

GAP-FREE NEURAL CIRCUITS – CLASS #5: *C. elegans* pharyngeal pumping

OUTLINE:

- **Background on behavior and anatomy**
- **Nervous system control of pumping**
- **Light-induced behavior and circuit**

***C. elegans* pharyngeal pumping and neural anatomy**

- SLIDES: video of pharyngeal pumping and animation of pumping
- DRAW: Pharynx with each piece labeled (corpus, anterior bulb, isthmus, posterior bulb)
- Pharynx sub-behaviors
 1. Contraction stroke
 - Corpus opens (negative pressure) and sucks in liquid
 - Grinder moves posterior
 2. Relaxation stroke
 - Corpus closes and liquid pushed out -> filter feeding
 - Grinder moves anterior
 3. Isthmus peristalsis moves bacteria into posterior bulb
- SLIDES: Muscles and cells of the pharynx
- WEB: wormweb.org with PM at center
- Some numbers
 1. Neurons = 20 individuals in 14 classes (some bilaterally paired) (bilateral redundancy)
 2. Muscles = 34 nuclei in 8 classes (PM1-PM8, with 3-fold symmetry)
 - Muscles and marginal cells connected by gap junctions
- Nervous system connectivity
 - 2 islands
 - Pharyngeal nervous system (20 neurons)
 - Main nervous system (282 neurons)
 - I1 (pharynx) o-----o RIP (main)
- NOTES:
 - Pharynx is a bit like the heart – rhythmic pumper

Nervous system modulation of pumping

- Pumping is modulated by bacteria (food):
 - Bacteria -> 4-5 Hz and rhythmic
 - No bacteria -> 1 Hz and erratic
- Where is the CPG for pumping?
 - Only 20 neurons, so systematically laser kill
 - MC: ½ Hz, erratic -> grow to adult but starved
 - M4: stuffed corpus, no ingestion -> larvae don't grow to adult
 - M3: delayed relaxation (minor)

- All others individually: no effect
- All but MC and M4 together: ½ Hz, erratic
- All 14 classes: pumping continues, stuffed corpus
- “Sufficiency”
 - Def #1: activation of neuron -> behavior or affects another neuron
 - Def #2: behavior persists in absence of other neurons
 - All but M4: slow pumping, but isthmus peristalsis is intact
- SLIDES: Pharyngeal electrophysiology
 - MC: initiates pump with pre-E excitatory spike
 - M3: encourages repolarization with P inhibitory spikes
- DRAW: MC, M3 and M4 on pharyngeal muscle [KEEP]
- Some mysteries:
 - How does food promote the activity of MC? -> food sensor, in pharynx or out?
 - How does contraction promote the activity of M3? -> proprioceptor?
 - How does food modulate peristalsis rate?
 - How does the pumping signal conduct through the muscle without initiating peristalsis?

Light-induced locomotion

- Behavior:
 - Light on head -> reversal
 - Light on tail -> forward acceleration
 - Most sensitive to lower wavelength light (<400 nm)
- No eyes and transparent, so light sensors unclear
- Previous work found that
 - ASJ and ASK are redundantly required for light-induced reversals
 - ASJ and ASK respond by depolarizing to light
 - *tax-2* and *lite-1* act in ASJ and elsewhere for depolarization and light-induced reversals