Arsenic in the Environment: Health Effects and Risk Assessment

Charles O. Abernathy, Ph.D.
Toxicologist, Office of Water
US EPA
Washington, DC

Characteristics
Sources
Uses

Arsenic Characteristics

- Most natural waters contain inorganic species
  - As (III) or arsenite predominant in ground waters H_3AsO_3
  - As (V) or arsenate in surface waters H_2AsO_4 & $HAsO_4^{-2}$

Natural Arsenic Levels

Crystalline Rock	Avg. 2 ppm
Soil	1-40 ppm
Ground Water	0.01 – 800 ppb As high as 40,000 in hot springs
Surface Water	2.38 – 65 ppb As high as 22,000 in river water

Some Arsenic Uses/Anthropogenic Sources

- Smelting of metals
- Pharmaceutical industry (medicines)
- Pesticide manufacture (very limited)
- Wood preservative – CCA [in phase out]
- Cattle and sheep dips
- Feed additives
- Dye stuffs
- Petroleum, coal, and wood burning
- Semiconductor manufacture
- Waste incineration

Toxicokinetics

Toxicokinetics

- Absorption
  - Soluble forms
    - Humans – 40 % to complete absorption
    - Animals – 50% to complete absorption
  - Insoluble forms
    - Limited absorption

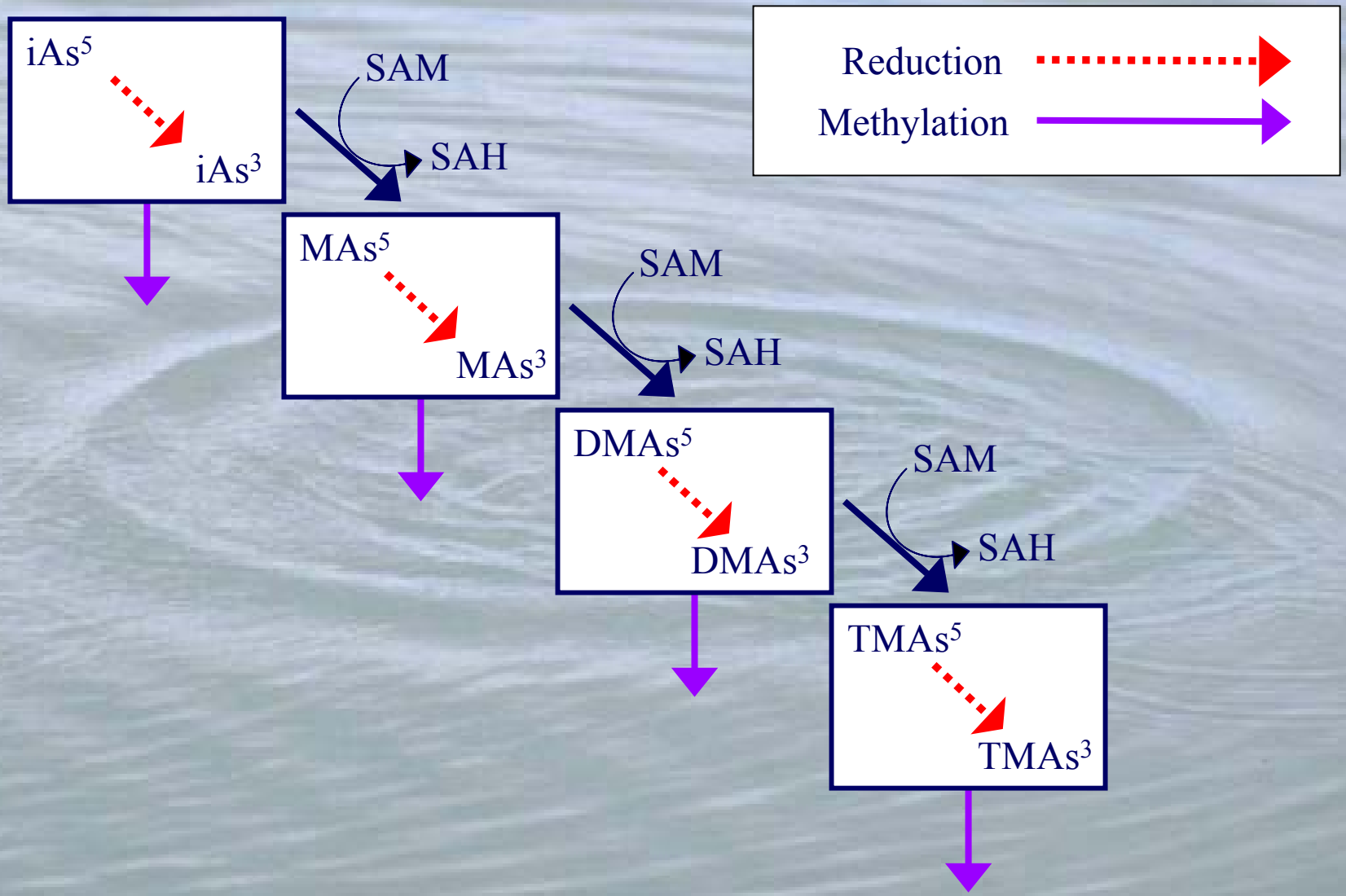
Toxicokinetics cont.

- Distribution
  - Found in all humans – Blood conc. (1-5 ppb)
    - Smokers (2 – 10 ppb)
    - Occupational exposure (~10 ppb)
    - Taiwan (20 – 60 ppb)
    - Poisonings (1,000 – 2,000 ppb)

Distribution

- Highest levels (ppb)
  - Nails (0.89)
  - Hair (0.18)
  - Bone (0.07 – 0.12)
  - Heart, kidney, liver, lung (0.03 – 0.05)

Metabolism of Inorganic Arsenic



Excretion

- Primarily via urine
  - 60% - 95% in 5 days
- Fecal excretion low

Adverse Health Effects

Non-Cancer

Acute Toxicity

Animal	LD_{50} (mg/kg)
Rats	15 - 293
Mice	26 - 43
Guinea pigs	9
Humans	1 - 4 (approx)

Acute Effects – Humans (est. LD_{50} ~ 1-4 mg/kg)

- Peripheral neuropathy
- Anemia
- Renal and liver dysfunction
- Skin pigmentation
- EKG abnormalities
- Severe GI effects

Chronic Toxicity: Humans
Vascular

- Taiwan
  - Blackfoot disease
- Poland
  - Vintners
  - 6 cases of gangrene
- Chile
  - Raynaud's disease

Chronic Toxicity: Humans

- Nervous system
  - Peripheral neuropathy – legs and arms
- Cranial nerves
  - Loss of hearing in Japanese infants

Adverse Health Effects

Cancer

Countries Reporting Tumors After Arsenic Exposure

- Taiwan
- Mexico
- Argentina
- Chile
- China
- Mongolia
- Japan

Cancers Associated with Exposure to Arsenic in Drinking Water

- Skin
- Bladder
- Lung
- Kidney
- Liver
- Prostate

Lifetime Risk of Cancer (per 1000)