

Fall 2009 Physics Colloquia Series

Prof. Zoltan Toroczkai

(Dept. of Physics, Notre Dame)

*Emergence of functional modules in
multitasking networks*

Friday, Sept. 25

2:30 P.M.

210 Robeson

Biological networks are known to possess functionally specialized modules, which perform tasks almost independently of each other. While proposals have been made for the evolutionary emergence of modularity, it is far from clear that adaptation on evolutionary time-scales is the sole mechanism that can lead to functional specialization. Here we show that phenotypic adaptation (non-evolutionary learning) can also lead to the formation of functionally specialized modules in a system exposed to multiple environmental constraints. We use the paradigm of neural networks to represent a task performing system, and use non-evolutionary learning algorithms as mechanisms for phenotypic adaptation. We show that for a network learning to perform multiple tasks, the degree of independence between the tasks dictates the degree of functional specialization emerging in the network. In order to uncover the functional modules, we introduce a method of node knockouts that explicitly rates the contribution of each node to different tasks (differential robustness). Through a specific example we also demonstrate the potential inability of purely topology-based clustering methods to detect functional modules. The robustness of the results in the present study suggests that similar mechanisms might be responsible for the emergence of functional specialization in other multitasking networks as well.