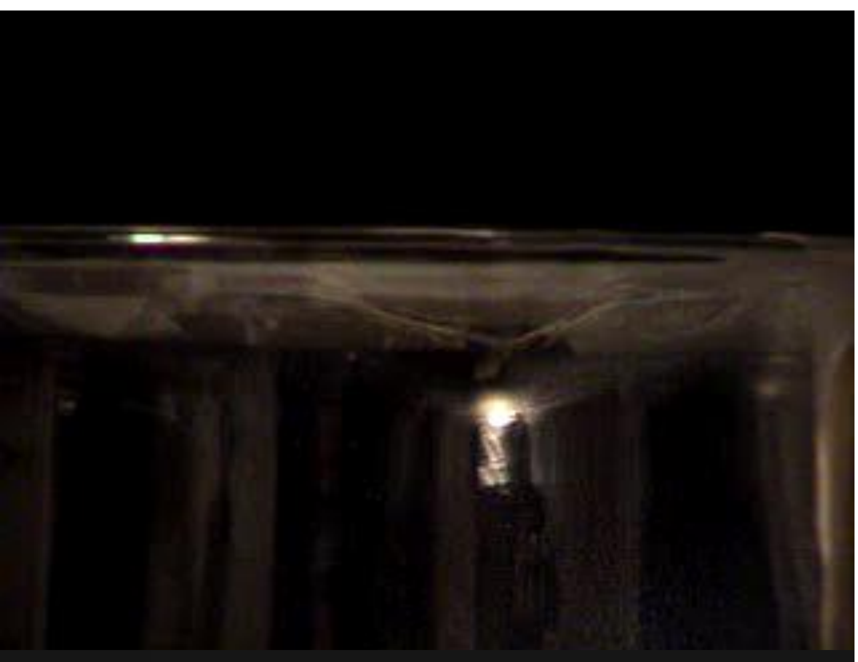
Functional Bases of Venom Injection

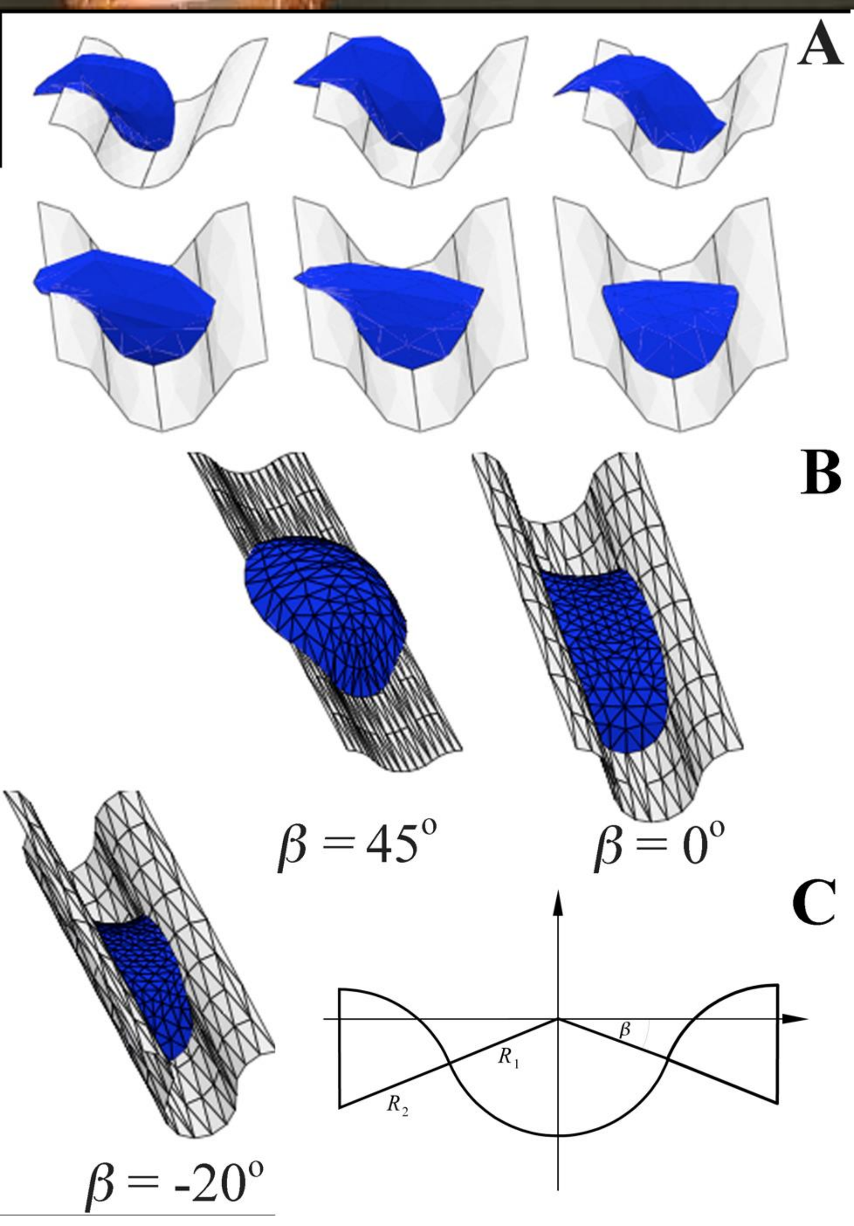


It is widely recognized that venom delivery systems have played a significant role in the evolutionary and ecological diversification of snakes. Despite this recognition — and decades of valuable research on the chemical, toxicological, and molecular aspects of venom — less is known about the underlying biophysics of venom injection.

In addition to the obvious safety issues, there are significant challenges to studying the functional bases of venom delivery. Venom expulsion typically lasts approximately 1/30th of a second, and the expulsion of one mass of venom changes the dynamics for subsequent expulsions.

My initial work centered on the anatomical bases of venom expulsion in rattlesnakes (Crotalus), and possible internal and external influences on venom flow. I have argued that there is little opportunity for fine internal control (or metering) of venom, but that the physical interaction between the viper and the target tissue will have a profound impact on the venom delivery system.

The emphasis on physical interaction between the snake and its prey, led me to explore venom expulsion in spitting cobras, since in these species venom expulsion occurs without direct physical contact. I was able to show that these elapids have a very similar control system for venom flow, but they have evolved a unique "release mechanism" that effectively replicates contact with the prey.



More recently I have been exploring the nature of venom delivery in snakes (and other reptiles) that have grooved teeth, rather than enclosed fangs. My colleagues and I have found that venom delivery in this system is dominated by the surface tension of the venom. The groove in the tooth decreases the surface tension energy, thereby promoting venom flow. The "chewing" behavior that is prevalent in rear-fanged snakes (which have grooved teeth) is a way of increasing the exposed surface area of the prey's tissue creating a physical attraction that literally pulls the venom into the prey's tissue.

If you would like additional information, I invite you to contact me at byoung@atsu.edu, or to explore some of my published work in this area:

Young, B.A., K. Dunlap, K. Koenig, and M. Singer (2004) The buccal buckle: the functional morphology of venom spitting in cobras. Journal of Experimental Biology 207: 3483-3494.

Young, B.A. and K. Zahn (2001) Venom flow in rattlesnakes: mechanics and metering. Journal of Experimental Biology 204: 4345-4351.

Young, B.A., M. Blair, K. Zahn, and J. Marvin (2001) Mechanics of venom expulsion in Crotalus, with special reference to the role of the fang sheath. Anatomical Record 264: 415-426.

Young, B.A., M. Phelan, M. Morain, M. Ommundsen, and R. Kurt (2003) Venom injection by rattlesnakes (Crotalus atrox): peripheral resistance and the pressure-balance hypothesis. Canadian Journal of Zoology 81: 313-320.

Young, B.A., M. Boetig, and G. Westhoff (2009) Functional bases of the spatial dispersal of venom during cobra "spitting". Physiological and Biochemical Zoology 82: 80-89.

Young, B.A. and K.V. Kardong (2007) Mechanisms controlling venom expulsion in the western diamondback rattlesnake, Crotalus atrox. Journal of Experimental Zoology 307A: 18-27.

Young, B.A., F. Herzog, P. Friedel, S. Rammensee, A. Bausch, and J. Leo van Hemmen (2011) Tears of Venom: Hydrodynamics of reptilian envenomation. Physical Review Letters 106: 198103.