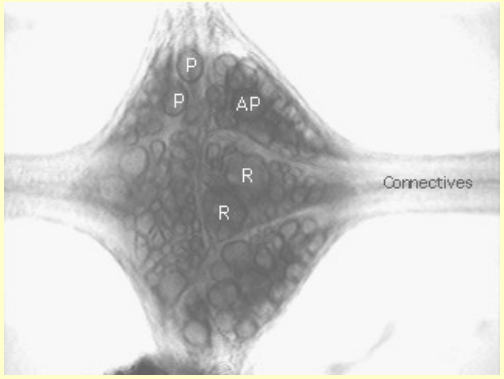
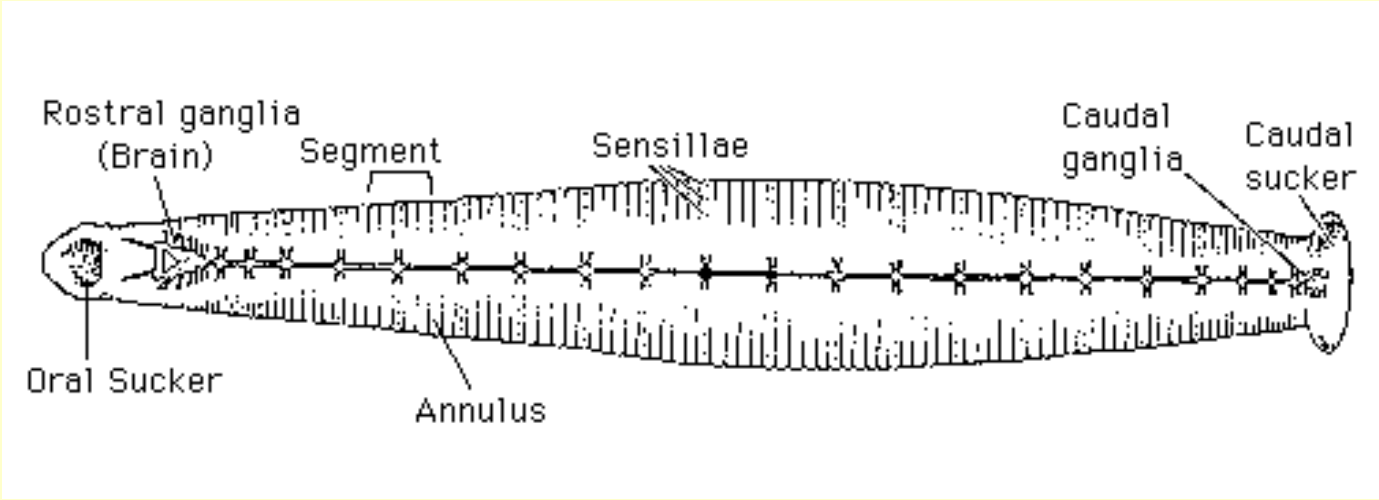
Levels of Emergence in the Leech

A Reminder…



Hirudo medicinalis



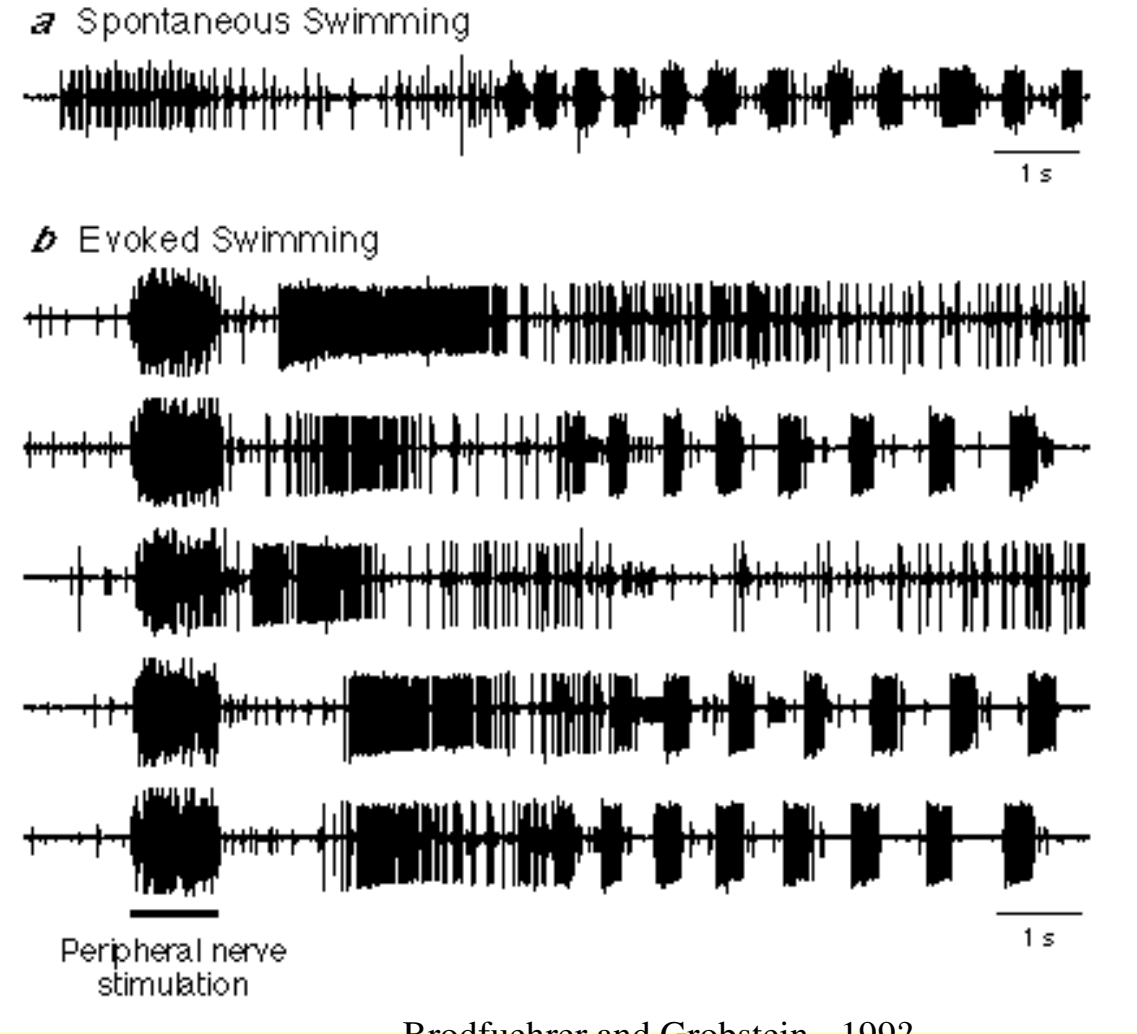
The swim system of the leech contains several possible sites of emergence

- Behavioral: randomness in swimming
- Network: sufficient complexity

Behavioral-level Emergence

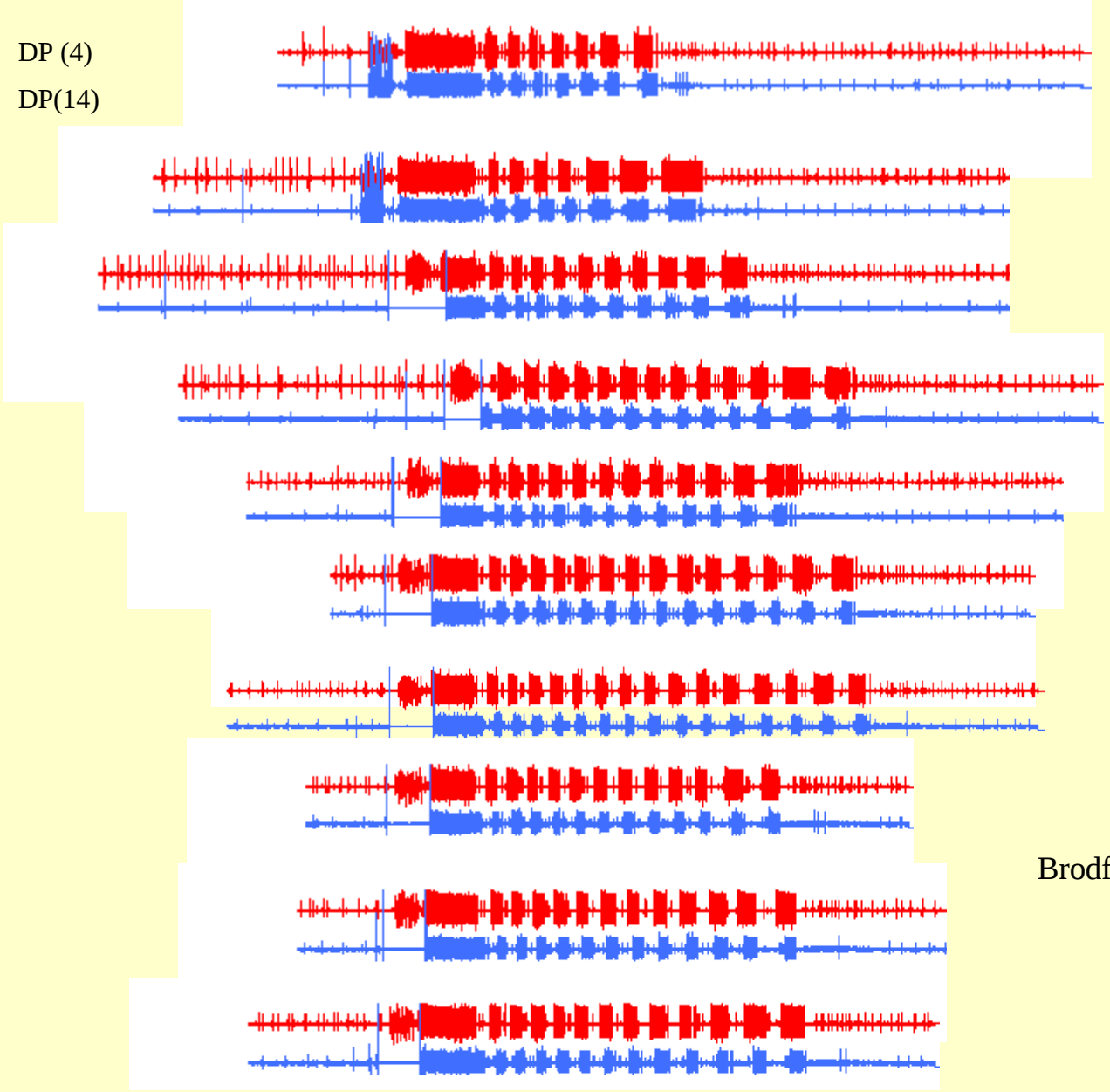
- “Random” variability can been observed in leech swimming
  - Initiation of swim
  - Length of swim bout
  - Individual cell responses

Swim Variability



Brodfuehrer and Grobstein - 199?

Swim initiation variability



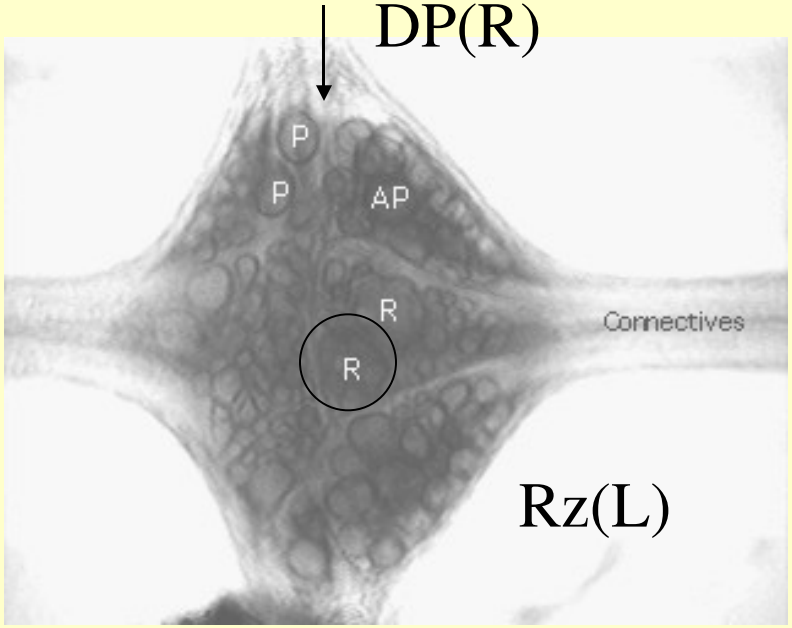
Brodfuehrer, 12/6/07

Swim Length variability

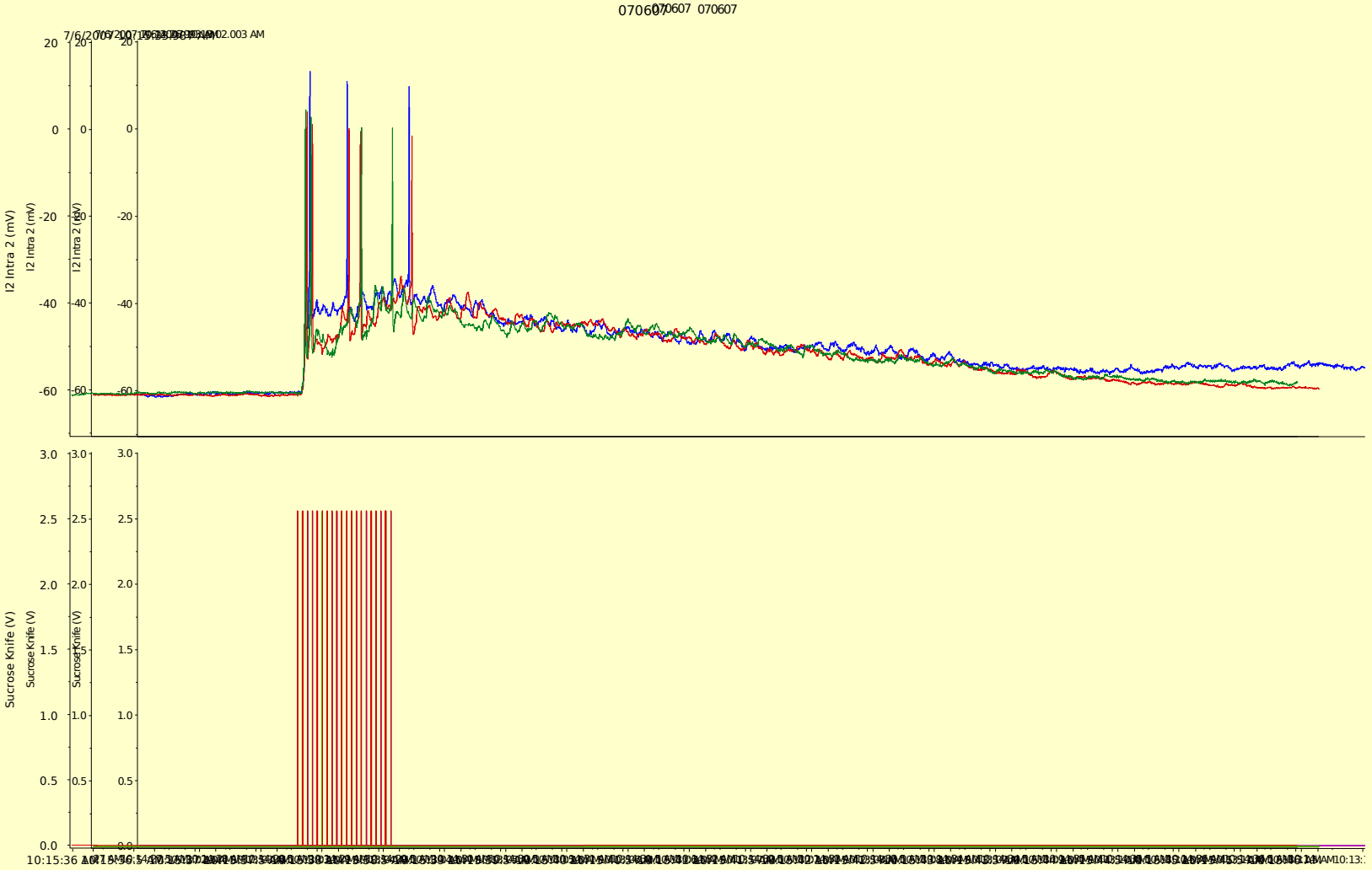
Variability at the Cellular Level

- Some variability can be seen in the response of specific cells to identical stimulations

Recordings of Retzius Cell response to DP Stimulation

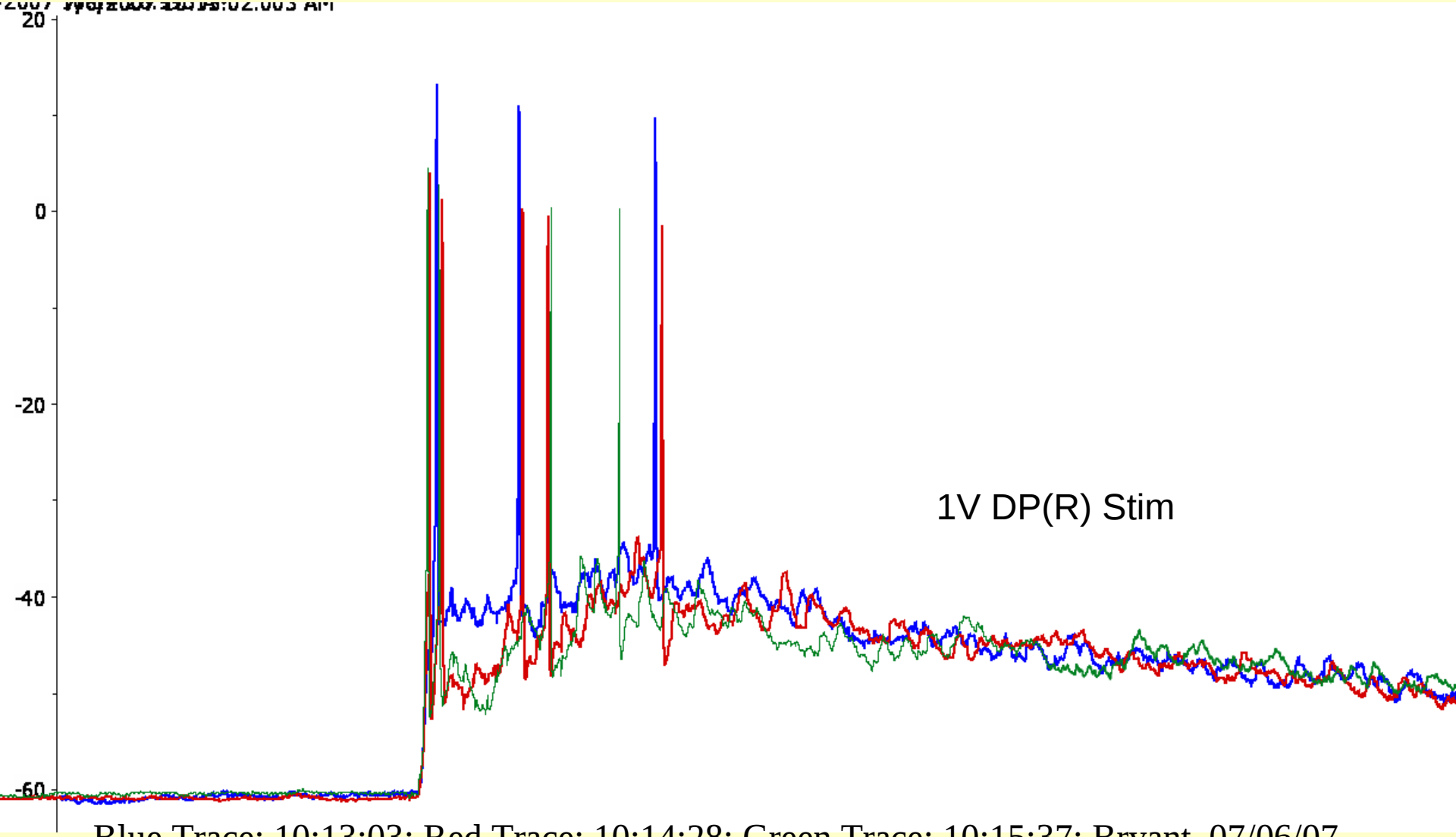


Comparing 3 Trials of 1V DP(R) Stimulation at Rz(L,11)



Blue Trace: 10:13:03; Red Trace: 10:14:28; Green Trace: 10:15:37; Bryant, 07/06/07

Magnified View of Previous Traces



Blue Trace: 10:13:03; Red Trace: 10:14:28; Green Trace: 10:15:37; Bryant, 07/06/07

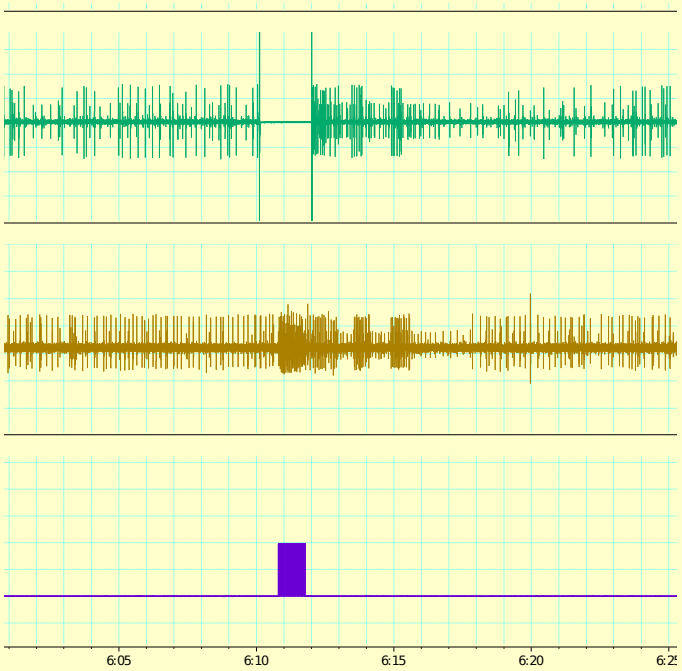
Network-level Emergence

- "In complex systems, the outcome is more than the sum of the parts. The difficult part, both empirically and conceptually, is ascertaining when and why the complexity is sufficient to produce the new effects"

Philip Clayton. "Conceptual Foundations of Emergence Theory". *The Re-Emergence of Emergence*, Eds. Philip Clayton and Paul Davies

Sufficient Complexity for Swimming

- How many ganglia does it take to produce "swimming"?



DP stimulation leads to swimming in M12-M13 cord