


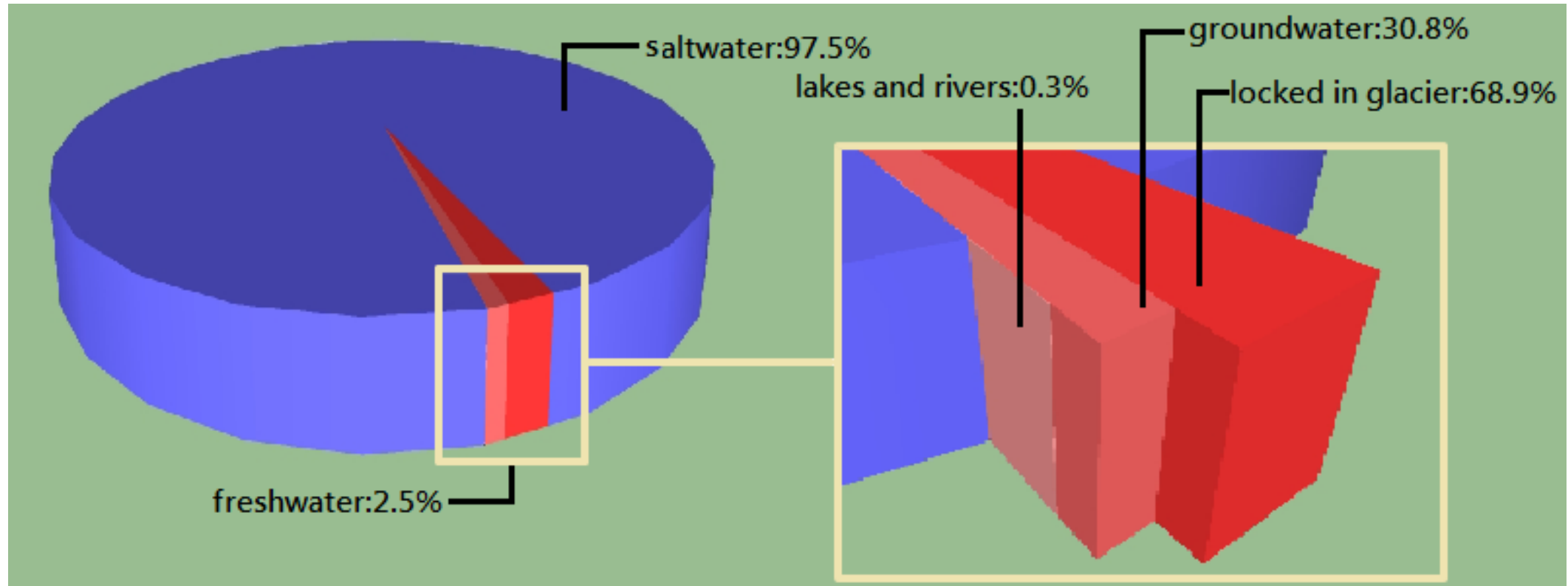
# Nitrates, Water Quality and Health



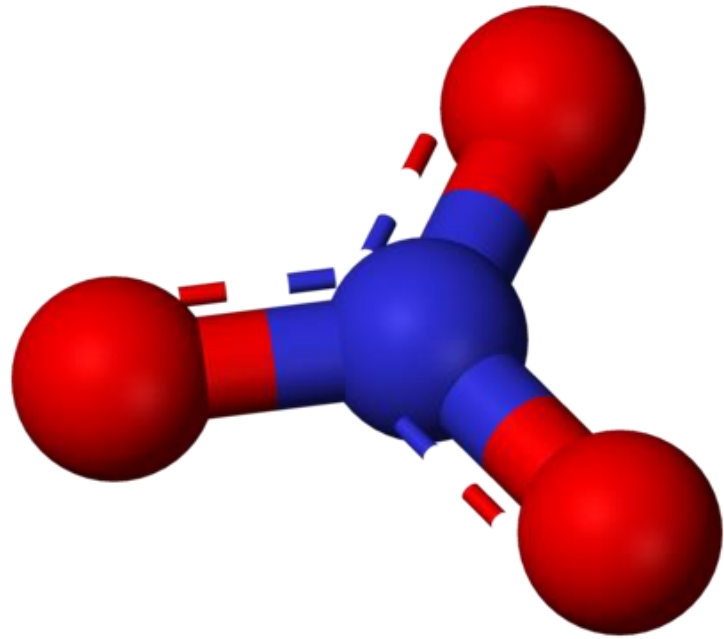
**Dr. Catherine Zeman, Professor, Environmental  
Health,**

**Public Health, HRCS, University of Northern Iowa**

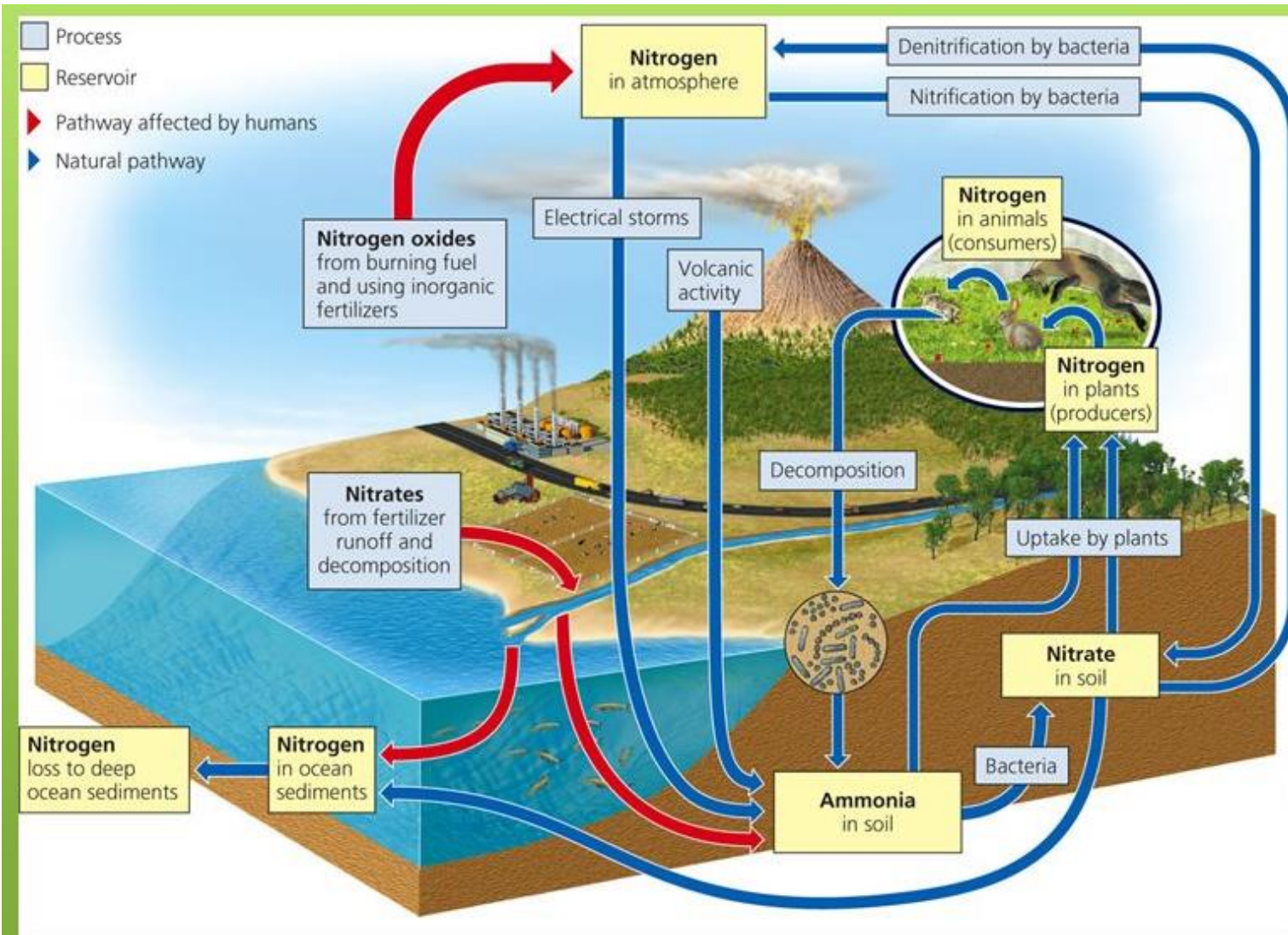
# Water, water, everywhere...



# What is Nitrate?



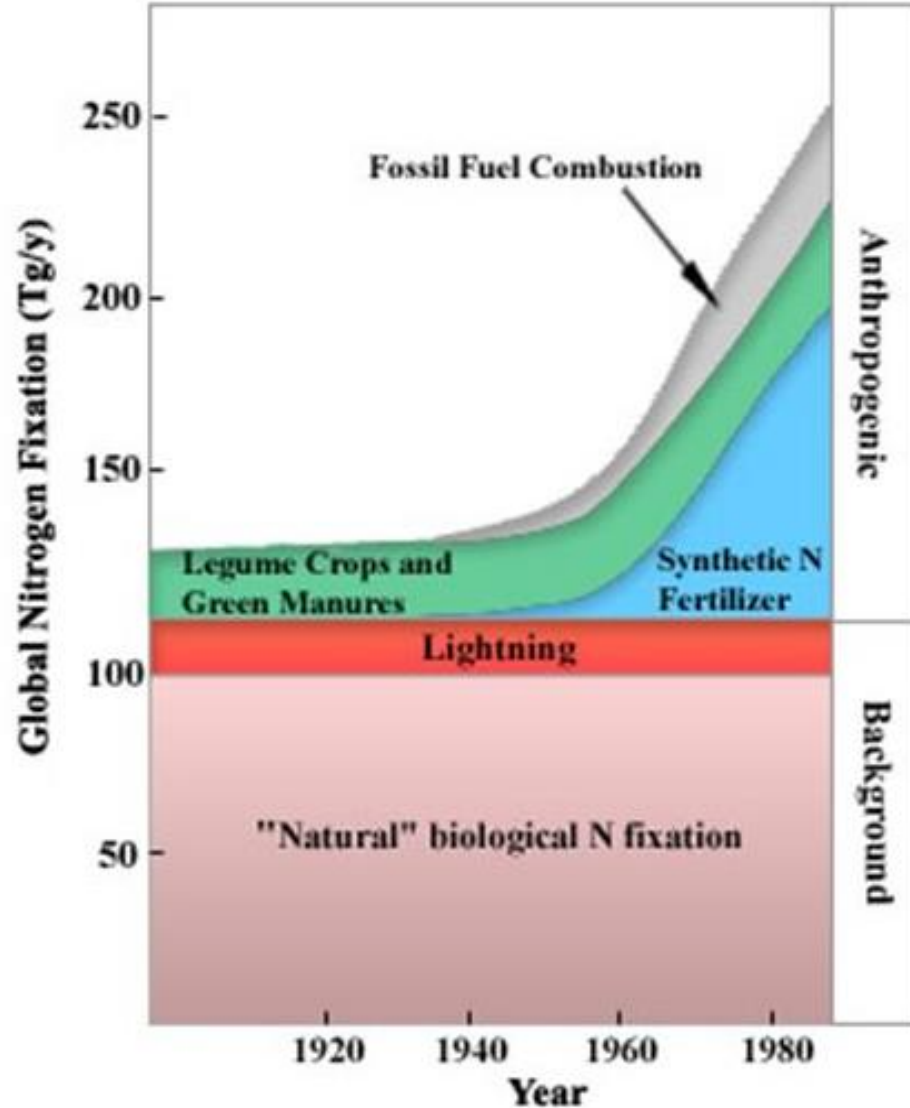
- Water soluble polyatomic anion (-1)
- $\text{NO}_3^-$
- Important functions in the body:
  - Antifungal/antibacterial (immunity)
  - Smooth muscle relaxation (blood pressure regulation)
  - Cardiovascular signaling (heart regulation)



# Nitrate in the Environment

- Majority as atmospheric gas
- A limiting factor for plant growth
- The Haber process (early 1910s)
- Fritz Haber 1918 Nobel Prize, Chemistry
- Wilkins (2019)

# Human vs. Environmental Nitrogen Fixation

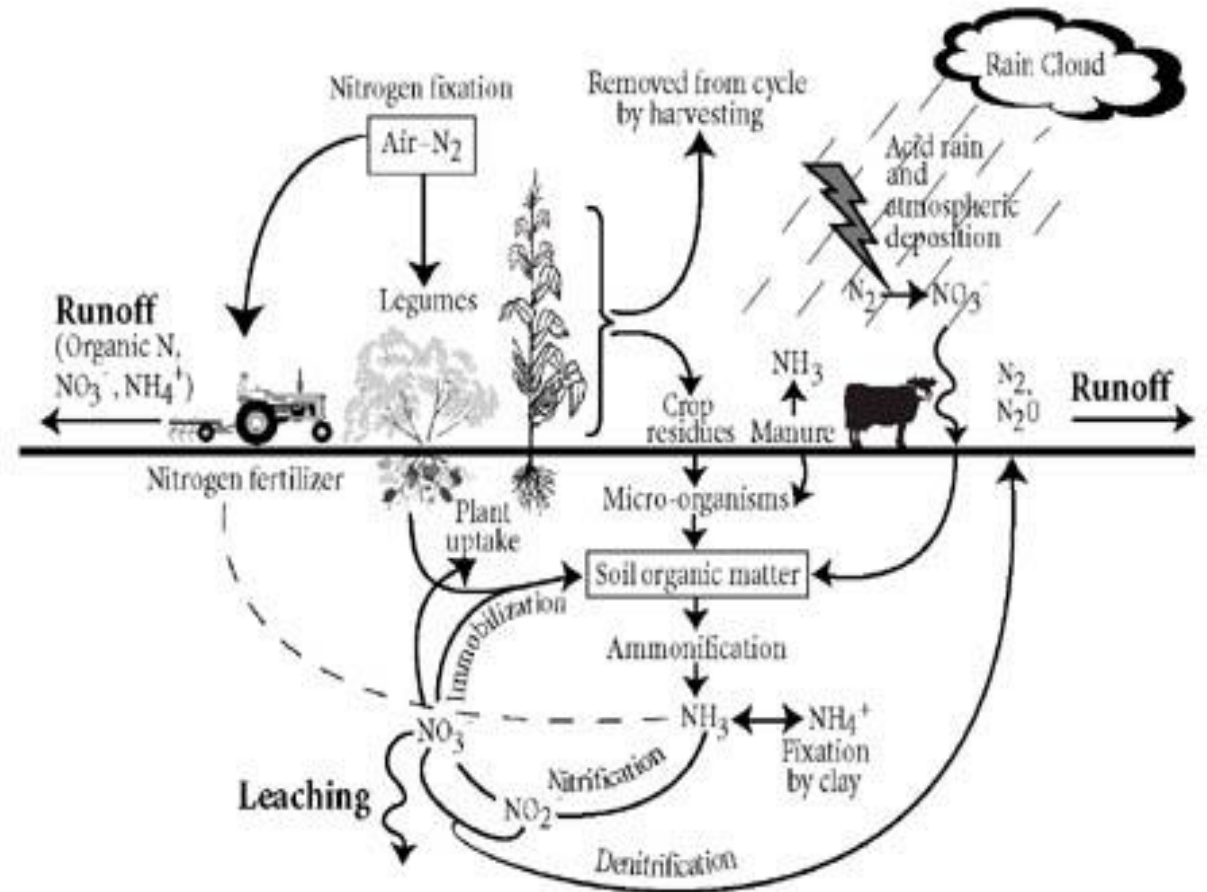


- $\text{N}_2$   $\rightarrow$   $\text{NH}_3$  or  $\text{NH}_4^+$
- Crop plantings, legumes
- Fossil fuel combustion
- Synthetic fertilizer
- Total human nitrogen fixation began exceeding environmental by mid-70s (Spiro and Stigliani, 2011)

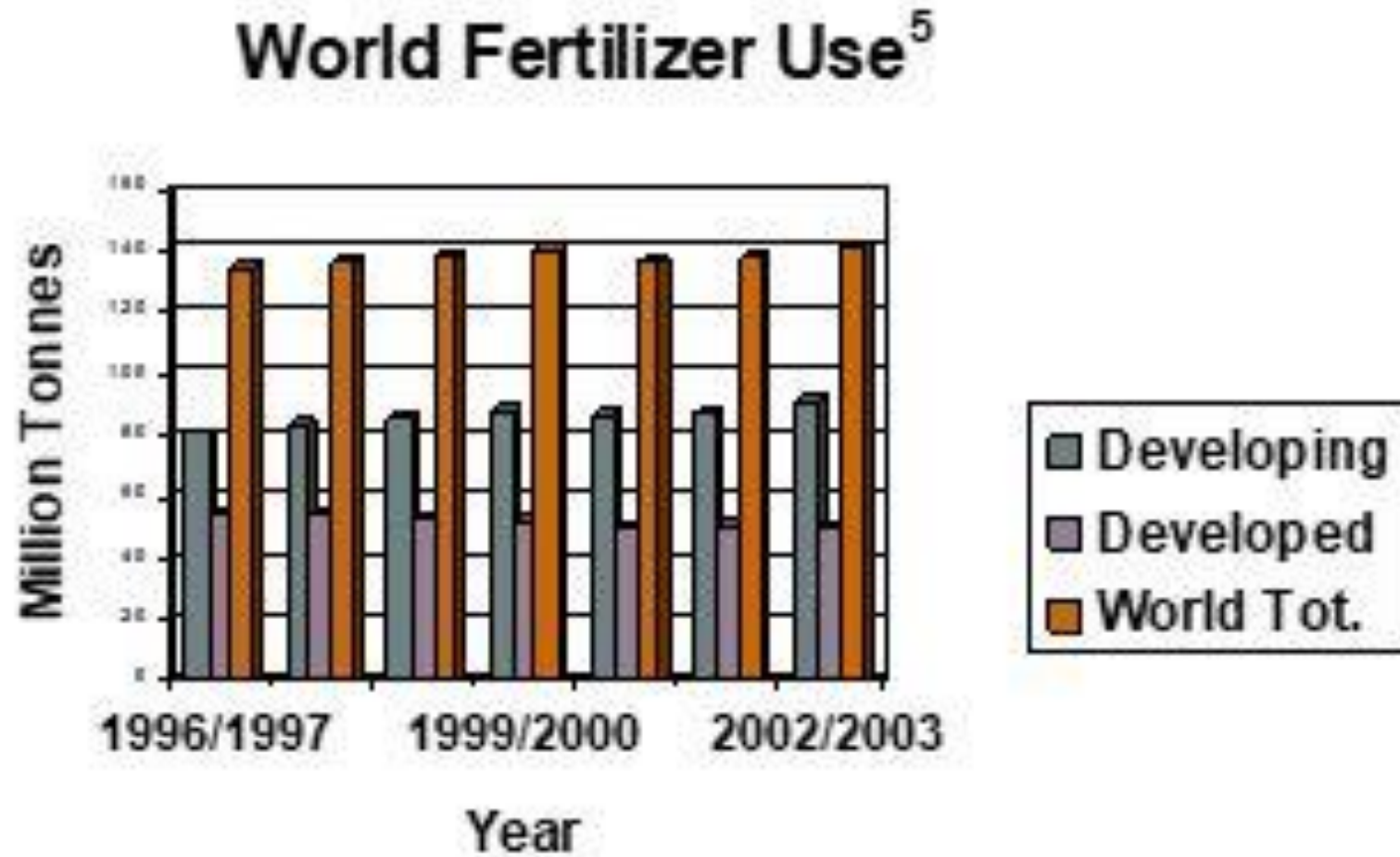


# Global Nitrogen Levels

- Science, 9, November 2001, Kaiser
  - 150 teragrams of fixed nitrogen per year – Anthropogenic
  - 1.5 X naturally fixed amount
  - 75% fertilizers, 25% fossil fuel combustion
  - Today the amount of anthropogenically fixed nitrogen is estimated at 160-210 teragrams/year, (Battye 2017)



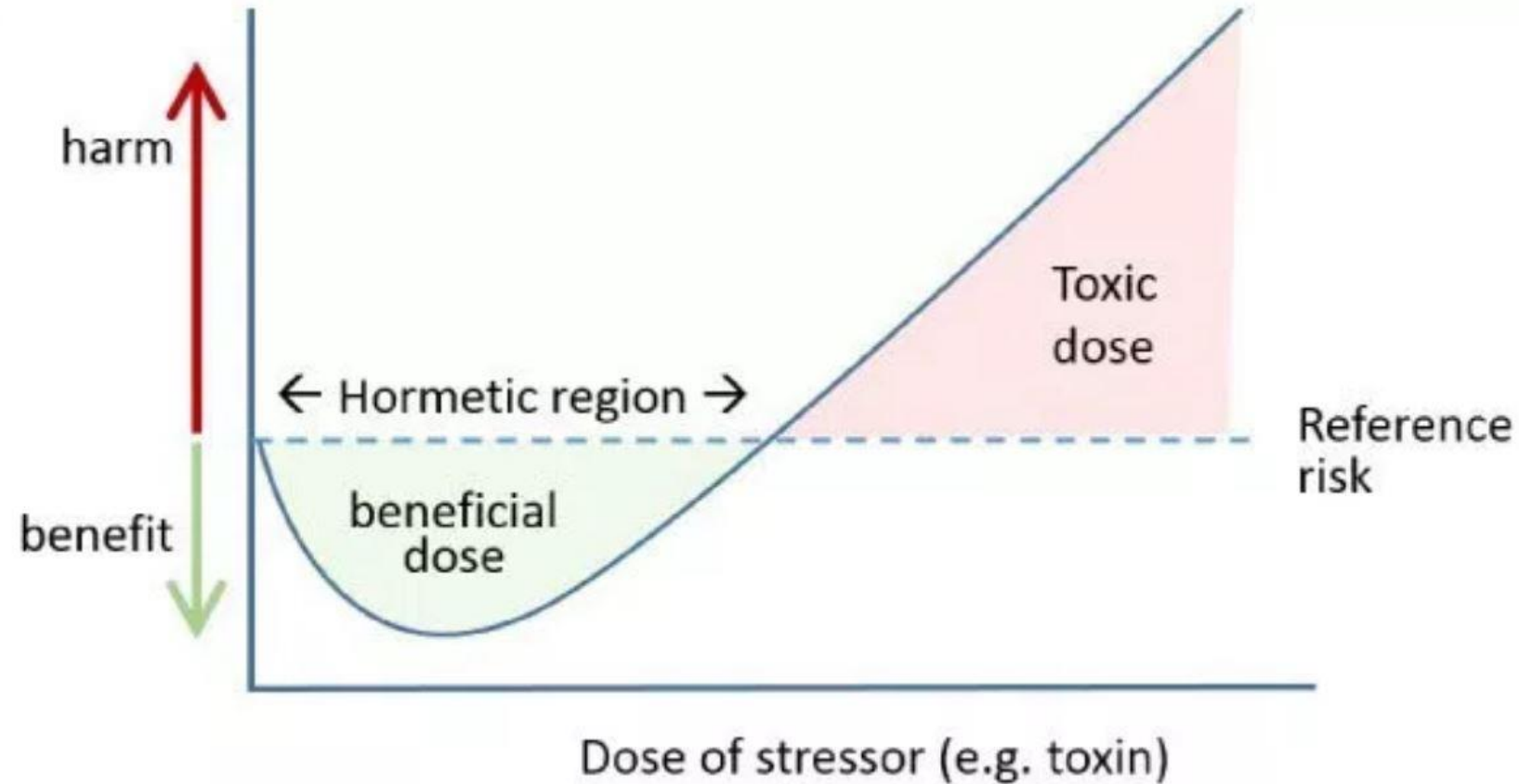
# Nitrogen Cycle Contributions



UN 2003



# Too Much of a Good Thing?



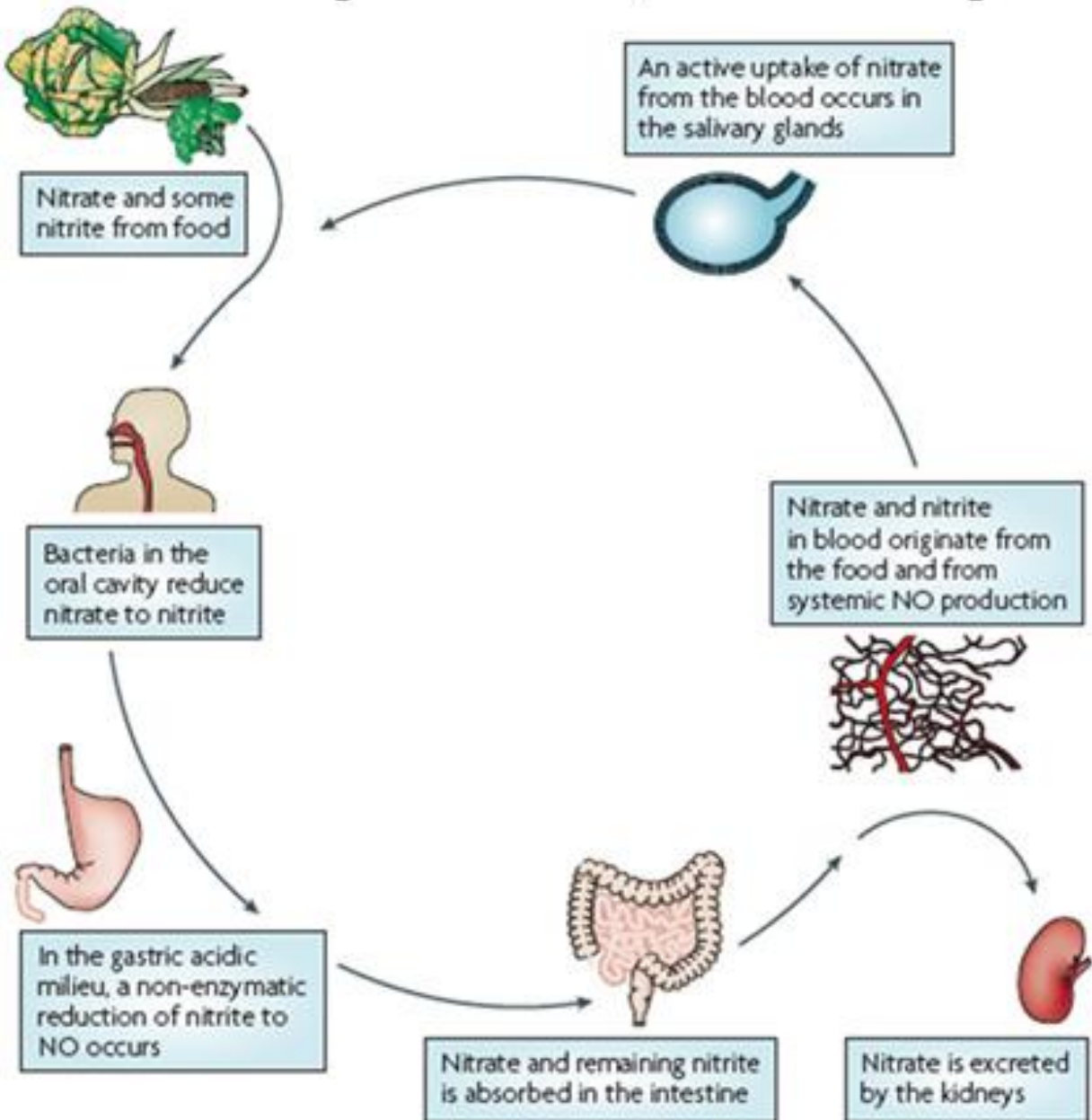


# Dietary Nitrates

Nitrate Content of Vegetables		
Vegetable	Serving Size	Nitrate (mg)
Rhubarb	1 cup diced	343
Butterleaf Lettuce	2 cups shredded	220
Agurula	2 cups	192
Salad mix, beet greens	2 cups leaves	135
Swiss Chard	2 cups leaves	109
Beets	.5 cup slices	94
Spinach	2 cups leaves	47
Cilantro	1 cup leaves	40
Basil	.5 cup leaves	22
Broccoli	1 cup chopped	18
Potato	.5 cup diced	8
SOURCES: The EFSA Journal (2008) 689, 1-79. Serving Size Information from USDA, 2011.		

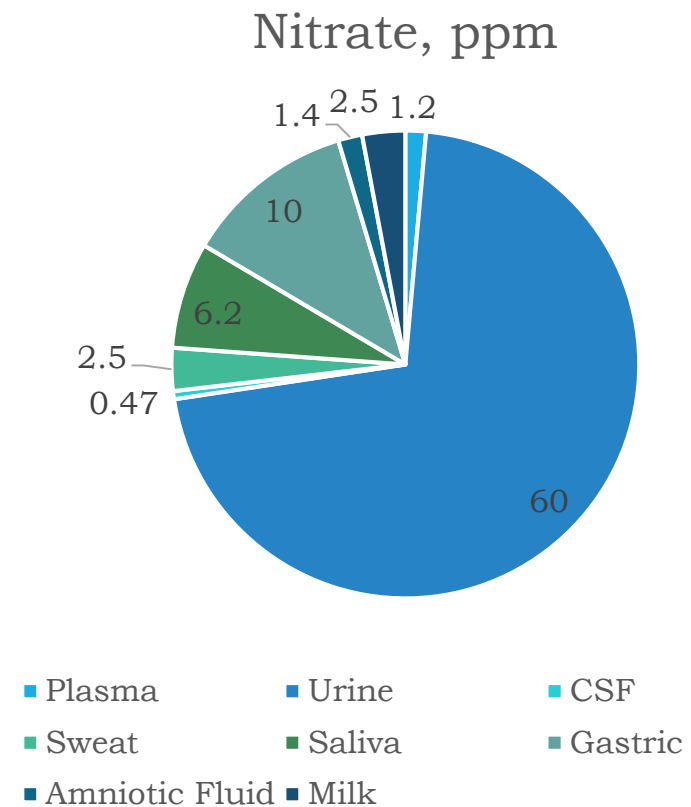


# The body nitrate/nitrite cycle



Lundberg et al. NatureRevDrugsDisc. 7:156 (2008)

## Nitrate in the body



L'hirondel (2002)

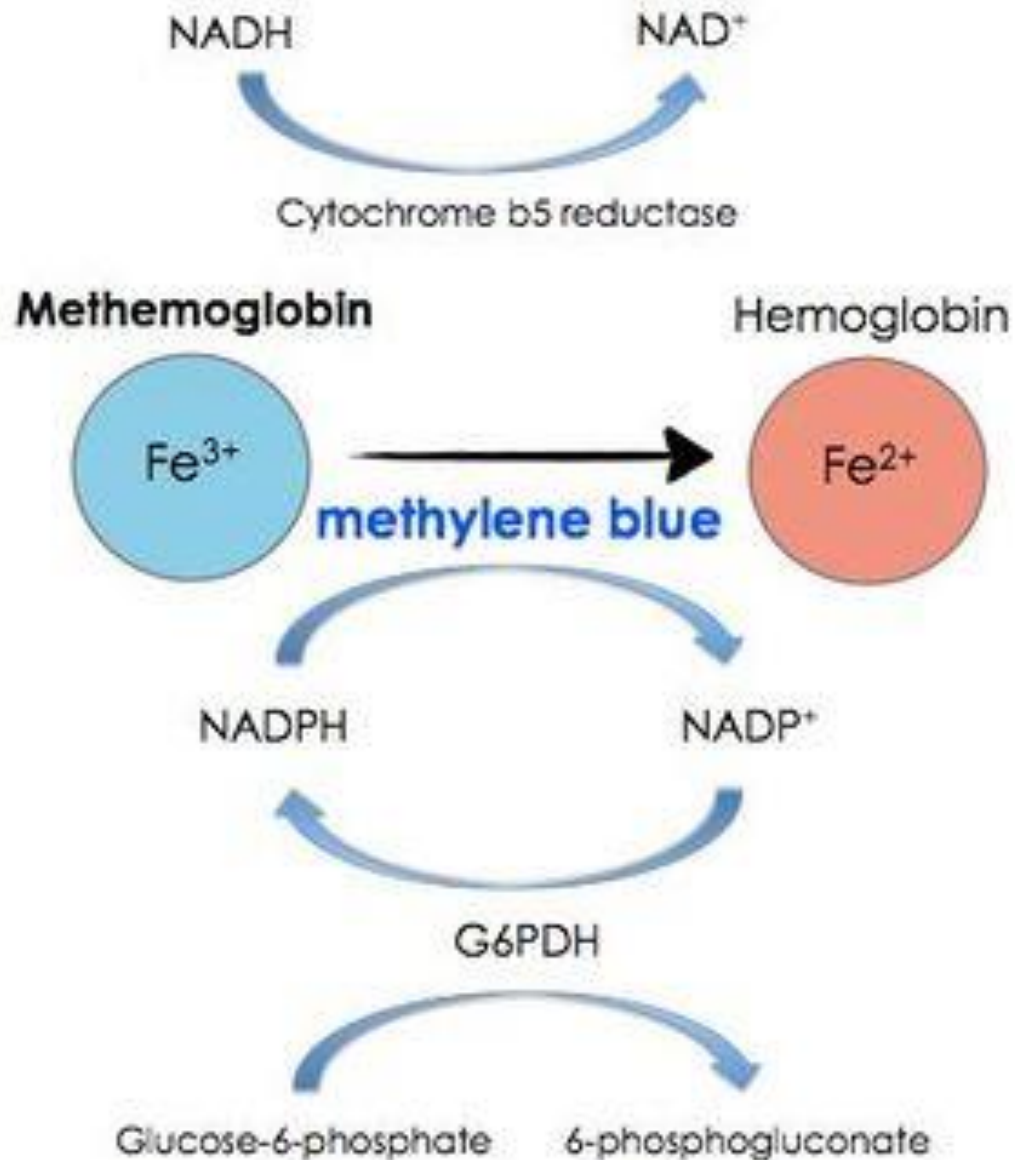
4/5/2019

# How is it regulated?

- Safe Drinking Water Act (1974, 86, 96)
- Public systems: 15 service connections or minimum of 25 people for 60 days/year
- MCL/MCLG – 10 ppm Nitrate-nitrogen







## Acute Health Concerns

- Methemoglobinemia in infants, iMHG less than 1 year
  - High water content in body
  - Largely fluid diet
  - GI tract bacteria aggressive in transforming nitrate to nitrite
- NADH/Nad<sup>+</sup> pathway poorly developed

# Methemoglobinemia

## Symptomology

MetHb levels (%)	Signs and symptoms
<3	None
3-15	Blue/slate-gray skin
15-30	Cyanosis, chocolate-brown blood
30-50	Breathlessness, headache, dizziness, syncopal attacks
50-70	Tachypnea, lactic acidosis, arrhythmias, seizures, CNS depression, coma
>70	Death

CNS: Central nervous system, MetHb: Methemoglobin



# Chronic Health Impacts

Health Concern	Study Types	Study Numbers
Arthritis	Lane 2003, Zeman 2011, Cohort	2
Birth Defects	Dorsch 1984, Arbuckle 1988, Brender 2004a/b, Croen 2001, Brender 2013 Correlational/Cohort	6
Bladder Cancer	Weyer 2001, Espejo-Herrera 2015 Cohort/Correlational	2
Blood Pressure	Pomeranz 2000, Cohort	1
Brain Tumor	Mueller 2001, Cohort	1
Colorectal Cancer	DeRoos 2003, Cohort	1

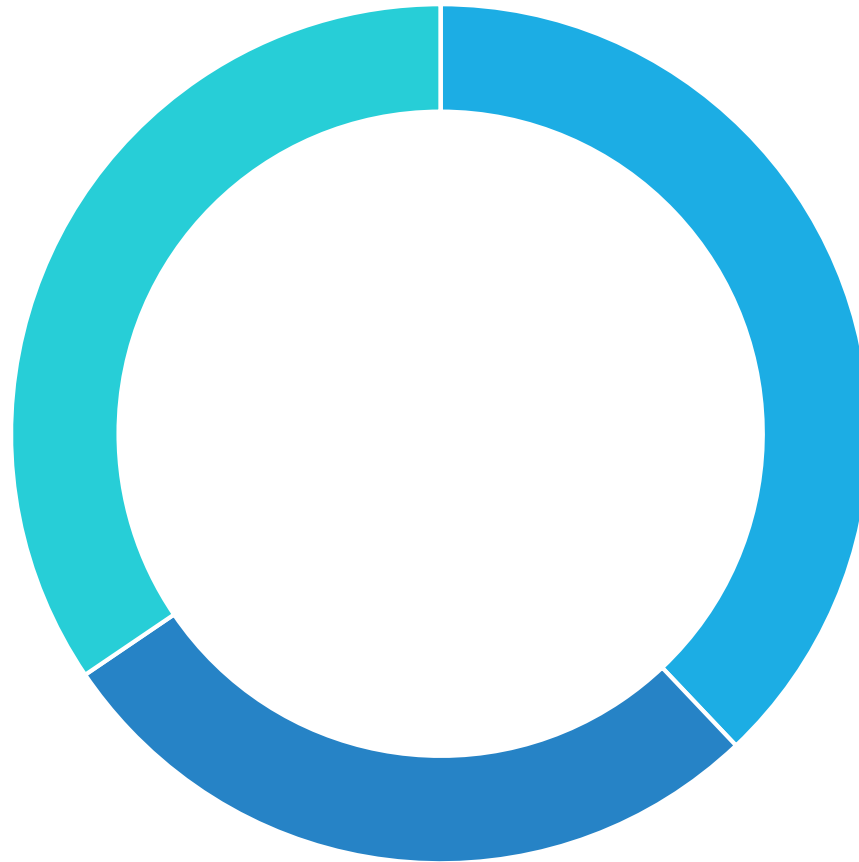
# Chronic Health Impacts

Health Concern	Study Types	Study Numbers
Diabetes Type 1	Parslow 1997, Kostraba 1992, vanMaanen 2000 Correlational	3
Gastric Cancer	Park 2011, Ramirez 2009, Sandor 2001, Ledda 2012, Morales-Surez-Varela 1995, Guillis 2002 Correlational/ Cohort	6
Genotoxicity	vanMaaneen 1996, Tsezou 1996 Cohort	2
Immunotoxicity	Ustyugova, Zeman and Beltz 2002, Zeman and Beltz 2011 in Vitro, Cohort	2

# Chronic Health Impacts

Health Concern	Study Types	Study Numbers
NHL	Ward 1996 Cohort	1
Ovarian Cancer	Weyer 2001, Choi 2015 Cohort	2
Prostate Cancer	Morales 1995 Cohort	1
Thyroid Cancer	Ward 2010 Cohort	1
Thyroid Hypertrophy	vanMaanen 1994 Cohort	1
Age Related MD	Klein 2013 Cohort	1

## Positive Findings Nitrate and Various Health Concerns



■ 0-5 ppm NO3-N      ■ >5.01-10 ppm NO3-N  
■ >10.01-20 ppm NO3-N    ■ >20.01 ppm NO3-N

# Positive Findings at What Exposures?





# Solutions?

- **Prevention** is always the best policy
- **Watershed Management Best Practices**
  - Spring pre-plant nitrogen not Fall or Fall applied with nitrogen stabilizer
  - Side-dress nitrogen
  - No-till/Conservation till
  - Maximum return to nitrogen rate
  - Cereal rye cover-crop
  - Extended rotations
  - Bioreactor
- **Creative Future Options**
  - Carbon pricing?
  - Farm Bill for carbon cycle and nitrate management?





# Solutions, Protecting Your Drinking Water

- Do you know your water?
- Well testing/maintenance
- Septic maintenance
- SDWA Consumer Confidence Reporting
- Distilled/RO Bottled
- RO Units

# Who advocates for clean water?

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Friends of the Big  
Sioux River

Environmental Law  
and Policy Center

US Water Alliance

Environmental  
Working Group

Natural Resources  
Defense Council

Environmental  
Defense Fund

League of  
Conservation  
Voters

Sierra Club

Other local groups?

Join, give money,  
participate, build a  
**relationship**  
(learning, giving,  
supporting)

# Closing Thoughts

9-10 Days  
Modeled on  
Permian Extinction



3 Days

3 Minutes



3 Weeks





# Thank-you and Questions!

- Contact:
  - Dr. Catherine Zeman
  - 319-273-7090
  - **catherine.zeman@uni.edu**