethyl)-pyridene) In the United States, nitrapyrin is registered by EPA as a pesticide. When applied in combination with ammonium –N containing fertilizers, the material must be incorporated.

In the soil DCD has a bacteriostatic effect on Nitrosomonas bacteria, i.e. the bacteria are not killed, but only depressed or inhibited in their activities for a certain period of time. Even several applications have only led to a depressive effect on *Nitrosomonas bacteria*.

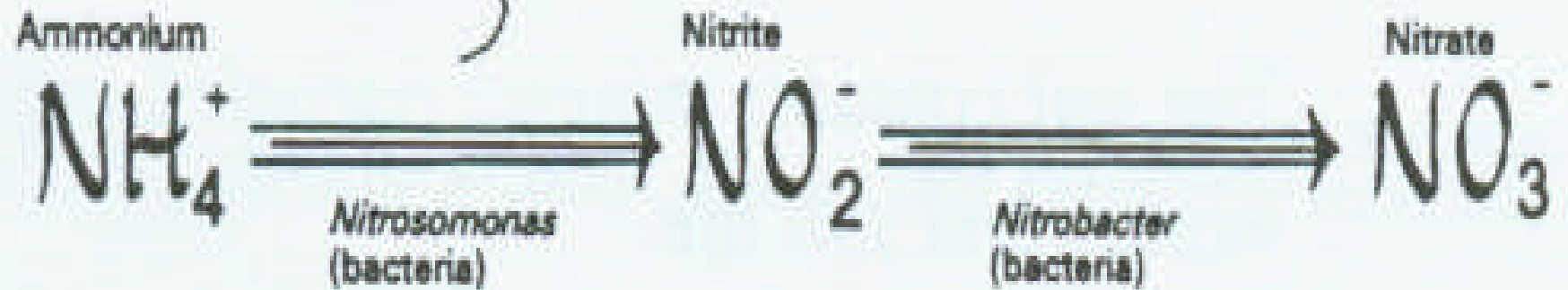
Sturm et al; 1994



# SIMPLIFIED NITROGEN CYCLE



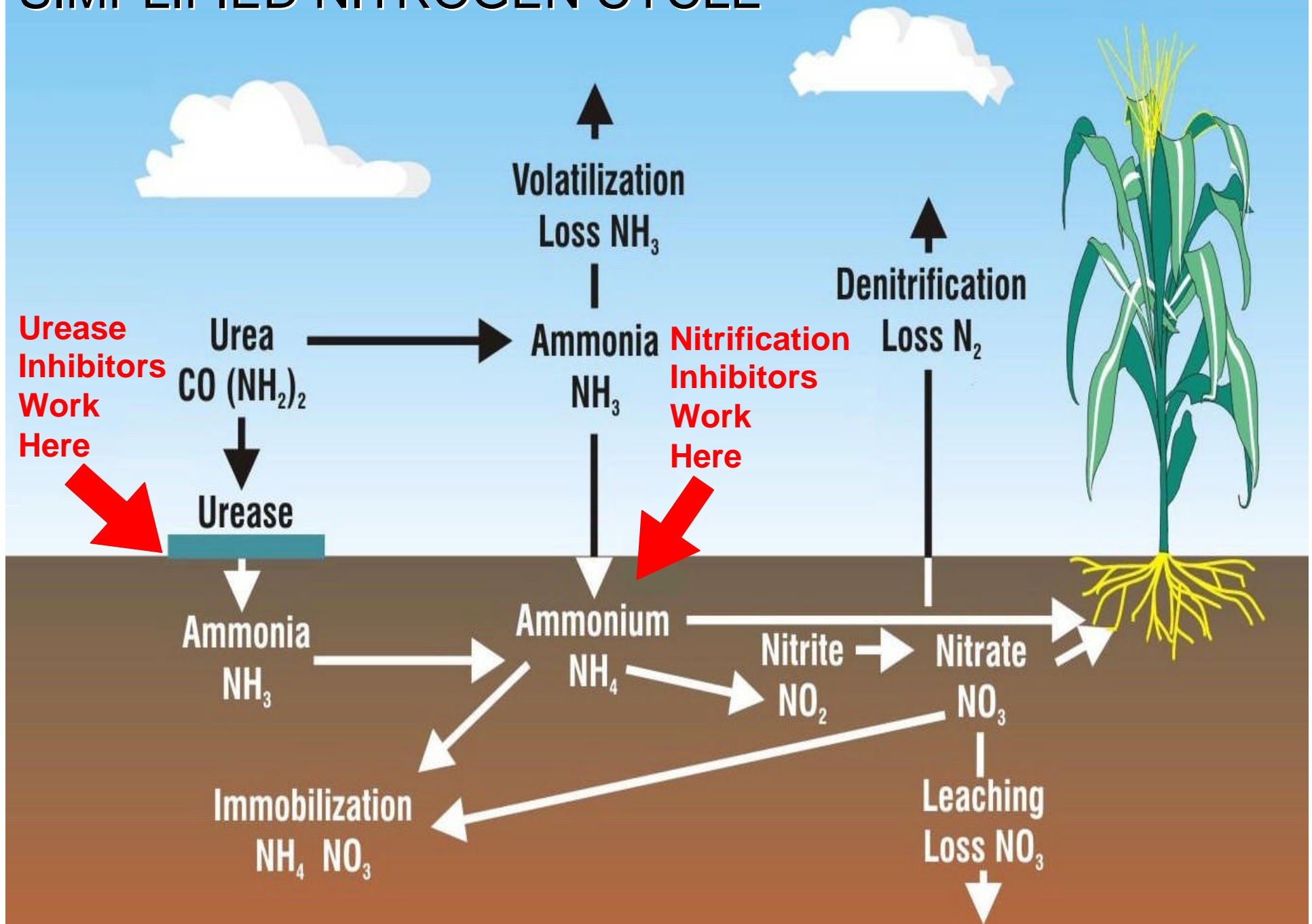
0.001 mm or 4/100,000 in.



# Denitrification

- Occurs in the  $\text{NO}_3$  form.
- Can cause nitrogen losses as high as 35%.
- Bacteria require oxygen.
- In water logged soils oxygen is not available
- Bacteria can remove the oxygen from  $\text{NO}_3$ .
- $\text{N}_2$  can escape to the atmosphere

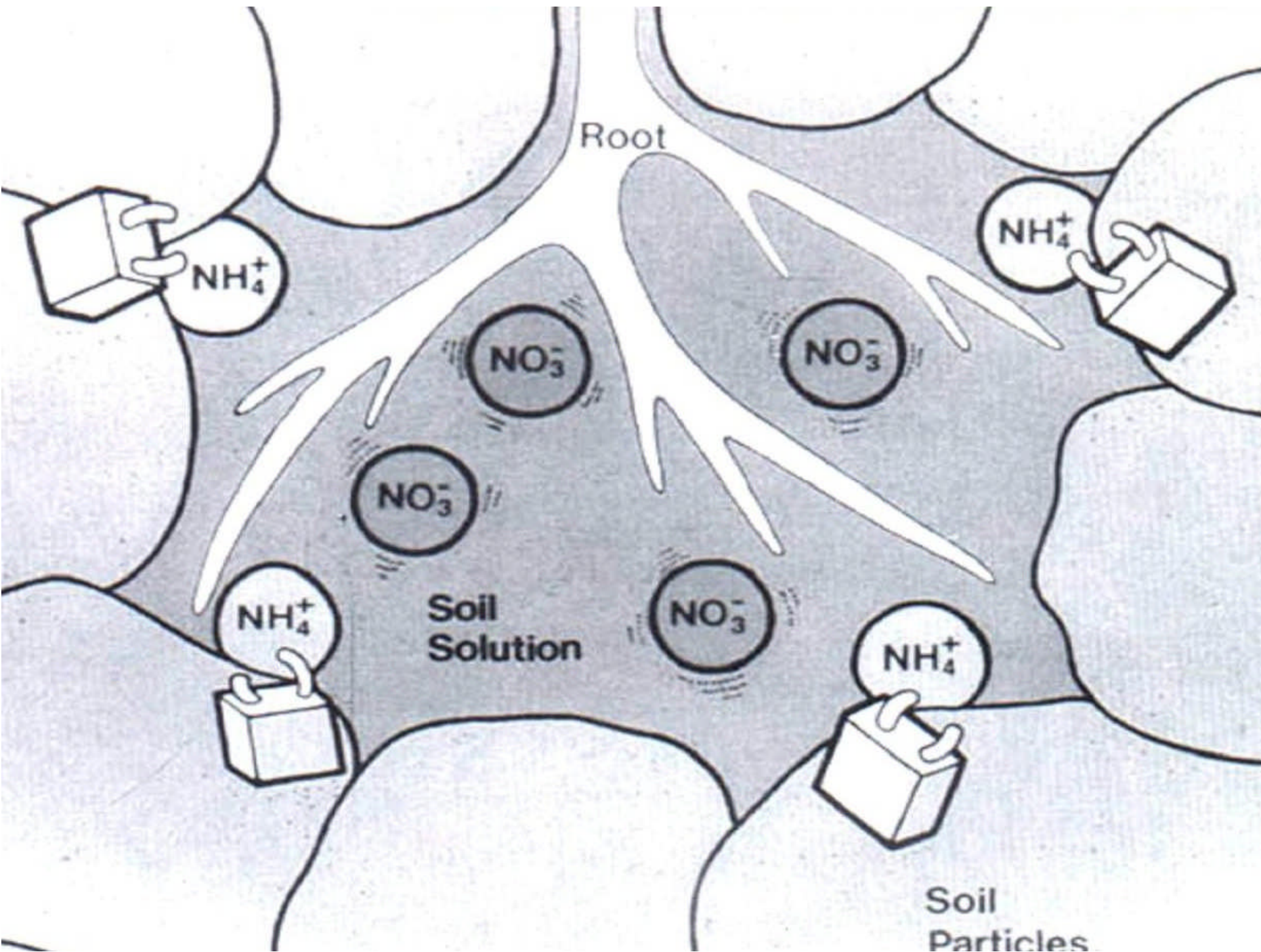
# SIMPLIFIED NITROGEN CYCLE



# Leaching Loss

- Can be reduced by:
  - Maintaining nitrogen in the stable  $\text{NH}_4$  form
  - Multiple applications
  - Slow release fertilizers
- Timing of application
  - Using nitrification inhibitors







$N_2$

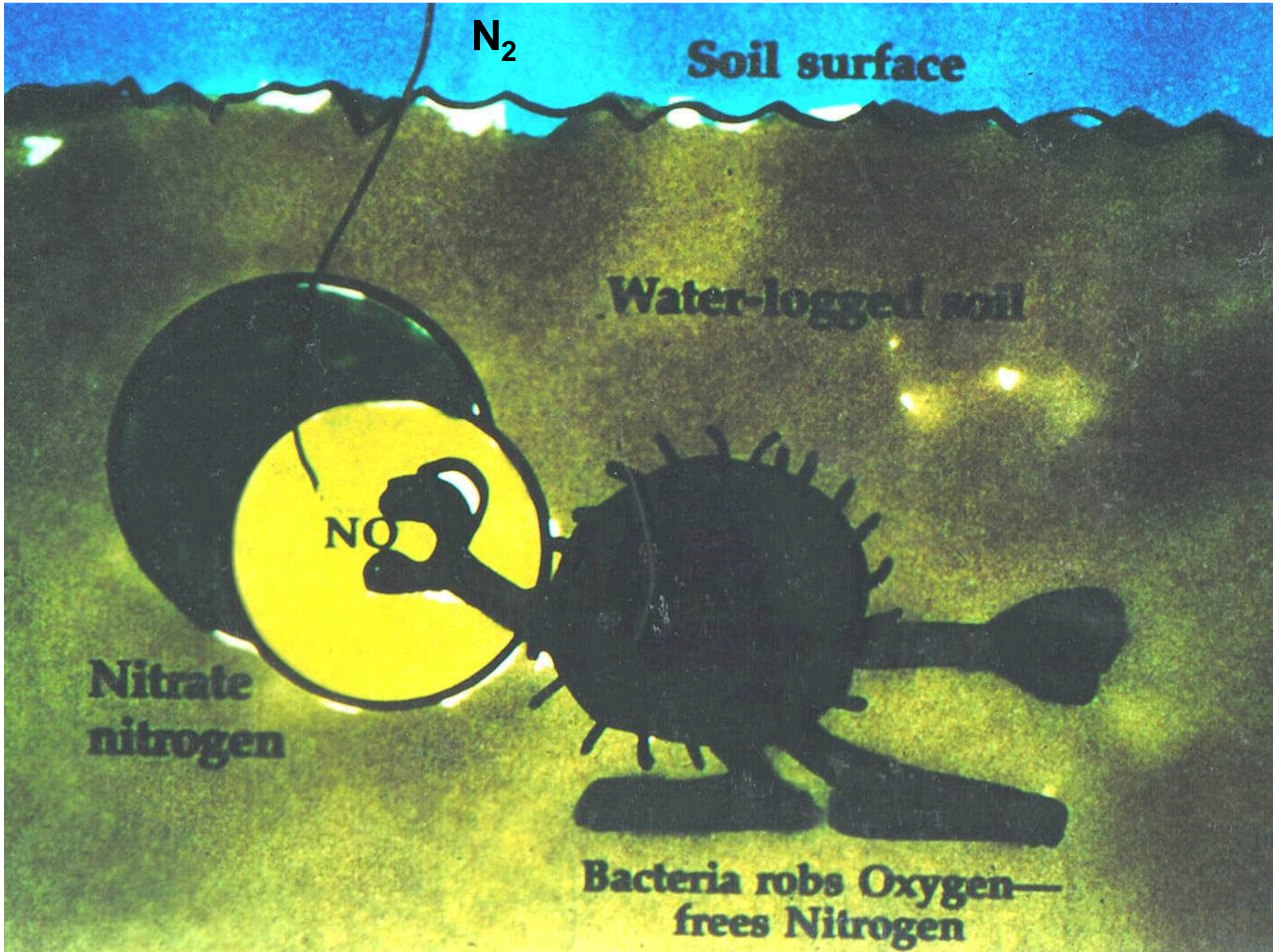
Soil surface

Water-logged soil

$NO_3^-$

Nitrate  
nitrogen

Bacteria robs Oxygen—  
frees Nitrogen







# Denitrification Losses

Soil Temperature	Days Waterlogged	Loss of Applied N(%)
55-60 degrees	5	10
	10	25
75-80 degrees	3	60
	5	75
	7	85
	9	95



# **Results of adding a urease and a nitrification inhibitor to Nitrogen**

- Minimize losses from:
  -  Immobilization
  -  Volatility
  -  Leaching
  -  Denitrification
- Enhances ammonium nutrition

# INHIBITOR TECHNOLOGY

To make efficient use of urea and ammonium fertilizers, reduce nitrate runoff and leaching, and the emission of ammonia and greenhouse gases, the incorporation of urease inhibitors and nitrification inhibitors into urea and Ammonium containing fertilizers should be recommended as a best management practice.

**Thank you for the  
Opportunity to Speak  
with You Today**



**SuperN**<sup>®</sup>  
Concentrate  
**N**STABILIZER™

**AGROTAIN<sup>®</sup> PLUS**

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