Ion channels in defecation motor program in nematode *Heterorhabditis megidis*

Yu. V. Panchin

IITP, RAS, Moscow, ypanchin@yahoo.com

V. P Kuznetsov

IITP, RAS, Moscow, scikvp@gmail.com

G. A. Slivko-Koltchik

IITP, RAS, Moscow, s.koltchik@gmail.com

D. A. Voronov

IITP, RAS, Moscow, da_voronov@gmail.com

The nervous system controls most rhythmic behaviors, with one remarkable exception. *Caenorhabditis elegans* nematode is continuously eating. While eating it rhythmically defecates with the stable period of 45-50 seconds [1, 2]. A signal that controls this behavior is generated and spreads through the gut cells. Intestine cells release protons to the lumen, activating and recruiting muscle cells into the process that causes defecation [3, 4]. All involved signaling is produced by endoderm cells without the participation of the nervous system. The small size of *C. elegans* cells impairs the use of standard electrophysiological methods. [5, 6, 7, 8, 9] We applied classical electrophysiological approaches to study this mechanism in nematode Heterorhabditis megidis with noticeably larger gut cells than those in *C. elegans*. By using microelectrode techniques, we have demonstrated that the defecation cycle is driven by a central pattern generator (CPG) associated with unusual all-or-none hyper-polarization “action potential” with a fixed duration of about one minute, a period of up to 15 minutes and an amplitude of about 60 mV. CPG cycles run through a sequence of gut cells connected via gap junctions. The dynamics of cell membrane conductance in the course of the defecation cycle in an isolated gut preparation was measured by intracellular application of short low amplitude current pulses. Then it was assumed that the total conductance is a superposition of two types of conductance of channels permeable to ions with different reversal potential of +70 mV and -100 mV. As a result, we separated total

membrane conductance into two components: one for a cation with extracellular concentration that is much higher than intracellular (presumably Na^+ or Ca^{2+}), and one for a cation with an intracellular concentration that is much higher than extracellular (presumably K^+). Based on data available for *C. elegans* we subsequently separated the conductance in putative Na^+ and Ca^{2+} components. This simplified model is in good agreement with observed patterns of gut cells oscillations and genomic and molecular data on intestinal calcium wave in *C. elegans*. We compare this rhythmical generation with action potentials of conventional excitable cells (neurons and muscles) and calcium waves described in the mammalian blood vessel endothelium and brain astrocytes.

This work was supported by the Russian Foundation for Basic Research [grant number 15-04-06148]

1. N. Croll, J. Smith (1978) Integrated behavior in the feeding phase of Caenorhabditis elegans (Nematoda), *J Zool*, **184**: 507–517.

2. K. Nehrke, J. Denton, W. Mowrey (2008) Intestinal Ca2+ wave dynamics in freely moving C. elegans coordinate execution of a rhythmic motor program, *Am J Physiol Cell Physiol.*, **294**: 333-344.

3. E. Allman, D. Johnson, K. Nehrke (2009) Loss of the apical V-ATPase a-subunit VHA-6 prevents acidification of the intestinal lumen during a rhythmic behavior in C. elegans, *Am J Physiol Cell Physiol*., **297**: 1071–1081.

4. A. Beg, G. Ernstrom, P. Nix, M. Davis, E. Jorgensen (2008): Protons act as a transmitter for muscle contraction in C. elegans, *Cell*, **132**: 149–160.

5. L. Avery, D. Raizen, S. Lockery (1995) Electrophysiological methods, *Methods Cell Biol.*, **48**: 251–269.

6. D. Raizen, L. Avery (1994) Electrical-activity and behavior in the pharynx of Caenorhabditis elegans, *Neuron*, **12**: 483–495.

7. D. Raizen, R. Lee, L. Avery (1995) Interacting genes required for pharyngeal excitation by

motorneuron MC in Caenorhabditis elegans, *Genetics*, **141**: 1365–1382.

8. R. Lee, L. Lobel, M. Hengartner, H. Horvitz, L. Avery (1997) Mutations in the alpha 1 subunit of an L-type voltage-activated Ca^{2+} channel cause myotonia in Caenorhabditis elegans, *EMBO J.*, **16**: 6066–6076.

9. B. Shtonda, L. Avery (2005) CCA-1, EGL-19 and EXP-2 currents shape action potentials in the Caenorhabditis elegans pharynx, *J. Exp. Biol.*, **208**: 2177–2190.