

EVE 486 Toxicology – Biological Poisons

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Biological Poisons

- There are MANY
 - Holly berries, daffodils, oleander, hemlock
 - Tiger snake venom, blue-ringed octopus venom, dart frogs
- Purposes
 - Defense
 - Predation
- Typically much more toxic than man-made chemicals (effective in small amounts)
- Human utility
 - Physiological research
 - Pharmacologic prototypes

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Toxins

- Toxic substances of biological origin
- Categorized based on the organism that produces them:
 - Bacteria
 - Fungi: *mycotoxins*
 - Algae: *phycotoxins*
 - Plants: *phytotoxins*
 - Animals: *zootoxins*
- **Venom:** an animal toxin that is produced in a salivary gland and is delivered to another animal through a bite or sting

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LD₅₀ Values of Some Common Animal Toxins

Species	Route	LD ₅₀ [mg/kg]	Locality
Scorpions			
Deathstalker	Subcut.	0.25	N. Africa, SW Asia
Fat Tail	Subcut.	0.32	N. Africa, Middle East
Arizona Bark	Subcut.	1.12	Arizona, Mexico
Spiders			
Black Widow	Subcut.	0.9	N. America, Europe
Brown Recluse	Subcut.	0.48	USA, Mexico
Funnel Web	Subcut.	??	Australia
Insects			
Common bee	Intraven.	6	Wide distribution
Wasp	Intraven.	2.5	Wide distribution
Harvester ant	Intraven.	0.12	N. America
Sea Creatures			
Box Jellyfish	Skin Con.	0.04	Indian, Pacific Oceans
Lionfish	Intraven.	1.1	All oceans
Stonefish	Intraven.	0.2	Indian, Pacific Oceans
Puffer fish	Ingestion	0.008	All oceans
Snakes			
W. Diamondback	Intraven.	4.2	N. America
King Cobra	Intraven.	0.35	Asia
Taipan	Intraven.	0.013	Australia
Black Mamba	Intraven.	0.25	Africa
Beaked sea snake	Intraven.	0.02	Indian, Pacific Oceans

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Animal Toxins

- **Spider Venoms**
 - Black widow spiders (*Lactrodectus* spp.)
 - Venom is neurotoxic
 - Effect: "Latrodectism" (pain, nausea, muscle contractions and cramps)
 - Brown recluse spiders (*Loxosceles* spp.)
 - Venom is cytotoxic and hemolytic
 - Effect: "Loxoscelism" (local and systemic effects associated with necrosis)
- In the US, 5-10 deaths/year

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Animal Toxins, cont.

- *Scorpions*
 - Very painful sting
 - Venom is generally neurotoxic
 - Most species relatively harmless to humans
- *Bees and Wasps*
 - Moderately painful sting
 - Venom is generally myotoxic (muscular)
 - Minimal toxic effect unless
 - *Multiple stings*
 - *Individual is allergic to venom*
 - In US, 50-100 deaths/yr

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Animal Toxins, cont.

- *Cnidarians* (jellyfish, corals, and anemones)
 - Nematocysts (thread-like “tentacles”)
 - Capable of discharge even if animal is dead
 - Box Jellyfish, *Chironex Fleckeri*
 - Extremely toxic
 - Excruciating sting can produce shock and drowning
 - 20-40 deaths/year in Philippines, alone
 - Portuguese Man-of-War, *Physalia*
 - Less toxic
 - Painful sting that leaves welts

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Animal Toxins, cont.

- *Mollusks*
 - Blue-ringed octopus, *Hapalochlaena lunulata* and *Hapalochlaena maculosa*
 - Capable of killing a human (painlessly) within 5 minutes
 - No known antidote
 - Bivalve mollusks: consumption may lead to
 - Amnesic shellfish poisoning
 - Diarrheic shellfish poisoning
 - Neurotoxic shellfish poisoning
 - Paralytic shellfish poisoning
 - Cone snails: ~two dozen humans confirmed killed

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Animal Toxins, cont.

- *Amphibians*
 - Poison dart frogs, *dendrobates* and *phylllobates*
 - >100 toxins have been identified in secretions
 - Weaponized by native Central/South Americans
 - Secretions may also have medicinal value
 - “Frog licking”
 - An hallucinogenic effect of the toxin
 - MANY hospitalizations

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Animal Toxins, cont.

- *Reptiles*
 - Venomous snakes
 - Venom may be *proteolytic, hemotoxic, neurotoxic, cardiotoxic* and/or *cytotoxic*
 - Approximately 125,000 deaths annually
 - The Russell’s viper kills more than any other (moderately toxic venom; although irritable and wide-ranging)
 - Inland Taipan has most toxic venom (very, VERY shy, however; no deaths ever documented)
 - Most *inject* venom; a few *spit*

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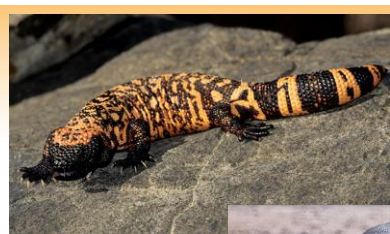


Animal Toxins, cont.

- *Lizards*

- Gila Monster, Mexican Bearded Lizard
 - SW USA and Mexico
 - Painful bite with neurotoxic or hemotoxic venom
 - Few (if any) deaths documented
- Monitor lizards, Komodo dragons
 - Likely “some” venom (debatable)
 - Komodo dragon has septic bacteria in saliva
 - Few human deaths recorded; most as a result of blood loss and/or shock

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Bacterial Toxins

- **Botulinum Toxin**
 - Neurotoxic protein that is produced under anaerobic conditions by the bacterium *Clostridium botulinum*
 - LD₅₀: approximately 0.25 - 1 ng/kg
 - Likely the most acutely toxic substance known
 - *Clostridium* spores are ubiquitously found in soil globally
 - Used in very small amounts both as a cosmetic treatment (Botox) and to treat painful muscle spasms (Dysport)

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Comparison of the Toxicity of Botulinum Toxin with Several Other Chemical Substances

Toxin	LD ₅₀ (µg/kg)	Molecular Weight
Botulinum toxin	0.00025	150,000
Batrachotoxin (amphibian dart poison)	2	538
Tetrodotoxin (puffer fish poison)	9	319
Sodium cyanide	10,000	65

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Bacterial Toxins, cont'd

- **Tetanus Toxin**
 - Described by Hippocrates 2500 years ago
 - Neuromuscular toxin produced by the bacterium *Clostridium tetani*
 - LD₅₀: approximately 2 ng/kg
 - Introduced into the body through skin lacerations, abrasions, and occasionally from body piercing or tattooing

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Fungal Toxins

- **Mushroom Toxins**

- Food processing (cooking, freezing, etc) will not "detoxify"
- LD₅₀
 - Death cap: 0.1 mg/kg
 - Psilocybins: 285 mg/kg
- four categories of toxic effect based on the primary toxicity
 - Gastrointestinal Effects
 - Disulfiram-Like Effects (anxiety, high BP)
 - Neurotoxic Effects
 - Cytotoxic Effects

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Algal Toxins

- **Cyanobacteria commonly known as blue-green algae.**
 - Primitive photosynthetic organisms
 - Approx. a dozen are toxic
 - Some of these are responsible for "swimmers itch"
 - Others linked to liver cancer
 - Still others produce a very dangerous neurotoxin
- **Other algal bacteria (eg. red tide) associated with massive fish kills and shellfish contamination**

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Higher Plant Toxins

- Many higher plants produce harmful substances that can produce injury and death if ingested
- Toxins are present in fruit, vegetable, garden, outdoor ornamental, and wild plants
- Plant toxins can be classified based on their general chemical structure:
 - Alkaloids (e.g., Yew, Poison Hemlock, Nightshade, Jimsonweed)
 - Proteins and amino acids (e.g., Castor bean)
 - Glycosides (e.g., Lily of the Valley, Foxglove, Oleander)
 - Oxalates (e.g., Philodendron, Dieffenbachia, Rhubarb)
 - Phenols, resins, and volatile oils (e.g., Poison Ivy, Poison Oak, Poison Sumac, Rhododendrons)
 - Phototoxins (e.g., St. John's wort)

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Conclusion

- Biological poisons are everywhere
- Many are just as dangerous (or much more so) than any chemical that's ever been produced
- They're evolving...

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