



Charles F. Stevens

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“The goal of my laboratory is to learn what classes of mathematical computations are carried out by neural circuits, and what design principles govern the construction of these circuits. This research starts with various types of experimental data—relating to brain structure, function, and development—and uses techniques employed by theoretical physics to discover general biological principles that apply to the brain.”

Virtually all of the neural circuits in the vertebrate brain possess what computer scientists call a *scalable architecture*, allowing them to increase their computational power by simply growing in size while conforming to a single basic design. The vast majority of computers currently in use have what is known as a *von Neumann architecture*, which is not scalable. For evolution to work, however, brains need to be able to adapt to increased demands without the need for significant reconfiguration. Research in Stevens’s laboratory is aimed at learning the design principles that endow vertebrate neural circuits with a scalable architecture.

How can the scalability of neural circuits be studied? Most vertebrate brains—for example, the human brain—are nearly the same size for a given species, so that circuits of very different sizes are not available for comparison. Brains across a series of evolutionarily related species, such as primates, have a range of sizes that can be studied, but these brains are not necessarily comparable because of adaptive specializations of

specific species. Stevens is interested in discovering principles that govern all vertebrate brains, so he started by comparing the brains of a single species, goldfish, which come in a variety of sizes but are strictly comparable. Fish, unlike mammals, continue to grow throughout their lives and add new nerve cells to their neural circuits as they grow older and larger. Of course, any principles discovered in fish must be confirmed by studies in mammals.

Scalability implies that quantitative aspects of brain structure and function follow what are called *scaling laws*, orderly relationships that, for example, dictate for all brains how the number of neurons in one brain area is related to the number of neurons in a second area that receives information from the first one. These scaling relations embody general design principles, and so the job of a theorist is to figure out the computational significance of the scaling laws and learn how the brain grows in a way that conforms to the scaling law during the organism’s development.

For more information, please visit
salk.edu/faculty/stevens.html

Left to right:

Back row: Amanda Vlasveld, Bayle Shanks, Joe Snider, Ruadhan O’Flanagan, Corinne Teeter, Jian Xu, Yongling Zhu, Carol Glogowski, Tresa McGranahan

Front row: Hosuk Lee, Chuck Stevens, Steve Heinemann, Jane Jenerette, Gustavo Dziejczapolski, Conny Maron, Jenn Greenhall

Not pictured: T.K. Booker, Cayenne Carlo, Ed Han, and Kacee Jones

