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Nutrient Cycling in Corn for Bioenergy

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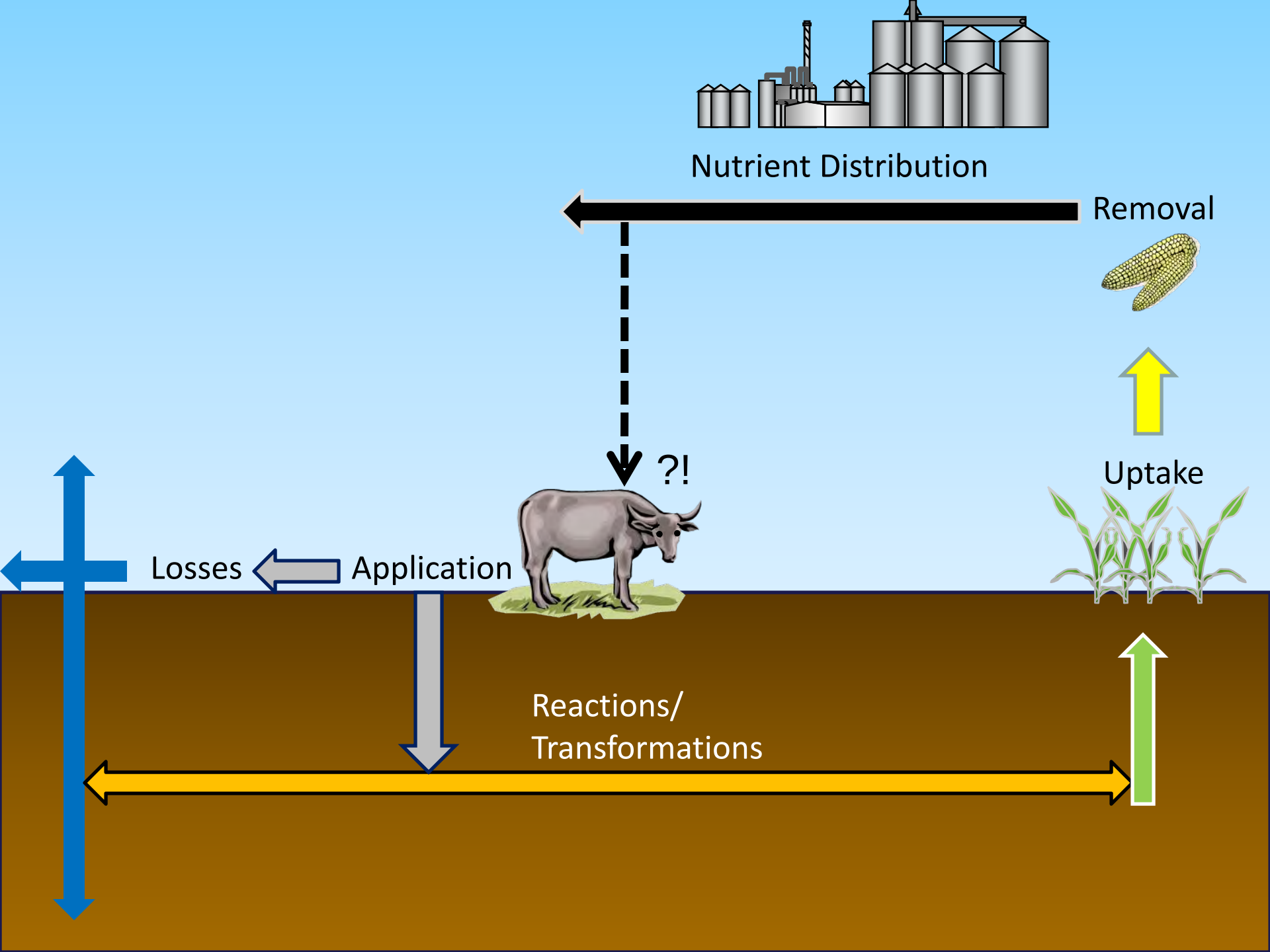
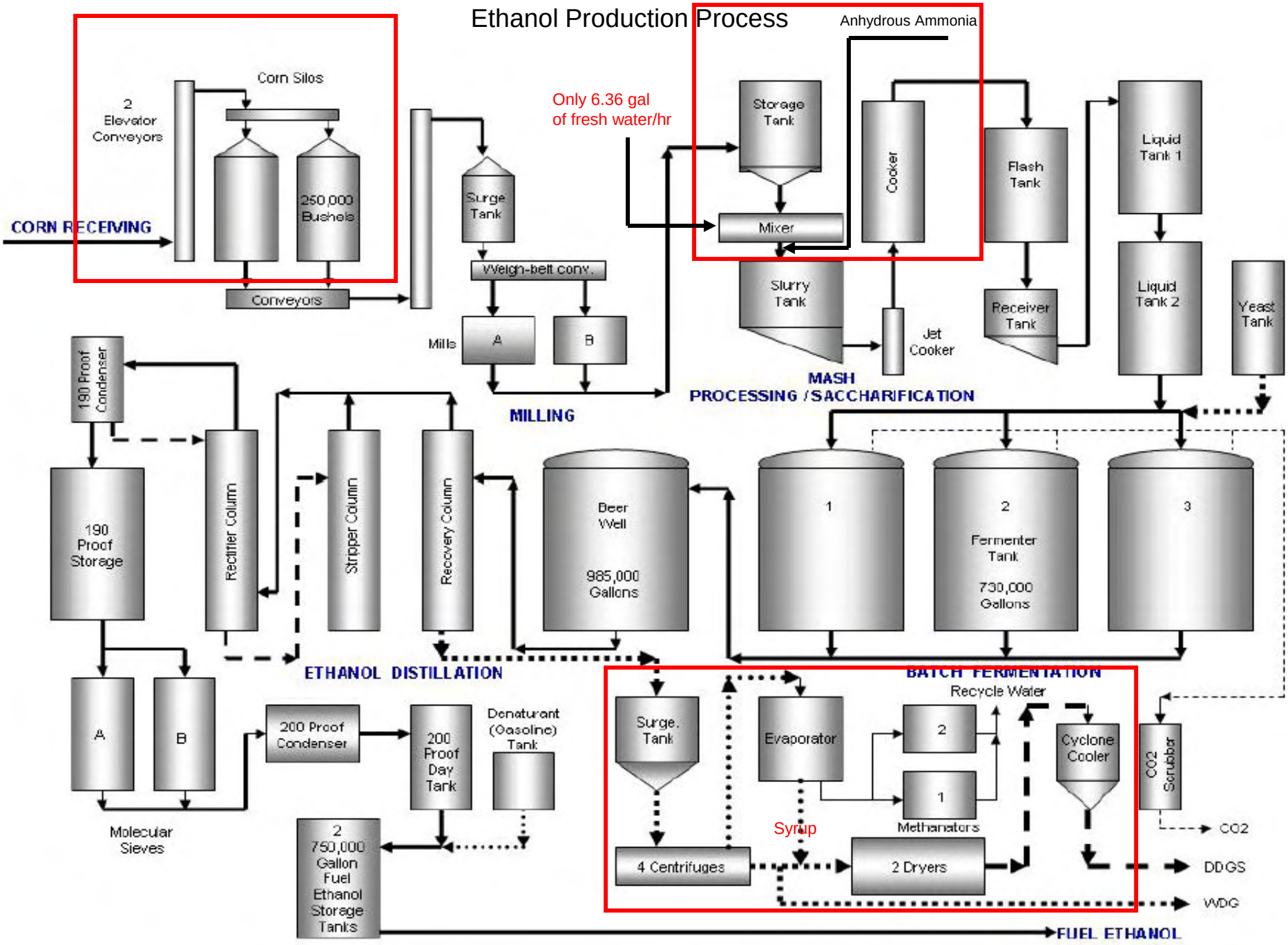
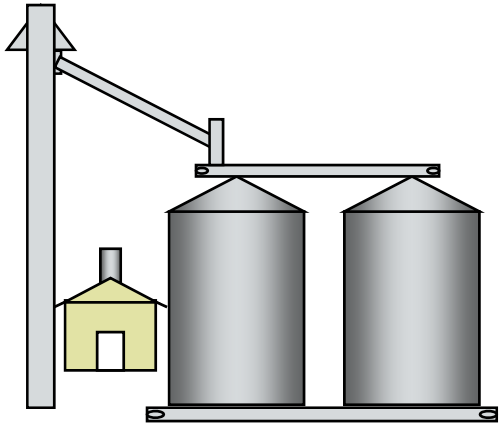

Nutrient Distribution
Removal
?!
Uptake
Losses
Application
Reactions/
Transformations

Ethanol Production Process



Corn Receiving and Storage



- This investigation used a working ethanol plant in Northwest Indiana as the primary source of information.
- Bio-Energy Company processes 14.3 million bushels of corn, produces in excess of 40 million gallons of ethanol, and 128,600 tons of 8.3% moisture DDGS annually.
- The plant came on stream in 2006 and uses anhydrous ammonia instead of sodium hydroxide to adjust the mash pH prior to fermentation.
- The plant is a closed system with only 6.4 gallons of fresh process water needed per hour. The remainder is recycled after the syrup evaporation process. The syrup is added back to the wet distillers grains prior to drying.

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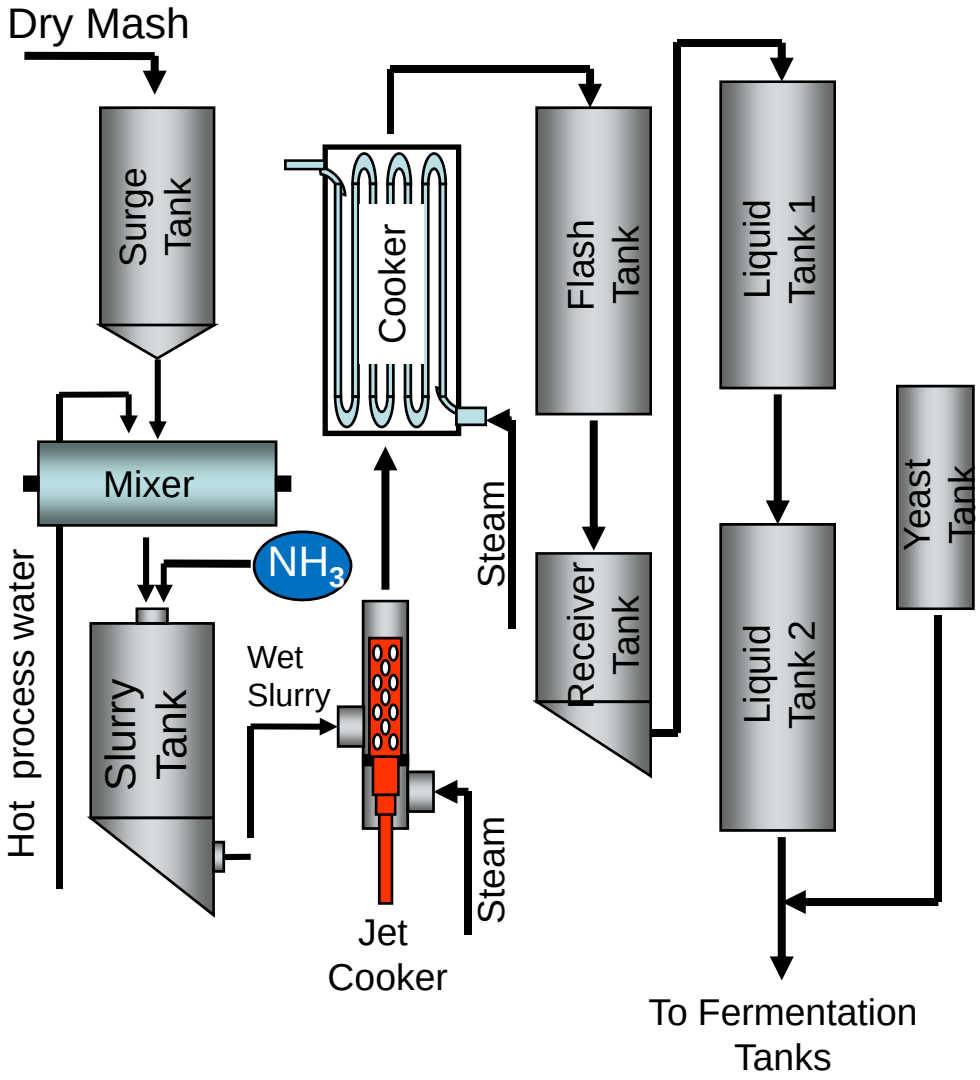
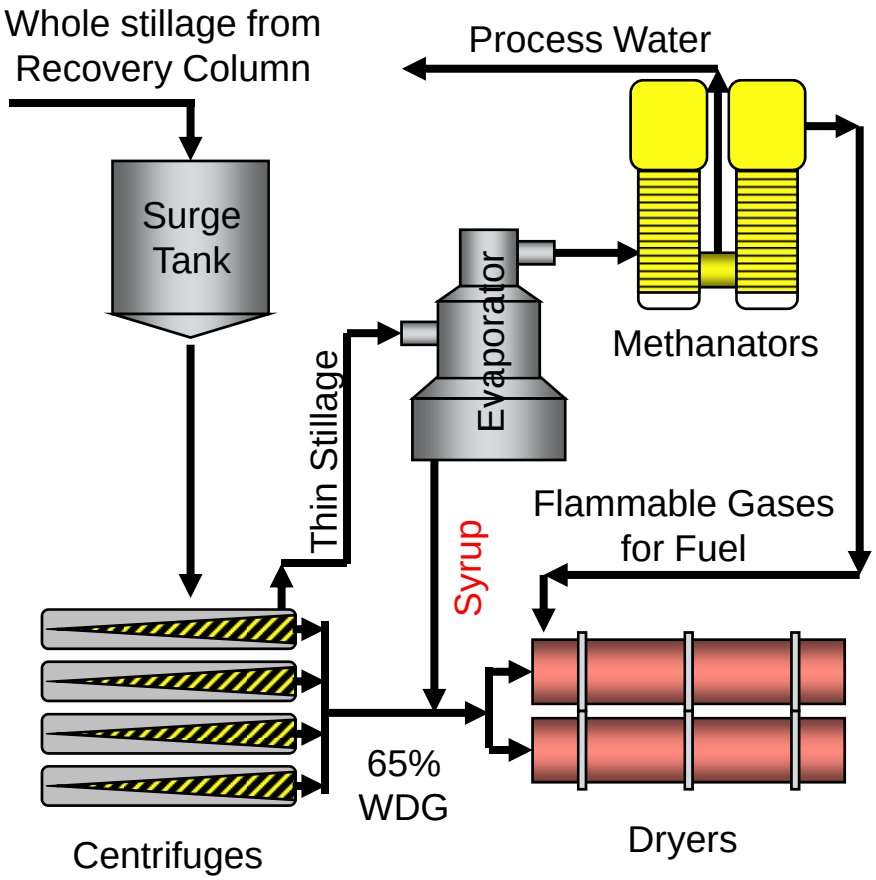
Anhydrous ammonia added to the process



- Anhydrous ammonia is added to the slurry for pH adjustment.
- Reduces Na content in DDGS which makes them more suitable for poultry.
- Adds a small amount of nitrogen to the DDGS.

DDGS Process

- The syrup making process is one of the main components in the nutrient recovery process.
- The whole stillage (beer, some alcohol, yeast cells, enzymes, water, etc.) is centrifuged.
- The thin stillage (supernatant liquid) is passed through the evaporator and most is condensed into a nutrient rich syrup. The solids (wet distillers grains) go to the dryers.
- The syrup is then sprayed on the wet distillers grains before entering the dryers.
- The remaining thin stillage not condensed becomes the process water for the next batch.



Dried Distillers Grains with Syrup

- We do not know the analysis of the corn coming into the system, but we do know the analysis of the DDGS going out
  - The DDGS is dried to about 8% moisture.
  - The crude protein, phosphorus, and potassium content are 30.1%, 0.85% and 1.17% respectively.
  - Nitrogen = Crude Protein/6.25
    - Nitrogen = 4.82%
- We are now able to calculate the total pounds of nutrient contained in the DDGS.

Calculating Grain Nutrient Concentration

$$(\text{Total bushels in}) \left(\frac{X \text{ lb}}{\text{bushel}} \right) = \text{Total lb nutrients out}$$

Reported

Calculated from total DDGS dry matter and nutrient concentration

- Solved for *X* lb/bu and compared those values to those reported in university Extension publications

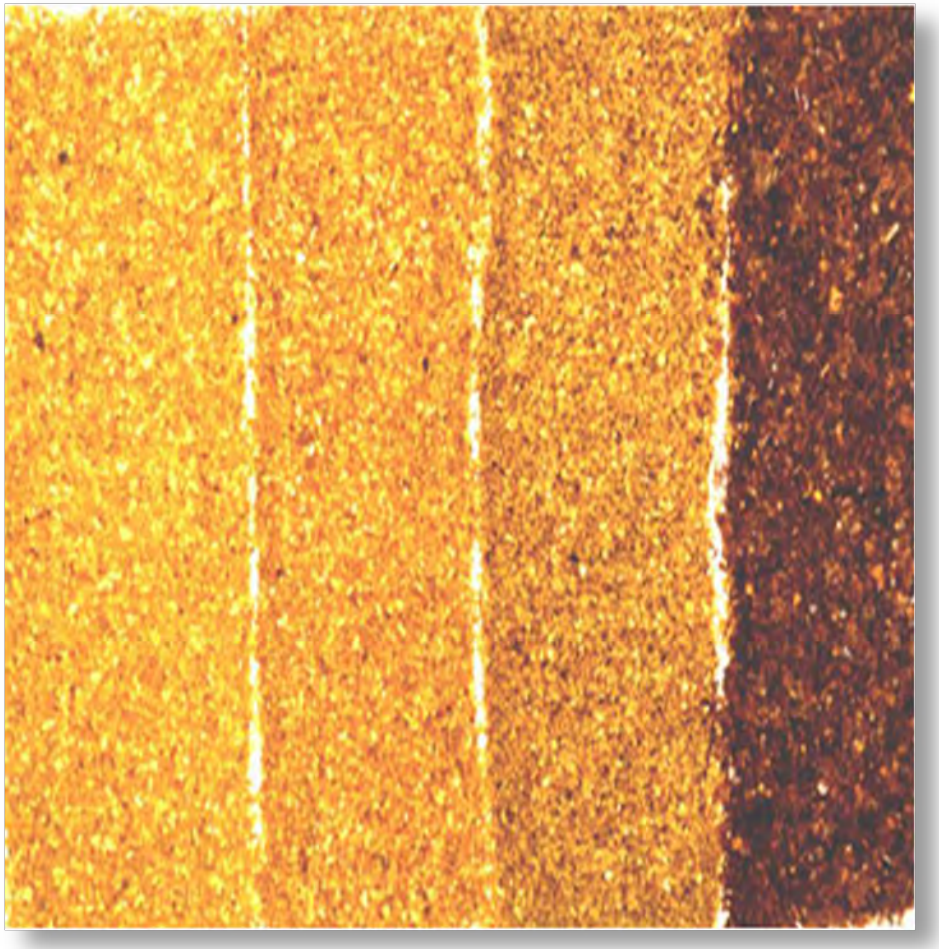
Calculating Grain Nutrient Concentration

- Using that formula, the amount of nutrients contained in the dried distillers grains with syrup is:

Value	Concentration		
	N	P_2O_5	K_2O
	---------- lb/bu----------		
Calc.	0.79	0.32	0.23
Pub. Min	0.70	0.31	0.19
Pub. Max.	1.00	0.60	0.35
Pub. Avg.	0.83	0.40	0.28
No. Pubs.	15	26	25

Feeding DDGS

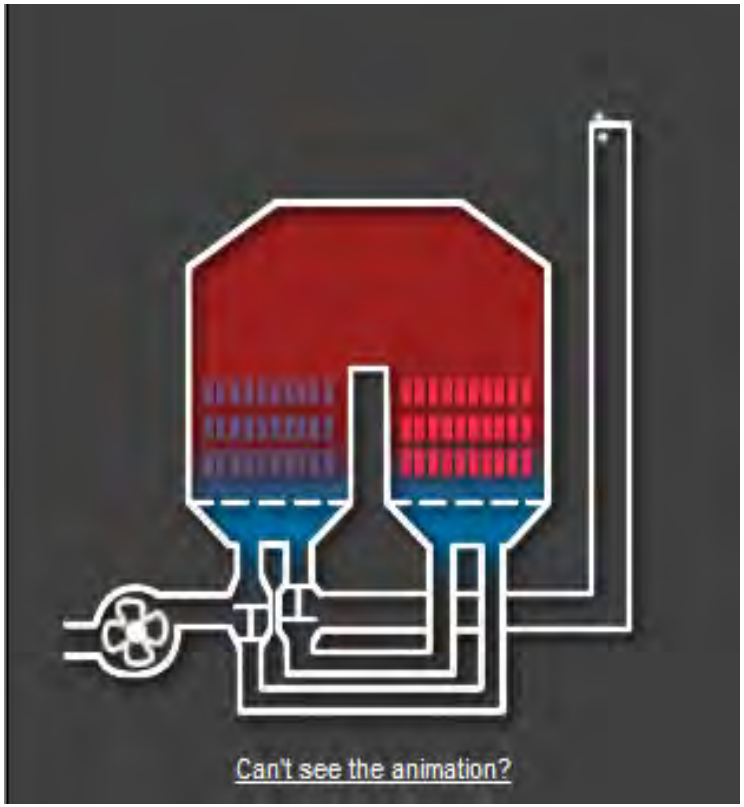
- Where are the challenges?
  - DDGS nutrient concentration is three times that of yellow dent corn. Less is needed.
  - Drying temperature influences lysine and phosphorus availability.
    - Temp. ↑, lysine ↓, avail. P ↑
    - Golden yellow DDGS is preferred for maximum availability of both.
  - Rations need to be balanced on phosphorus to prevent higher excretion losses.
  - Universities have published maximums for DDGS inclusion in poultry, beef, dairy, and swine rations.



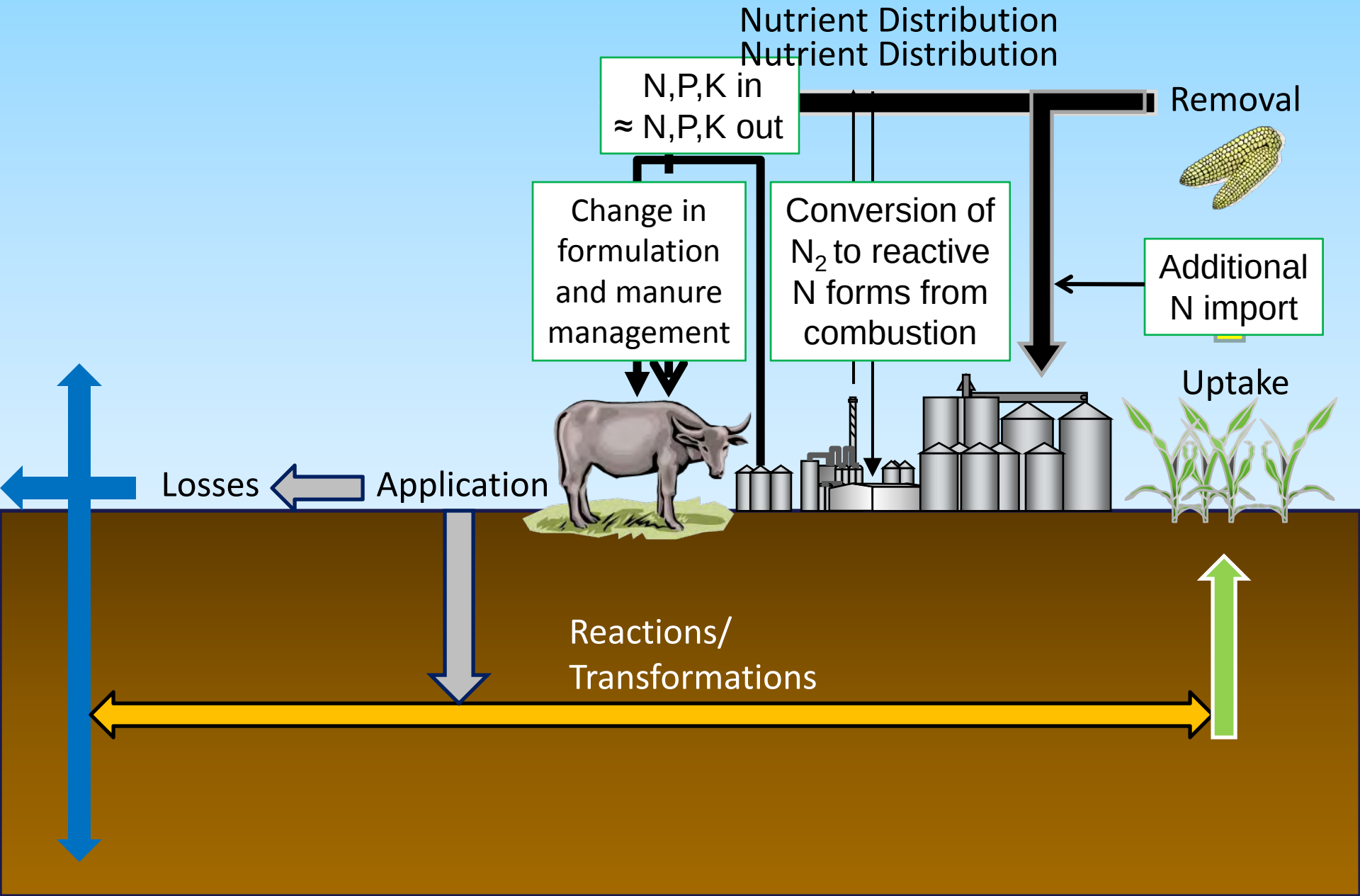
N, P, K and the Ethanol Process

- Conclusions:
  - N, P, K in from the corn grain is N, P, K out in the dried distillers grains with solubles.
  - The closed system ethanol plants virtually stop any losses of N, P, or K from the process.
  - Nutrient losses from DDGS are controlled by ration balancing for livestock.
  - Balanced rations and manure management are critical when feeding DDGS.
  - The loss of N, P, and K from the land comes from exporting DDGS outside the community.

NO_x Losses



- NO_x losses to the atmosphere are not associated with the corn grain or the DDGS themselves.
- Losses are associated with combustion of natural gas to provide energy for the drying process.
- NO_x emissions are regulated by state and federal EPA. The federal maximum allowable is 100 TPY. Iroquois Bio-Energy's State maximum is set at 93.6 TPY, and with RTO and HRSG, are currently running at 32.7 TPY.


Nutrient Distribution
Nutrient Distribution
N,P,K in
≈ N,P,K out
Removal
Change in formulation and manure management
Conversion of N_2 to reactive N forms from combustion
Additional N import
Uptake
Losses
Application
Reactions/
Transformations