Animal Health Effects of Cyanotoxins

EPA Cyanosymposium 2026

March 23, 2026

https://www.nrdc.org/stories/freshwater-harmful-algal-blooms-101

Disclaimer:

This presentation should not be construed to represent any Agency determination or policy, or promotion of a product.

OHHABS Overview of HAB-related Animal Illnesses 2019-2022

- HABS events ranged 227-372 per year
- 367-102,071 animal illnesses reported per year; 2022 included >100K fish ; 2021 included 2,642 bats
- Domestic pets 100% dogs; livestock 100% cattle
- All years included marine mammals (i.e. sea lions, seals, dolphins)
- Most common signs of illness in dogs: vomiting, diarrhea, lethargy, and ataxia
- Onset ranged 2 minutes to 3 days; Duration ranged from minutes up to 7 days
- Most common toxins: microcystin(89-93%), anatoxin(9-17%), cylindrospermopsin(3-8%), saxitoxin(4-7%)
- 6-25% of events occurred in salt water
- Diatoms and dinoflagellates identified most years

State of California
OEHHA

EPA

Marine HAB-associated illnesses in marine mammals

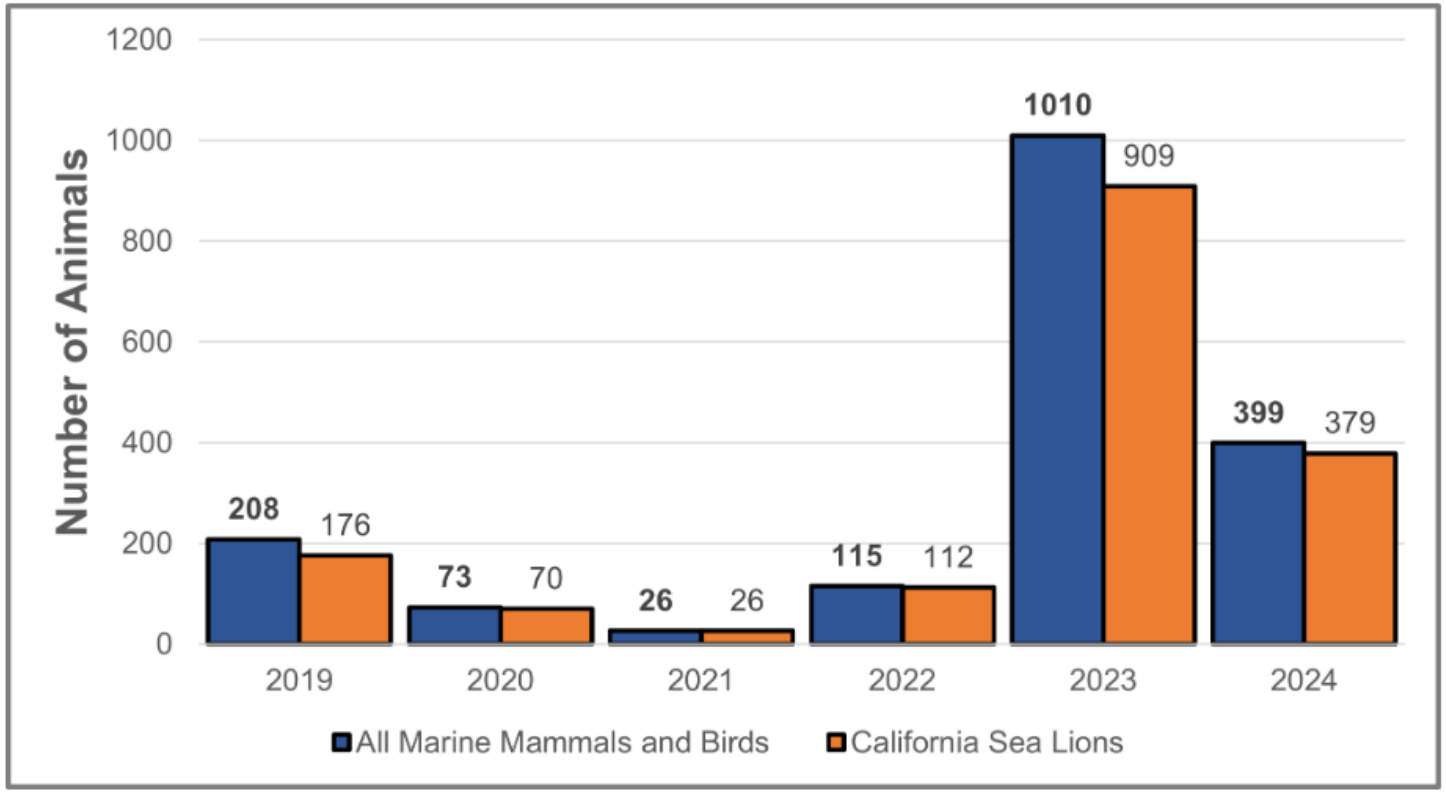


Figure 1. Marine HAB-associated illnesses in all marine mammals and birds (blue bars) reported to OHHABS from 2019 – 2024. California sea lions (orange bars) are also shown as a subset of all reported marine stranding events. Numbers represent individual animals.

Recent Notable Mass Mortality Events

2020 Botswana- 350 elephants died; suspected neurotoxin

2021 Washington State- >2500 bats died due to anatoxin-a

2025 South Australia- deaths in the millions due to Karenia cristata bloom; represents 550 taxa

Common Cyanotoxin Health Targets

Hepatotoxins

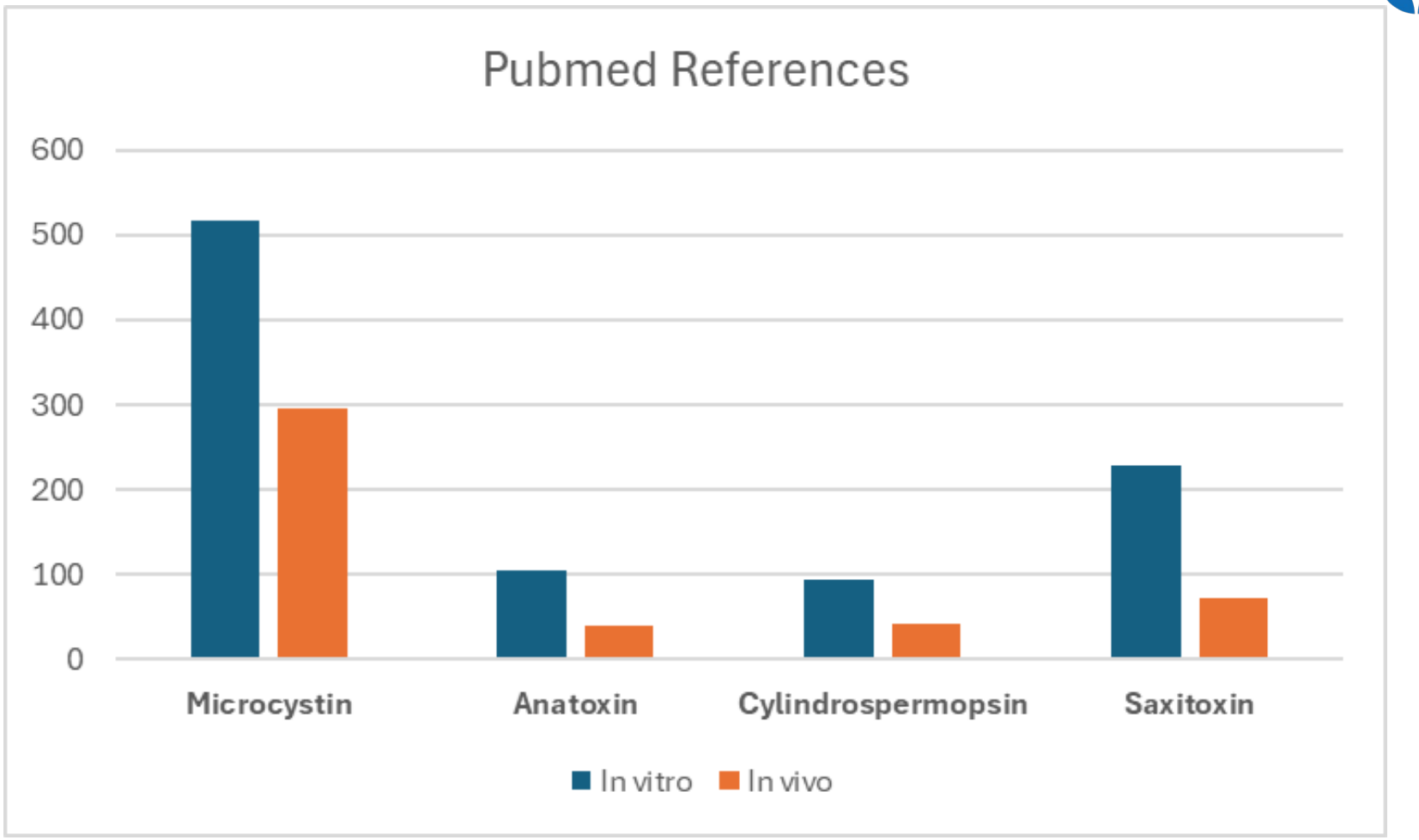
Microcystins (MC), Nodularins (NOD) (brackish), Cylindrospermopsin (CYN)

Neurotoxins

Anatoxins (ATX), Saxitoxins (STX) (fresh and marine), Guanitoxin (GTX)

Dermatotoxins

Lipopolysaccharides (LPS), Lyngbyatoxins (fresh and marine), Aplysiatoxin (marine)



Pubmed Search 3-16-26

Dose required to be lethal to 50% of mice tested

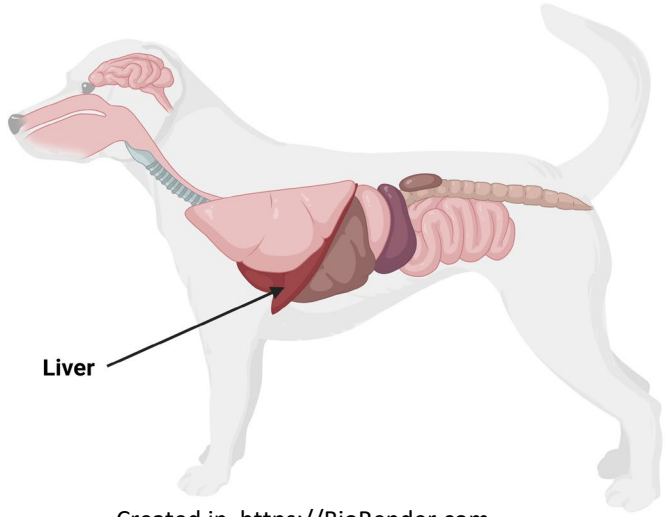
Cyanotoxin	Oral LD_{50} mg/kg	Source
Cylindrospermopsin	0.2 (after 6 days)	Ohtani et al. 1992
Neosaxitoxin	0.4	Coleman et al. 2018
Saxitoxin	1.07	Finch et al. 2023
Dihydro-anatoxin-a	2.5	Puddick et al. 2021
Microcystin LR	5	Fawell et al. 1994
Anatoxin-a	10.6	Puddick et al. 2021

Exposure Routes

- Primarily oral with water and/or bloom material
- In fish and shellfish consumed by other animals
- Some occurrences after consumption of blue-green algal supplements
- Inhalation of water droplets containing toxin

Hepatotoxins

Microcystins
Nodularins
Cylindrospermopsin

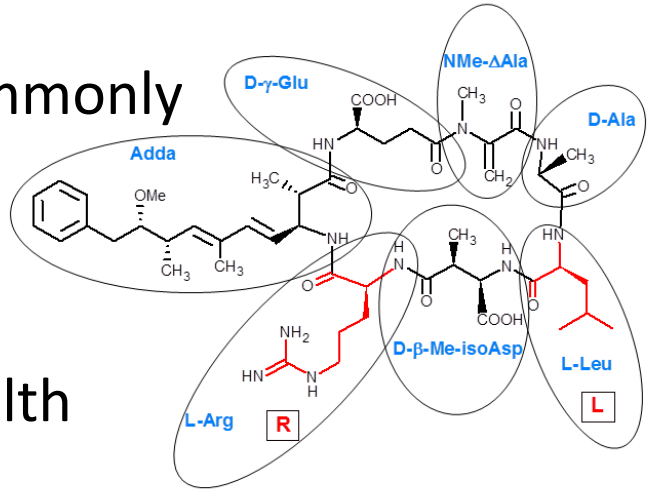


https://www.whole-dog-journal.com/health/liver-disease-in-dogs/

Created in https://BioRender.com

Microcystins and Nodularins

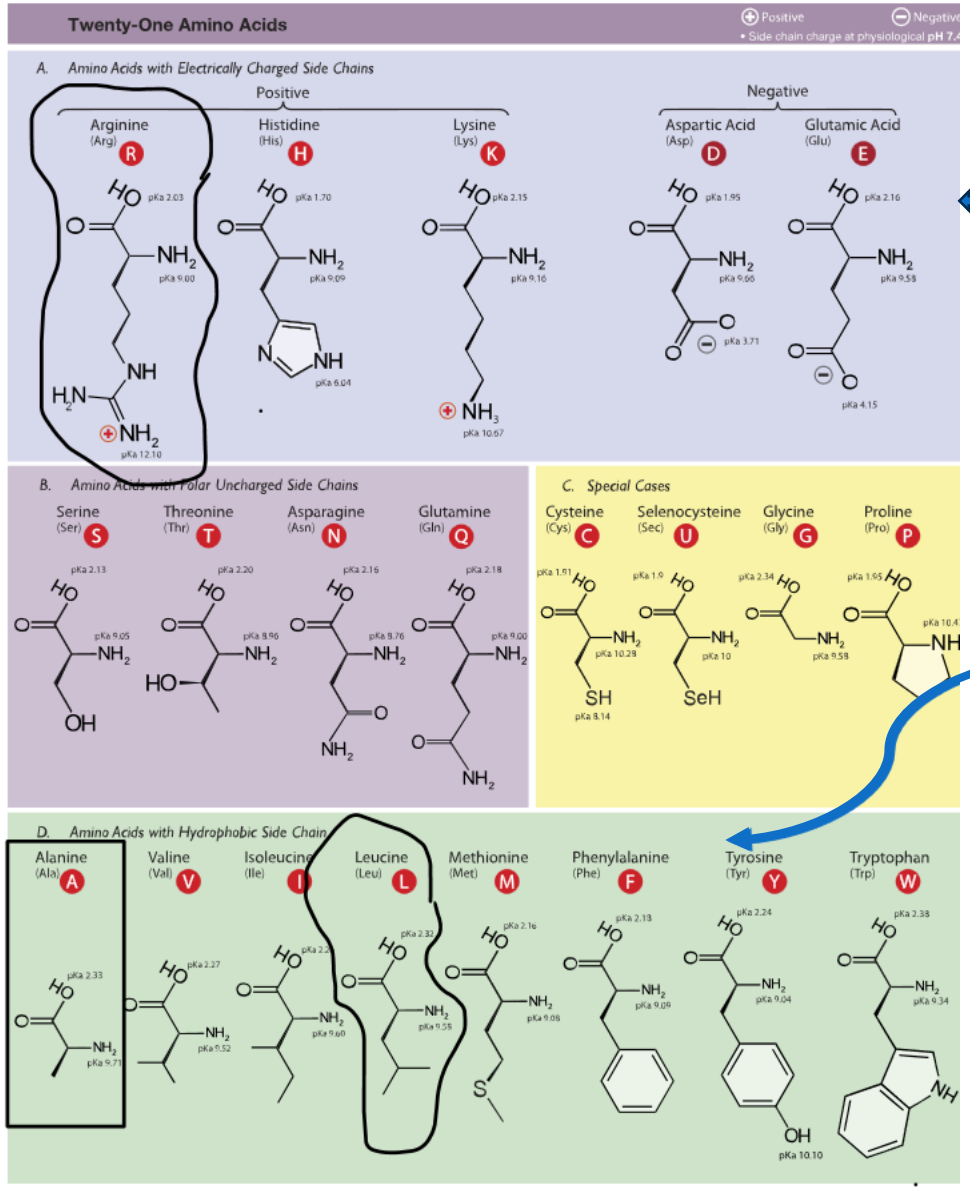
- Cyclic hepta- and penta-peptides with similar structures and mode of action
- Toxicity varies with congener (structure and hydrophobicity contribute)
- Requires active transport into target tissues; commonly organic anion transporting polypeptides (OATP)
- Liver is primary target, but can also affect kidney, brain, lungs, heart, and reproductive health



MC-LR Molar Mass 995.189

MC-LR Toxicity

- Most-studied microcystin
- Low absorption with oral exposure
- Absorbed from small intestine; 1° in ileum
- Bind and inhibit protein phosphatases which leads to:
  - ➢ Oxidative stress
  - ➢ Cytoskeleton disruption
  - ➢ Cell death
- Dose-dependent liver damage; inflammation-necrosis
- Possible carcinogen/tumor promotor



Arginine (R) has electrically charged side chains

Hydrophobic amino acids

Alanine (A) is small and hydrophobic

Leucine (L) is moderate size and hydrophobic

Chernoff et al. Comparative Toxicity of 10 MC Congeners (https://doi.org/10.3390/toxins12060403)
doi: 10.3390/toxins13020086

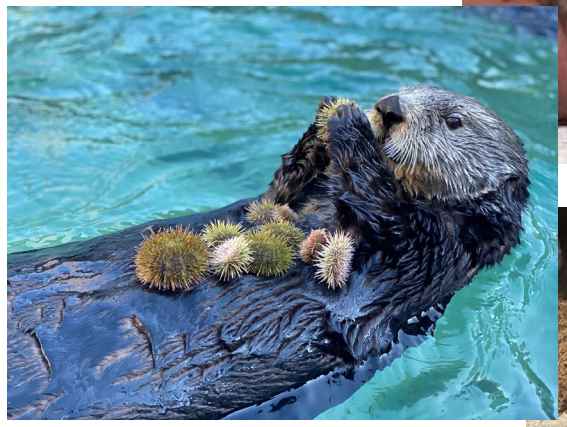
Dose–Response Study of Microcystin Congeners MCLA, MCLR, MCLY, MCRR, and MCYR Administered Orally to Mice (doi: 10.3390/toxins13020086)

Relative toxicity:
LA>LR>LY>YR>LF, LW, WR, and RR(3 isotypes)

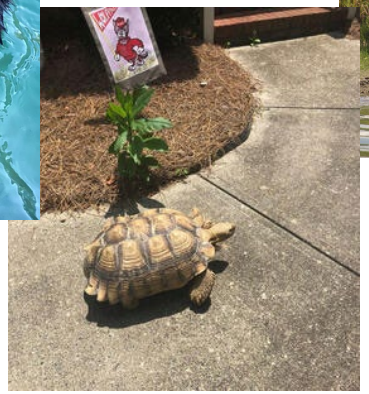
Animal Deaths Associated with MC/NOD

Isolated and mass casualty events

- Dogs
- Cattle
- Fish
- Waterfowl
- Turtles
- Deer
- Rhinos
- Zebras
- Marine mammals (biomagnified in clams, oysters, and mussels they consume)

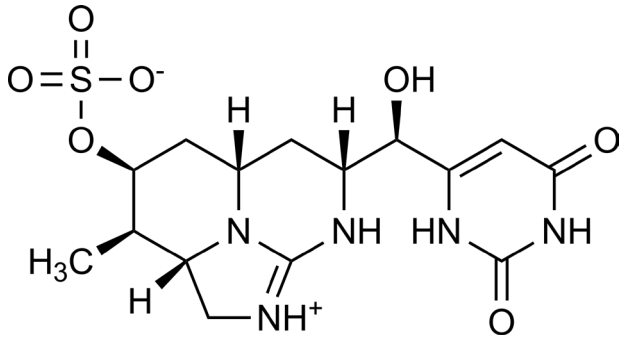


https://oceans.ubc.ca/2023/08/18/hungry-hungry-otters-looking-at-captive-sea-otters-to-understand-their-wild-counterparts/



Cylindrospermopsin

- Very water-soluble alkaloid; 5 congeners identified
- Majority of toxin is extracellular; Can be stable in water up to a month(s)
- Toxin enters tissues mainly by active transport
- Main target is liver, followed by kidney
- Slow-acting toxin; max effect may take 1 week
- Inhibits protein synthesis, causes oxidative stress, cytotoxicity, and DNA modification
- Has been associated with thrombi causing hemorrhage in various organs (intestines, lungs, heart, small capillary beds)



Cylindrospermopsin **Molar Mass** 415.43
By Photocyte - Own work, CC0,
https://commons.wikimedia.org/w/index.php?curid=129799820

Cylindrospermopsin

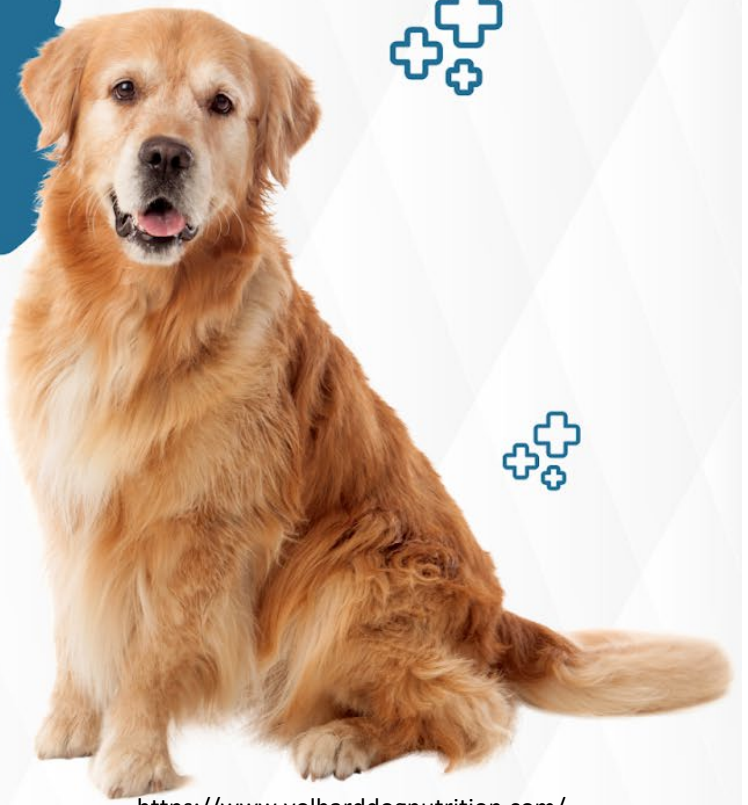
- Limited reports of animal illness or death- cattle in Australia; possibly under-reported due to slow onset of signs

- 90-day study in mice- daily oral dosing of 0, 75, 150, and 300 µg/kg/d of purified CYN
  - At end of study, all mice appeared normal
  - All dose levels produced enlarged livers and kidneys-significance varied with dose and sex
  - Liver enzymes elevated at high dose
  - Cholesterol decreased in males
  - Anemia and elevated WBC's at high dose in males
  - Histopathological lesions in liver and kidney
  - Genes including Bax (apoptosis), Rpl6 (tissue regeneration), Fabp4 (fatty acid metabolism), and Proc (blood coagulation) were differentially expressed

Chernoff N, Hill DJ, Chorus I, Diggs DL, Huang H, King D, Lang JR, Le TT, Schmid JE, Travlos GS, Whitley EM, Wilson RE, Wood CR. Cylindrospermopsin toxicity in mice following a 90-d oral exposure. J Toxicol Environ Health A. 2018;81(13):549-566. doi: 10.1080/15287394.2018.1460787. Epub 2018 Apr 25. PMID: 29693504; PMCID: PMC6764423.

THE 4 FUNCTIONS OF YOUR DOG'S LIVER

1. Synthesis and Regulation of Nutrients
2. Production of Plasma Proteins and Blood Clotting Factors
3. Vitamin and Mineral Storage
4. Detoxification



https://www.volharddognutrition.com/

Presenting Signs for Cyanobacterial Hepatotoxin

- Vomiting, diarrhea (collecting early vomitus for testing could be helpful)
- Lethargy
- Low glucose
- Elevated liver markers (ALT, bilirubin)
- Anemia
- Possibly jaundice (days into illness)

Rule outs to consider (not complete)

- Infectious (Leptospirosis)
- Other toxins (xylitol, sago palm, mushrooms (amanita))

Call poison control helplines: e.g. Pet Poison Helpline, ASPCA Animal Poison Control

Treatment for Most Suspected Cyanotoxin Illnesses

Owner

- Wash all contamination off fur
- Start a pet poison control case

Supportive care (veterinarian)

- Induce vomiting/Administer charcoal
- IV Fluid therapy
- Check bloodwork to guide treatment
- Anti-nausea medications
- Gastroprotectants
- Antioxidants (e.g., n-acetylcysteine)
- Cholestyramine- binds bile acids and prevents reabsorption; documented to help with MC
- Vitamin K if low red blood cells
- Oral liver protectants

Foss AJ, Aubel MT, Gallagher B, Mettee N, Miller A, Fogelson SB. Diagnosing Microcystin Intoxication of Canines: Clinicopathological Indications, Pathological Characteristics, and Analytical Detection in Postmortem and Antemortem Samples. Toxins (Basel). 2019 Aug 3;11(8):456. doi: 10.3390/toxins11080456.

Diagnosis

Identify toxin or producing organisms in stomach contents

Identify toxin in urine: MC up to a month

Veterinary Resources

CA OEHHA Blue-green Algae: A Veterinary Reference
https://oehha.ca.gov/sites/default/files/media/downloads/risk-assessment/fact-sheet/vethabsfactsheet2017.pdf

CDC's Veterinarian Reference for Cyanobacterial Blooms
https://www.cdc.gov/harmful-algal-blooms/communication-resources/veterinarian-reference-for-cyanobacterial-blooms.html

Cornell's Blue-green algae poisoning: Cyanobacteria toxicosis
https://www.vet.cornell.edu/departments-centers-and-institutes/riney-canine-health-center/canine-health-topics/blue-green-algae-poisoning-cyanobacteria-toxicosis

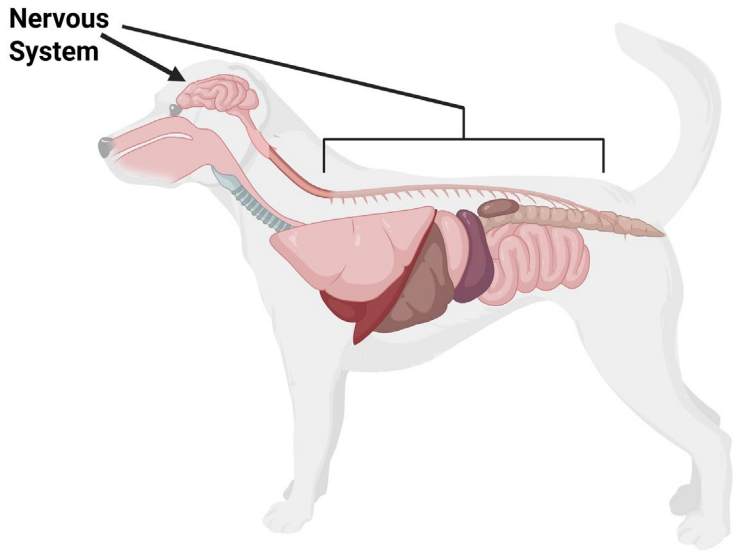
Merck's Manual
https://www.msdvetmanual.com/toxicology/algal-poisoning/algal-poisoning-of-animals

Neurotoxins

Anatoxins (ATX)

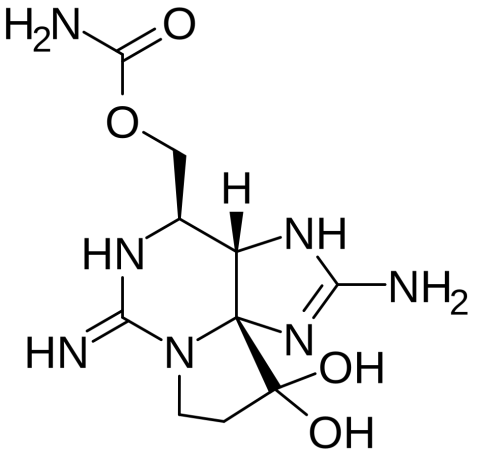
Saxitoxins (STX) (fresh and mar

Guanitoxin (GTX)

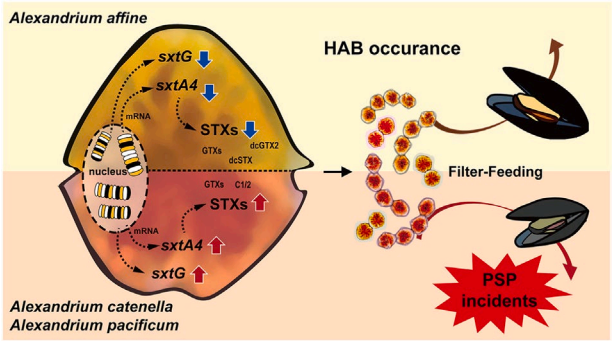


Saxitoxins

- Known as paralytic shellfish poisoning (PSP)
- Over 50 variants identified; most common: saxitoxin(STX), neosaxitoxin NSTX, gonyautoxins (GTX), and decarbamoylsaxitoxin (dcSTX)
- Produced by dinoflagellates and cyanobacteria (marine and freshwater)
- Accumulates in filter feeders and causes bans on shellfish



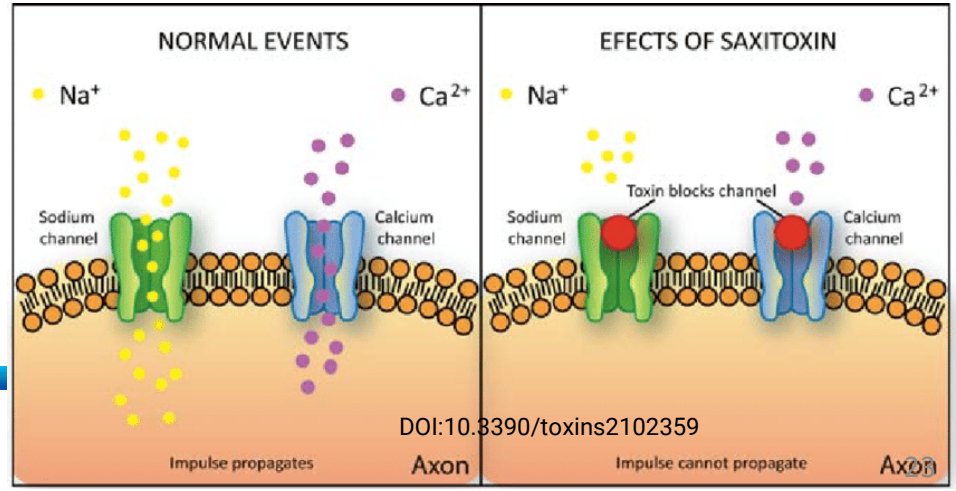
Saxitoxin Molar mass 299.291



https://doi.org/10.1016/j.marenvres.2023.105874

Saxitoxins

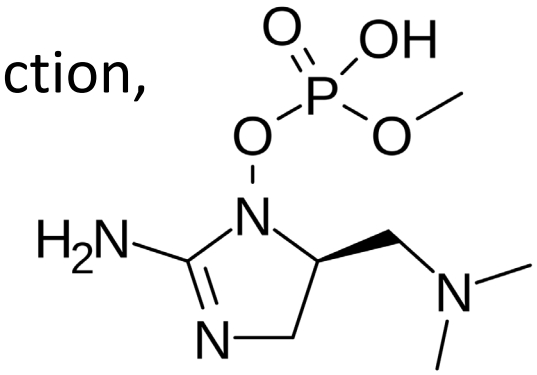
- Blocks sodium channels in neurons which prevents nerve transmission
- Causes tingling/numbness of the face, lips, and extremities and can progress to weakness, ataxia, and respiratory failure due to diaphragm paralysis
- Occurs 10 minutes to 3 h after eating bioaccumulated food source



DOI:10.3390/toxins2102359

Guanitoxin (formerly Anatoxin-a(s))

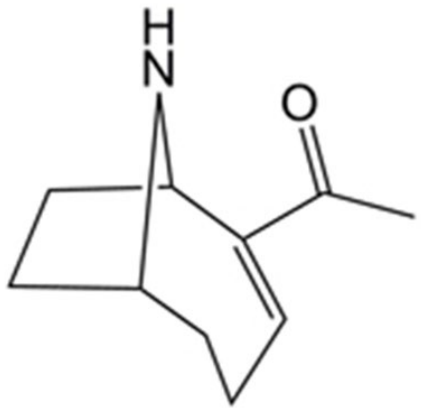
- Toxin is a natural organophosphate
- Signs of exposure: drooling, twitching, excessive tear production, weakness, and respiratory failure
- Target is acetylcholinesterase at muscarinic and nicotinic receptors in peripheral and parasympathetic NS
- Produced by common ATX producers: *Oscillatoria*, *Phormidium/Microcoleus*, *Dolichospermum*, *Aphanizomenon*, *Cuspidothrix*, *Tychonema*, and *Planktothrix*.
- Atropine will reverse the muscarinic effects (drooling), but not the nicotinic effects (respiratory paralysis)



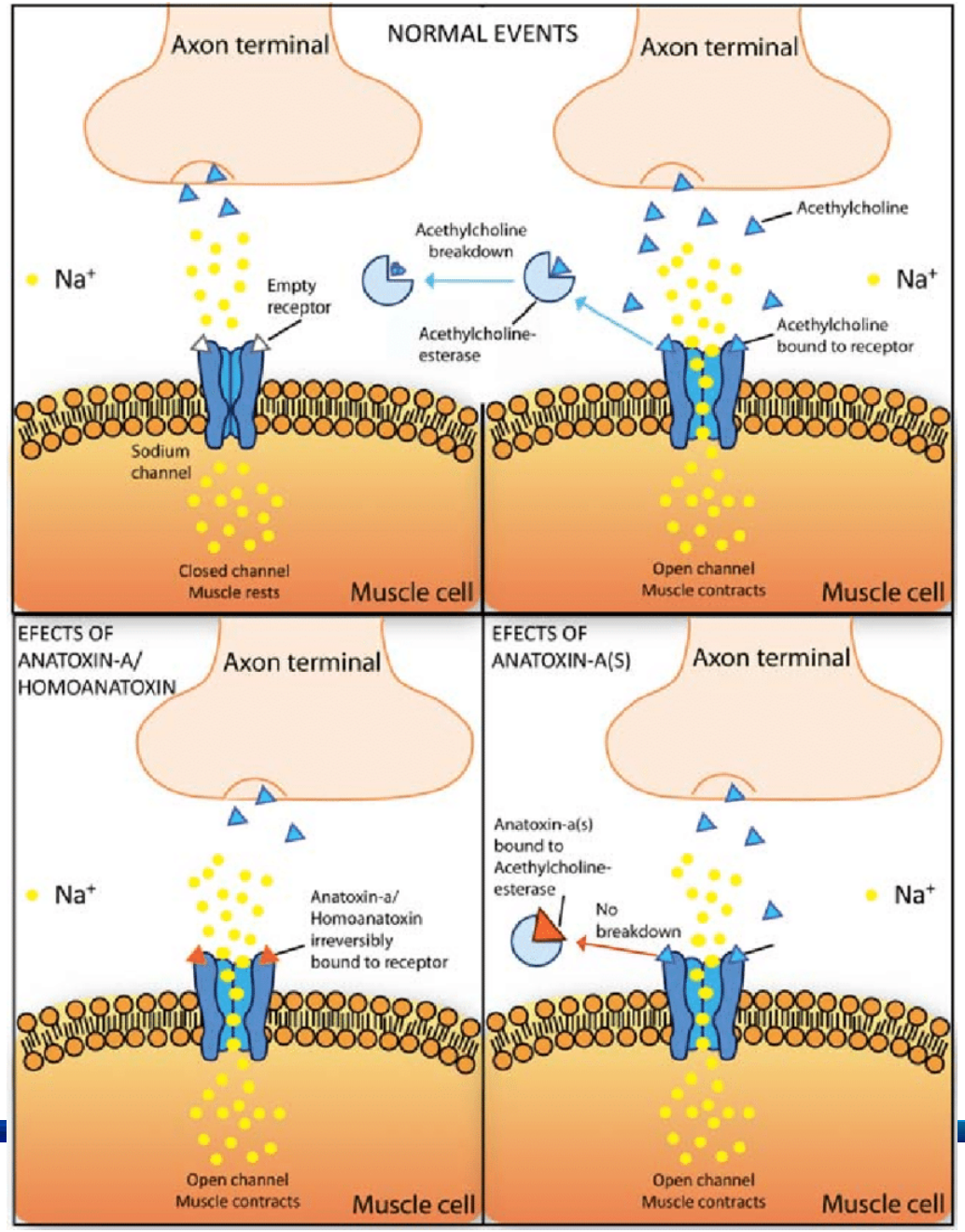
Guanitoxin Molar Mass 252.211
By Ed (Edgar181) - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=56576465

Anatoxins (VFDF- very fast death factor)

- Small, hydrophilic secondary bicyclic amine alkaloid
- Found in water column blooms and benthic blooms
- Rapidly degrades in light and higher pH
- Specific targets are *nicotinic* acetylcholine receptors (nAChR)
- Clinical signs 1° from effects at neuromuscular junctions, but these receptors are throughout the peripheral and central nervous system (NS)
- ATX has higher affinity to receptor than ACh and nicotine



Anatoxin-a Molar mass 165.232

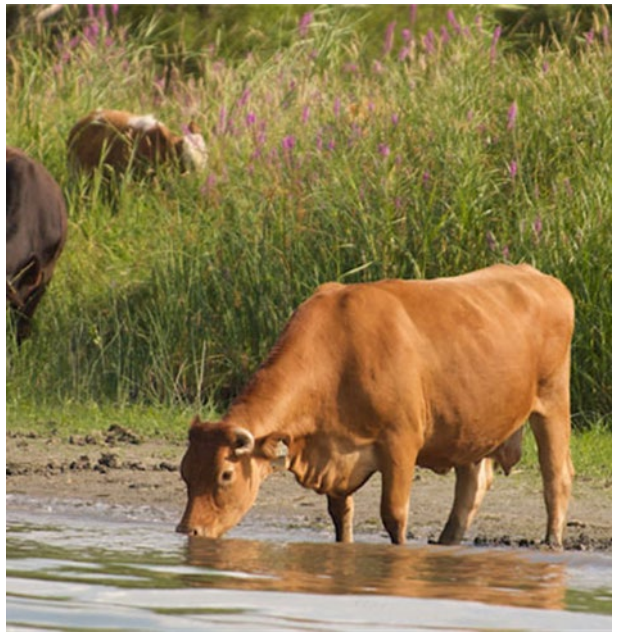


Diversity and Impact of Prokaryotic Toxins on Aquatic Environments: A Review - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Schematic-representation-of-Anatoxin-a-Homoanatoxin-a-and-Anatoxin-as-molecular_fig4_51785338 [accessed 19 Mar 2026]

Symptoms with ATX Exposure

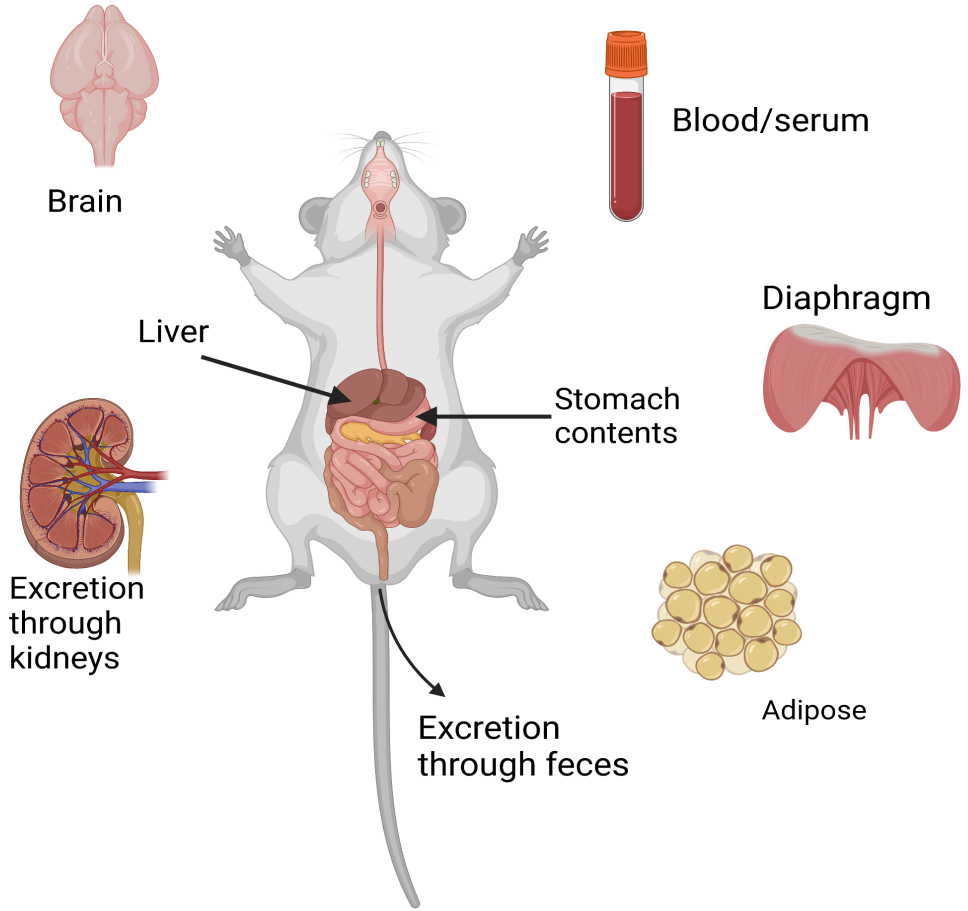
- Incoordination
- Tremors/Fasciculations
- Weakness/Collapse
- Seizures
- Respiratory distress
- Death

Confirmed reports of illness and lethality in dogs, livestock, and wildlife due to ATX



Pharmacokinetic Evaluation

- Analyzed with pharmacokinetic modeling to maximize use of data
- Can aid risk assessment
- New information for anatoxin-a
- Done with a 2-stage pilot informing the larger PK study



Pharmacokinetic Findings

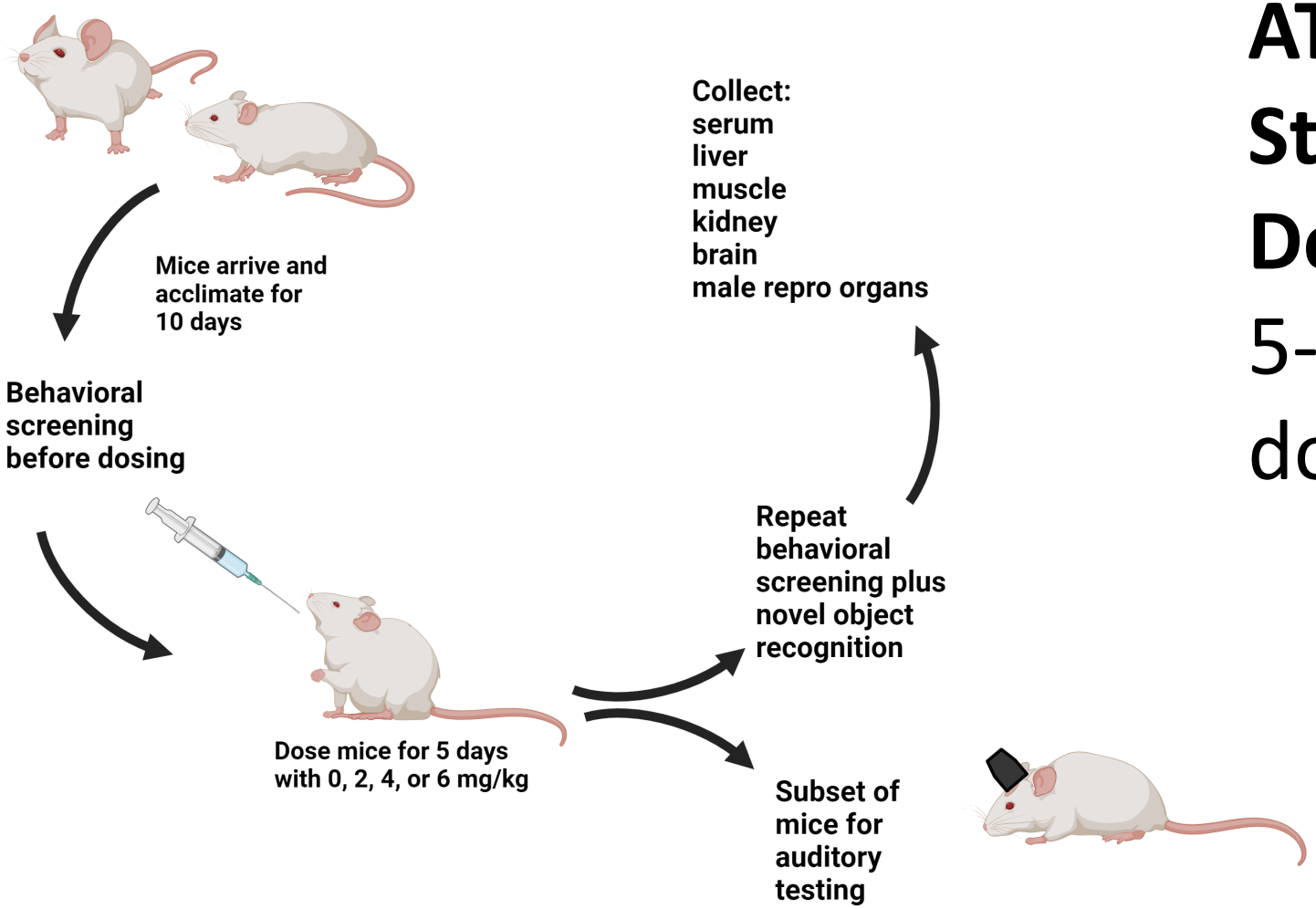
Article currently in clearance process

- Rapid absorption and elimination
- Estimated oral bioavailability 5-10%
- Dihydro-anatoxin-a was found in all tissue and blood samples

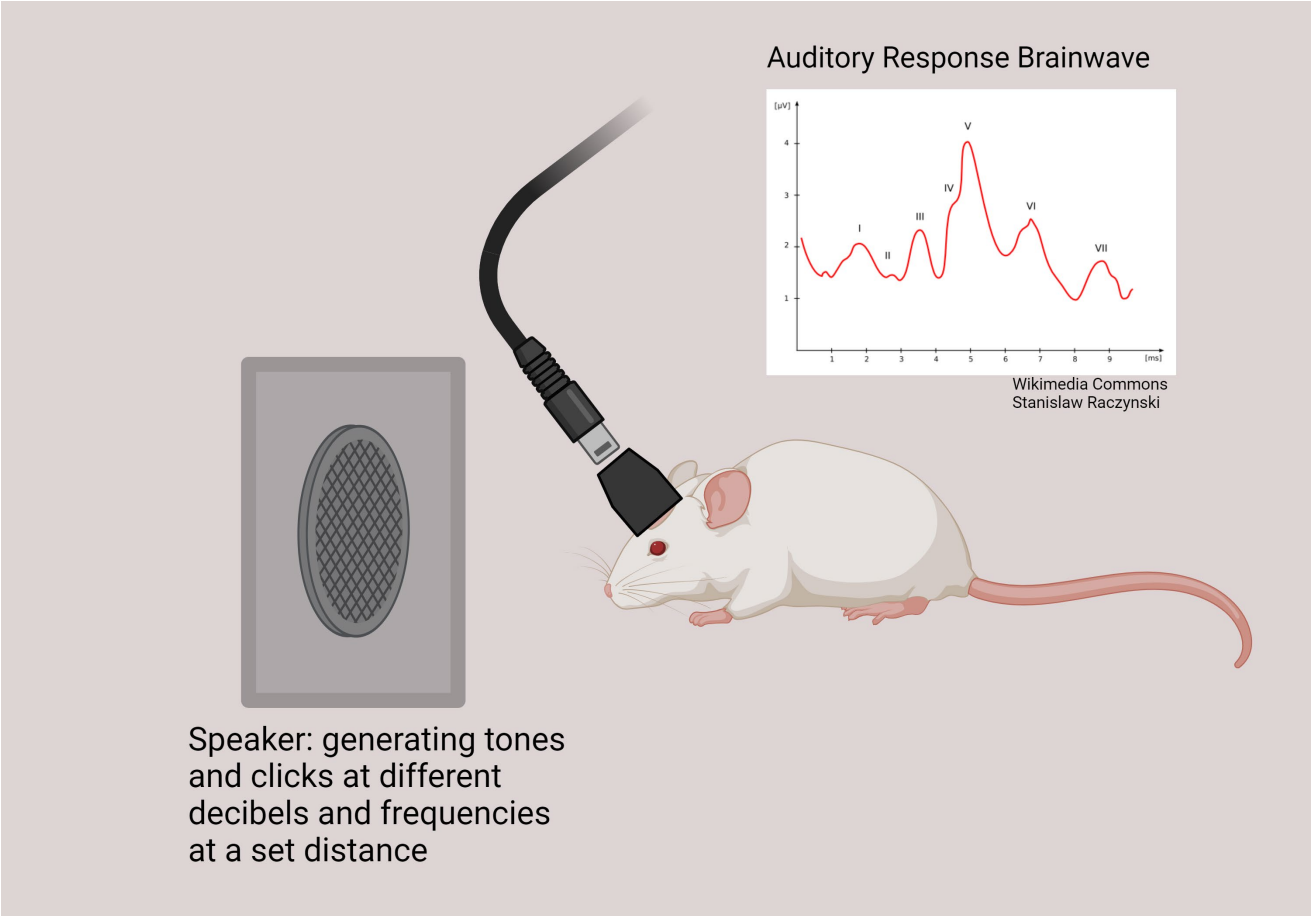
Future development of a physiologically-based pharmacokinetic (PBPK) model would incorporate bioavailability and provide better health effect extrapolation between species

ATX Study Design

5-day oral dosing



Auditory Testing in Mice Treated with ATX



Dermatotoxins

Lipopolysaccharides (LPS)-substance in outer membrane of bacteria

Lyngbyatoxins (fresh and marine)- “seaweed or swimmer’s itch”

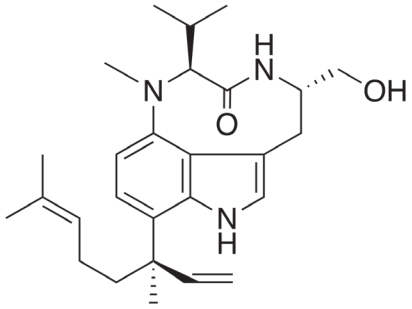
Aplysiatoxin (marine)

Dermatotoxins are irritating to skin, eyes, and respiratory tract

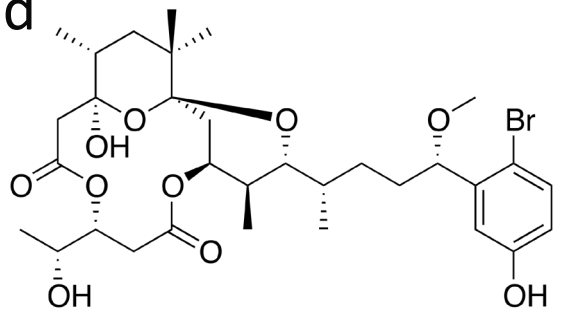
https://www.petmd.com/dog/general-health/home-remedies-for-dog-itchy-skin

Lyngbyatoxins and Aplysiatoxins

- Produced by fresh and marine cyanobacteria as protection from fish predators
- Skin redness can occur 3-20h after exposure and last 2-12d
- Can cause gastrointestinal and neurologic signs if ingested
- Contains a nucleophilic indole ring that binds to and activates protein kinase C (PKC)--tumor promotor



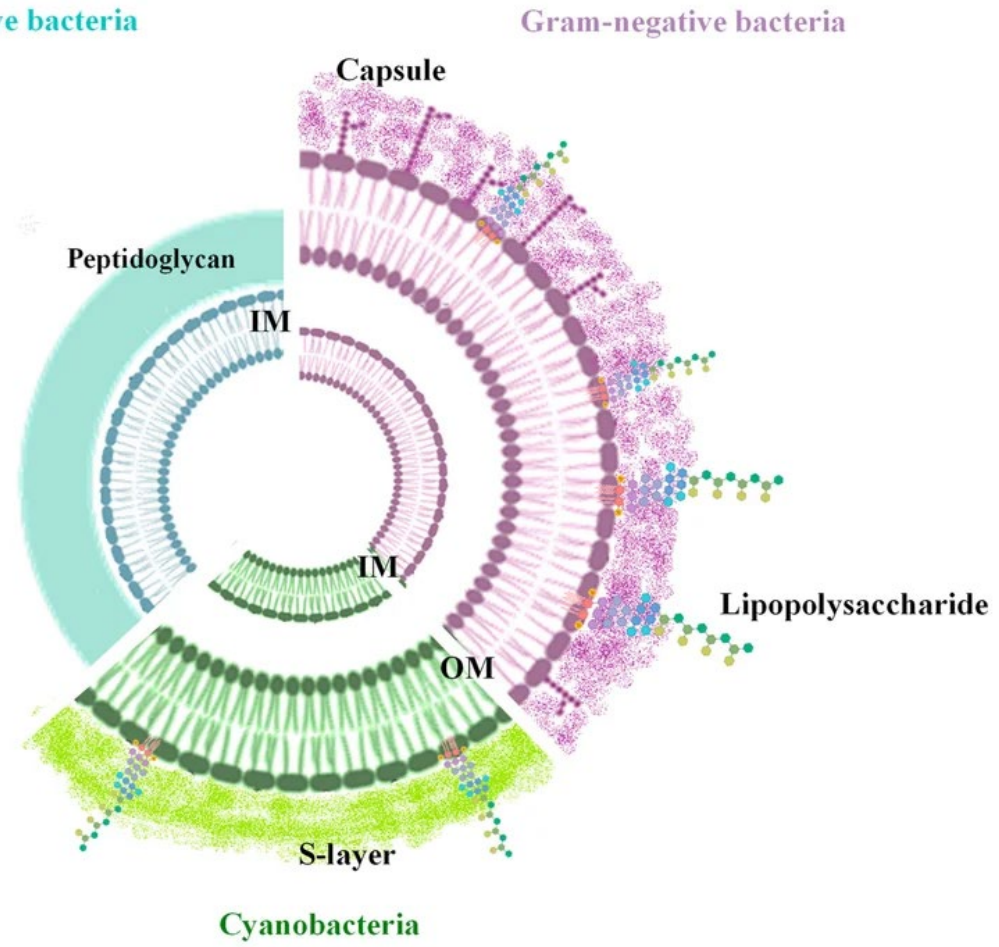
Lyngbya-a Molar mass 437.628
By Charlesy - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=8268223



Aplysiatoxin Molar Mass 671.674
By Charlesy - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=8291335

Lipopolysaccharides (LPS)

- Component of cyanobacterial outer membrane
- Very irritating to skin, respiratory tract, and gastrointestinal tract
- A common component of HABs
- Intestinal inflammation can make other toxins more available for absorption
- Can block the receptors for more potent LPS from non-cyano gram(-) bacteria
- Difficult to separate LPS effects from other 2° metabolites in blooms



Outer membrane differences between gram(+), gram(-), and cyanobacteria

Casillo, Angela & D'Amico, Raffaele & Lanzetta, Rosa & Corsaro, Maria. (2024). Marine Delivery Vehicles: Molecular Components and Applications of Bacterial Extracellular Vesicles. Marine Drugs. 22. 10.3390/md22080363.

Summary

- Important to consider cyanotoxin exposure as a rule out for animal (and human) illnesses- will need more education of public and veterinary community; especially in states where it may be a novel issue

- Certain cyanobacteria can produce multiple known and unknown toxins; 10-15% of OHHABS events had multiple toxins

Needs:

- Affordable and available toxin identification; POC tests
- Improved reporting/tracking; use OHHABS
- Additional health effects research; increased collaborations

Resources

- **North Central Region Water Network-Harmful Algal Blooms and Their Health-Related Effects on Animals**
  https://northcentralwater.org/wp-content/uploads/sites/317/2024/01/HABs-Algal-Blooms_010324_ADA.pdf
- **Laboratories that Analyze for Cyanobacteria and Cyanotoxins**
  https://www.epa.gov/habs/laboratories-analyze-cyanobacteria-and-cyanotoxins
- **State & Tribal HAB Programs and Resources**
  https://www.epa.gov/habs/state-tribal-hab-programs-and-resources
- **ITRC Visual Guide to Common Harmful Cyanobacteria**
  https://hcb-2.itrcweb.org/appendix-a/
- **Great Lakes HABS Collaborative Documents**
  https://www.glc.org/work/habs/publications
- **U.S. National Office for Harmful Algae Blooms**
  https://hab.whoi.edu/regions-resources/
- **Oregon Health Authority HABS Info**
  https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Pages/index.aspx

IOC-UNESCO Taxonomic Reference List of Harmful Microalgae: Cyanobacteria Updates

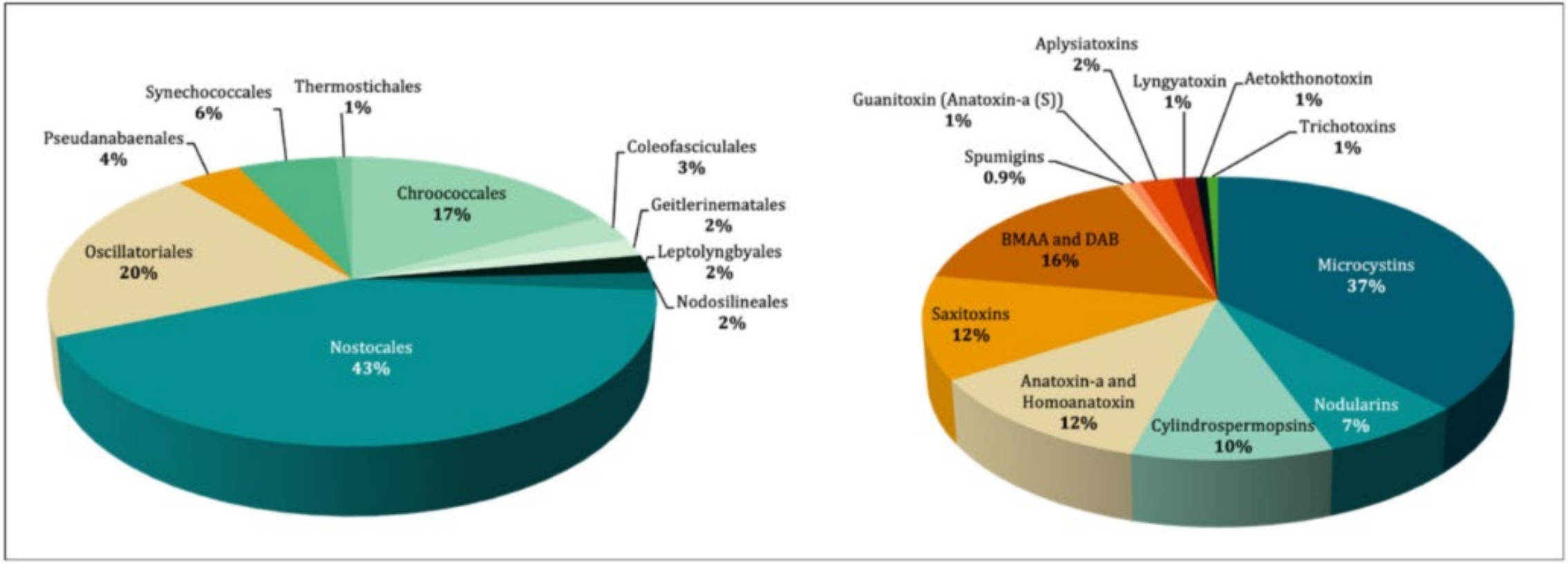


Fig. 3. Proportional representation of (A) cyanobacterial orders that include toxic taxa (10 of the 19 currently recognised orders) and (B) cyanobacterial toxins produced by the 99 cyanobacterial taxa included in the IOC-UNESCO Taxonomic Reference List of Harmful Microalgae (December 2025).

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https://doi.org/10.5281/zenodo.19045655

HARMFUL ALGAE NEWS NO. 82 / 2026