Today’s Presentation

• Cyanobacteria primer
  • where do they come from?
  • What do they look like?
  • How do they behave?

• Blooms
  • What causes them?
  • Why do we care?

• What can we do
  • Current state of the science
Harmful algal blooms may have killed this carnivorous theropod dinosaur, discovered by researchers excavating a series of 70-million-year-old bone beds in northwestern Madagascar.

ANDREW FARR

Did tiny algae fell mighty dinosaurs?

By Carolyn Gramling | Aug. 29, 2017, 3:57 PM

Seventy million years ago, they all came to drink in the rapidly drying river: long-necked sauropods, fish, theropods, crocodiles, insects, and even small birds. Three were left. The priest and the tiny...
Where are they found?
Blue-green algae...algae or bacterium?

- Structurally like bacteria, functionally like plants
- Lacking a nucleus or membrane bound organelles
- Cyanobacteria photosynthesize their own food
Handheld 2-Channel Fluorometer

Approximate Light Absorption
- Chlorophyll
- Phycocyanin
- Rhodamine

Approximate Light Emission
- Phycocyanin
- Rhodamine
- Chlorophyll

Likewise, each compound emits its own unique light.
Thylakoids provide a greater surface area for chlorophyll and other molecules involved in photosynthesis.

The gas vesicles buoy this photosynthetic organism to the lighted water surface, where it often forms conspicuous scums.

Phycocyanin pigments
Types of Cyanobacteria

- Forms
  - Unicellular
  - Colonial
  - Multi cellular filamentous

- Can be less than 2μ
- Close to 100 genera
- 2,500 species
What Do They Look Like?
Anabaena/Dolichospermum

- Filamentous/beadlike 5-20\(\mu\)m
- Heterocysts
- Akinetes
- Benthic form
- Gas vesicles
  - Dolichospermum
  - Planktonic
  - Toxin forming
- Bloom former
- Taste & Odor
Aphanizomenon

- Filamentous 3-8μ
- Cells joined end to end
  - cylindrical
- Heterocysts and akinetes
- Bloom former (nutrient rich)
  - Usually with others
- Gas vesicles
- High temp/light promotes blooms
- Taste & Odor
Microcystis

- Colonial form, cells 2-5µ
- Often found with others
- Gas vesicles
- Mucilage
- Nutrients
- Warm & calm promotes blooms
  - Can be dense
  - Can be many species in same bloom
Types/forms of Cyanobacteria

“Annie (Dolly), Fannie, and Mike”
Contiguous U.S., Average Temperature, January-December

-1.4°F/Century
Mean: 52.02°F
Avg Temperature

[Graph showing temperature trends from 1895 to 2016 with a linear trend line.]
What Causes Harmful Cyanobacteria Blooms?

- Climate changes
- Nutrient loads
- Warmer waters
- Low “flushing” rates
- Anoxic conditions
  - Sediment nutrients
- Watershed dehydration
Runoff Volume
Phosphorus Inputs
Sediment Inputs

Adapted From: Wisconsin DNR
What exactly is a “Bloom?”
“You know it when you see it”

- Increase of cyanobacterial biomass
- Couple days to a couple weeks
- Single, or few species
- Visible

Algae blooms are different….and not potentially toxic!

Non-bloom formers – Pico cyanobacteria
  - Less than 2µm
  - Often widely dispersed
  - Easily aerosolized/volatilized
How Harmful Algal Blooms (HAB’s) Form
As many as three cell divisions per day

- Warming
  - Algae- <59°F
  - Cyano- >79°F
- Stratification
- Anoxia/nutrient release
Wind Action

Disruption of buoyancy
Inability to regulate buoyancy

100 fold increase in cell counts/ml
Super Concentration and Decomposition of bacteria

wind

1,000 fold increase in cells/ml
• Toxicity not affected by boiling water
• Cell death releases the toxins
• Cell rupture releases toxins
• Ingestion release toxins
Jar & Stick Test
Toxins Associated with Specific Genera

**CYANOBACTERIA**
- Anabaena
- Aphanizomenon
- Microcystis
- Oscillatoria
- Lyngbya
- Nostoc
- Gloeotrichia

**TOXIN**
- Saxitoxin
- Anatoxin
- Microcystin
- Nodularia
- Cylindrospermopsin
- Lyngbyatoxin
- BMAA
- Taste & Odor
TOXINS

Oral LD$_{50}$ µg/Kg

• Saxitoxin 9
• Anatoxin (VFDF) 20
• Microcystin-LR 50
• Nodularia 50
• Cylindrospermopsin 200
• Ricin 0.02
• Cobra 20
• Curare 500
• Cyanide 1,500
• Strychnine 2,000
Cyanotoxin targets

- Saxitoxin: Neurotoxin
- Anatoxin: Neurotoxin
- Microcystin-LR: Hepatotoxin, tumor promoter
- Nodularia: Hepatotoxin, tumor promoter, weak carcinogen
- Lyngbyatoxins: Dermatoxin
- Cylindrospermopsin: Neurotoxin, multiple organs, genotoxin
- BMAA: Neurotoxin
Routes & Types of Exposure

- **Dermal – Acute – Lyngbya toxin**
  - Itchiness, mild to severe skin rashes (i.e. Lyngbya)
  - Symptoms occur within hours of direct exposure

- **Ingestion – Acute – Microcystin toxin common**
  - Most common with pets & wildlife (direct consumption, licking fur)
  - Drinking water, cooking, recreation (boiling doesn’t help!)
  - Usually hepatic – can be lethal (minutes)
  - Neurotoxin pathway – PSP, BMAA (bioaccumulates/bioconcentrates)

- **Inhalation – Chronic – non-bloom forming pico cyanobacteria**
  - Compelling evidence with BMAA and ALS
  - Transport at the molecular level
Toxicity Associated with Cyanobacteria

• We still don’t know when toxins are expressed, but
  • Often when waters warm up and “hyper blooms” occur
  • A visual bloom doesn’t necessarily mean toxins are present
  • Clear water doesn’t guarantee toxins aren’t present
  • Much research currently underway

• Toxins are not limited to the large bloom forming cyanos
  • Pico cyanobacteria – low concentration, chronic exposure
  • Blooms can be locally isolated in small areas
  • Blooms can occur at depth
Treatment Options

• Nutrient reductions
• Flocculants/binders
• Oxygenation/aeration
• Ultrasound/sonication
• Algaecides
• Rooted plants
• Trophic balance
• Dredging
• Flow manipulation
• EPA Approved APP
• iPhone and Android compatible
• New launch very soon
• Intro and training video clips
• Downloadable via APP stores or from Cyanos.org